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Designing a Model to Improve the Role of Science and Technology Parks in the Development of Agricultural Technologies

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Abstract

The present study aimed to propose a model for enhancing the role of science and technology parks in developing agricultural technologies. It utilized applied, retrospective, quantitative, and qualitative methods. The qualitative section targeted all managers of agricultural science parks, with 27 participants selected via snowball sampling and interviewed face-to-face. For the quantitative part, Cochran's formula determined a sample size of 90 managers from agricultural parks and associated companies, data collected through a questionnaire. Data analysis employed multivariate analysis, with data from interviews analyzed using three-stage open, axial, and selective coding, yielding 6 categories and 181 concepts. Spearman correlation coefficient assessed relationships between strategies for enhancing science parks' role and research variables, showing significant positive correlations across various dimensions including behavioral and attitudinal motives, social and economic structures, environmental potential, social capital, educational and credit strategies, macro and micro interfering factors, and consequential aspects of infrastructure and institutions. Strategic design for enhancing science parks' role considers causal, intervening, and contextual variables, with adopted strategies showing the highest direct impact, followed by intervening factors, and contextual and causal factors influencing the improvement mechanisms.

Keywords:
Technology development, agricultural technologies, science and technology parks

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INTRODUCTION

The recent developments in population growth, advancements in science and technology, and growing environmental concerns have significantly heightened the importance of agriculture. Rapid population growth, particularly in the developing world, has turned food supply and security into a critical challenge, with thousands dying daily from hunger in various countries (Zhao and Yan, 2014). The agricultural sector, as the primary provider of food, plays a pivotal role in ensuring food security and delivering essential ecosystem services, including food provision. Agriculture is crucial not only for meeting food needs but also for achieving Sustainable Development Goal 2 (SDG 2 – zero hunger), alongside other Sustainable Development Goals (Viana et al., 2022). Moreover, prioritizing the agricultural sector is recognized as one of the most effective strategies for combating poverty in developing nations. Industries linked to agriculture, particularly in these regions, hold critical importance due to their role in utilizing existing technologies, completing production chains, creating value, generating employment through agro-industries, and facilitating exports of processed goods, thereby contributing to foreign exchange earnings (Xia and Li, 2017). Despite its significance, the agricultural sector faces persistent constraints and challenges stemming from both external and internal factors. External challenges include economic, social, and technical behaviors of other sectors, while internal issues arise from intra-sectoral inefficiencies (UNCTAD, 2017). Policies aimed at developing the agricultural sector have consistently encountered obstacles, with prominent issues including lack of cohesion, inconsistency, and susceptibility to non-economic objectives (Haji Shamsaei et al., 2017).

Failure to fully and scientifically exploit natural resources such as water, incorrect agricultural practices, the weak financial foundation of most farmers, and the primitive nature of agriculture—characterized by limited use of machinery, materials, and modern methods—have significantly impacted the income of farmers and industries related to the agricultural sector. Additional factors include the increasing fragmentation of small-scale farming units, governmental policies that neglect investment in agriculture, and the reluctance of agricultural graduates to work in the private sector (Karimi Tararani et al., 2020). Key challenges also stem from the lack of an entrepreneurial culture in agriculture, insufficient adoption of new technologies, failure to train an entrepreneurial workforce aligned with societal needs, lack of interest and requisite skills among graduates, the high costs of agricultural research, and the failure to utilize and commercialize research findings (Ahmadkhani et al., 2020). Entrepreneurship barriers in the agricultural sector can be categorized into five main groups: educational-extension, economic, supportive, technical-managerial, and infrastructural barriers (Maleksaeidi & Memarbashi, 2023).

The primary solution in many countries for addressing agricultural challenges has been the establishment of production and research hubs, particularly science and technology parks focused on agriculture. Agricultural science parks are proposed as a practical approach to addressing these issues while supporting agricultural entrepreneurs (Fakoor & Ansari, 2010). Science and research parks, along with incubators and accelerators, serve as concurrent drivers of innovation (Lassoued et al., 2023). Agricultural science and technology parks (ASTPs) act as critical growth poles for agricultural modernization (Wang et al., 2021). The main distinction between classic science parks and agricultural science parks lies in their management and scope. Unlike classic parks, agricultural science parks extend beyond indoor spaces, encompassing farms and production zones. In addition to the facilities offered by traditional development centers and parks, agricultural parks provide specialized resources such as greenhouses, agricultural fields, irrigation systems, and specialized laboratories (Mottaghi Talab & Dawaei, 2003). However, in Iran, issues such as flawed design and poor decision-making regarding these development parks and centers have hindered their effectiveness. A comparison between the technological capabilities and skill levels of companies in advanced technologies and the number of parks in Iran versus those in other countries highlights a trivialized view and misjudgment of the nation's capacities and prerequisites. Even when these complexes are physically established, with significant expenditures from the national budget, they often result in "ghost towns"—uninhabited complexes or those occupied by entities mismatched with the intended technological ecosystem of the parks (Haji Gholam Saryazdi, 2020).

In a country like Iran, the development of parks and centers is essential for ensuring the success of their tenants and residents. To achieve this, it is crucial to expand their functional scope and address the structural weaknesses and limitations of these entities. Simply replicating models from other countries cannot adequately resolve the challenges faced, whether in fostering the growth of mature companies within parks or in supporting start-ups in these centers (Darreh Shiri et al., 2019). Managers and planners of these development parks and centers must first gain a comprehensive understanding of the state of innovation and technology within the country, including their relationships, actors, weaknesses, and missing links. Based on this understanding, they should devise strategies to address these deficiencies and pave the way for sustainable success (Davoodi et al., 2011).

In a study by Shen and Xiu (2012), factors such as the park's image, proximity to universities and institutions, and responsiveness to local needs were identified as key contributors to the success of science parks. Most successful science parks were situated near universities and industrial centers, benefiting from close relationships with universities through shared infrastructure (e.g., laboratories), services, and collaborative research groups. These findings highlight the vital role universities play in the development of science and technology parks. Another significant factor is the presence of risk-taking investment companies, which, alongside universities, drive the growth of science parks. Financial institutions, service companies, and local shareholder companies further contribute to the development and success of these parks (Song & Li, 2018).

Addressing these factors and implementing effective mechanisms to enhance the processes and innovation within agricultural science and technology parks can serve as a pivotal driver for agricultural development. However, many existing centers in Iran have struggled to develop appropriate technologies, transfer knowledge, and commercialize research findings in collaboration with universities (Davoodi et al., 2011). This limitation underscores the need for a robust model to improve the performance of agricultural science parks and foster the development of agricultural technologies.

A science park is a professionally managed organization whose primary goal is to enhance the community's wealth by promoting innovation and increasing the competitiveness of its associated businesses and knowledge-based institutions. Science parks achieve this by facilitating the flow of knowledge and technology among universities, R&D centers, private companies, and the market. They support innovation-based companies through development centers and generative processes, providing high-value-added services, workspaces, and quality facilities to resident institutions (Darreh Shiri et al., 2019).

Globally, science parks have gained significant attention as functional structures for advancing technology, fostering a knowledge-based economy, and creating specialized employment opportunities. These modern structures aim to establish dynamic environments that nurture technology chains, orient research products, enable collective collaboration, and support the targeted activities of researchers, inventors, and technology-focused companies in specialized fields (Nik Neshan et al., 2018).

Today, we are at a pivotal point in modern technological evolution, which is set to revolutionize agricultural activities. The convergence of information and communication technologies, biotechnology, and nanotechnology forms the core axis of these advancements. These technologies will undoubtedly shape the future of agriculture and environmental management (Sadeghi et al., 2014). To harness the opportunities presented by technological evolution and address the challenges of globalization, nations must adopt innovative strategies that foster entrepreneurship and innovation. Science parks serve as a mechanism for transitioning traditional economic bases to advanced technology and addressing scientific underdevelopment. They also tackle the lack of a systematic relationship between universities and society. While scientific endeavors underpin these parks, business-oriented relationships are equally vital. Decisions about establishing and expanding science parks must consider market feasibility, technical, financial, and economic aspects, and park size (Jafarnejad & Ghasemi, 2008).

Science parks provide institutions with high-value-added services, quality working spaces, and advanced facilities. Globally, they are categorized into types such as technology parks, research parks, and technological hubs or zones (Kakaei et al., 2021). Despite their variety, all these parks emphasize entrepreneurial processes and behaviors aimed at creating added value for their associated companies (Ghaffari et al., 2020).

The primary goal of companies within science parks is to foster innovation, enhance competitiveness, and improve their economic standing. In the global economy, the pillars of success are technology, research and development, knowledge management, and above all, innovation (Kakaei et al., 2021). Research serves as the foundation of innovation, with universities and higher education institutions playing a critical role in unlocking regional and national potential. Science and technology parks act as vital bridges between universities and businesses, addressing barriers such as communication gaps and differing interests between entrepreneurs and academics (Islami & Feizi, 2008).

The success of science parks—economic, social, and political—depends on several factors spanning the design, development, and maintenance stages. Experience in industrializing nations suggests that creating sustainable functions and achieving a positive economic impact require persistence and consistent support from both the government and society throughout the implementation phase. The theoretical framework of

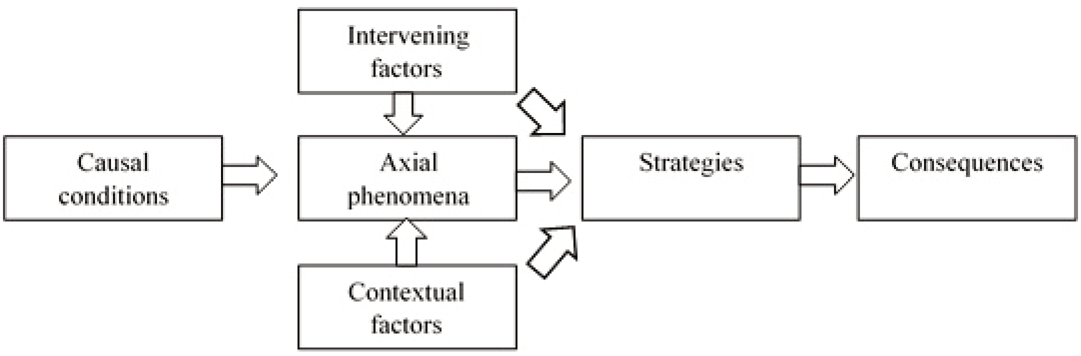

Figure 1. Theoretical Framework of the Study.

this research encapsulates these considerations, as illustrated in Figure 1.

METHODOLOGY

The present study employs a mixed-methods approach, combining qualitative and quantitative methods due to the nature of the research subject. The qualitative phase relies primarily on semi-structured interviews for data collection. The statistical population includes authorities, experts, and managers of agricultural science parks. A sample of 27 individuals was selected using snowball sampling, where interviewees recommended other informed participants. Of the respondents, 24 held a Ph.D., 23 were male, and 2 were female, with ages ranging from 32 to 65. After 27 interviews, the researcher determined that data saturation had been achieved, making further interviews unnecessary. The qualitative data were analyzed using grounded theory, which involved open, axial, and selective coding of texts, documents, and interview transcripts.

In the quantitative phase, the research adopts a non-experimental, survey-based strategy and is applied in nature. The statistical population comprises all managers of agricultural parks and companies within the parks. Due to the diversity of companies and activities, stratified sampling was employed. Using the Cochran formula, the sample size was calculated to include 90 managers.

The research instrument was a questionnaire developed by the research team. This questionnaire was informed by the findings of the qualitative phase and refined through collaboration with experts and specialists. Indicators for the questionnaire items were derived from 181 axial categories identified in the qualitative analysis. The Content Validity Ratio (CVR) method was used to validate these indicators, and the final questionnaire was distributed to the target population. The reliability of the questionnaire was assessed using the Combined Reliability (CR) method. Data analysis was performed using SPSS-win22 and LISREL Ver.8.5.

RESULTS AND DISCUSSION

The participants in the qualitative section were all married individuals aged between 30 and 50 years. A total of 27 interviews were conducted, ensuring theoretical saturation of

Table 1
Validity and Reliability of the Questionnaire Parts.

Factor	AVE	CR	Cronbach's alpha
Behavioral motives	0.563	0.864	0.775
Attitudinal motives	0.512	0.789	0.701
Social structures	0.577	0.881	0.787
Economic structures	0.622	0.912	0.812
Environmental potentials	0.634	0.941	0.844
Inter-group social capital	0.622	0.867	0.844
Educational strategy	0.680	0.769	0.901
Credit Strategy	0.723	0.902	0.789
Macro intervening factors	0.589	0.889	0.765
Micro intervening factors	0.601	0.812	0.855
Social consequences	0.623	0.798	0.834
Economic consequences	0.689	0.865	0.795
Infrastructure consequences	0.705	0.911	0.821
Institutional Consequences	0.599	0.822	0.765
Improvement of the role of the park	0.654	0.789	0.886
Obstacles and barriers	0.743	0.912	0.769

the data. The data analysis followed a three-step process: open, axial, and selective coding. Initially, a line-by-line analysis technique was applied to analyze the interviews. Agricultural technology development was treated as an axial phenomenon because its influence was evident throughout the data, allowing other categories to revolve around it.

After analyzing the data, labeling events, and extracting concepts, similarities and differences were identified. This process resulted in the identification of six categories and 181 concepts. During axial coding, the categories derived from open coding were grouped into six broader categories: axial category, causal conditions, intervening factors, contextual factors, strategies (actions or reactions), and consequences. The axial category, "improving the role of the park in the development of agricultural technology," was central to the model due to its pervasive presence in the data.

Causal factors were identified as those directly contributing to the improvement of the park's role in agricultural technology development. These included behavioral and attitudinal motives. Behavioral motives comprised 14 propositions linked to opportunities for advancing science and technology parks, government support, employment, enhanced social status, access to facilities, job independence, and income generation. Attitudinal motives focused on performance improvement, such as access to information, economic risk immunity, quality of life enhancement, and vulnerability reduction.

The contextual conditions category encompassed subcategories like social structures, economic contextualizing frameworks, and environmental and institutional potentials, which formed the foundational basis. Strategies were grouped under capital, education, and credits, highlighting interconnected and directly influential factors for improving the role of science and technology parks. Intervening factors represented practical, mediated actions, classified into macro and micro agencies.

Finally, the consequences category encompassed outputs such as social, economic, infrastructure, and institutional transformations, illustrating the outcomes of the processes and strategies identified.

The grounded theory results revealed five core categories and 14 specific categories. Analysis of the 181 axial categories and the research background in improving the role of parks showed a complete alignment. The three-stage data reduction process is illustrated in Figure 3.

In the quantitative section, personal and oc-

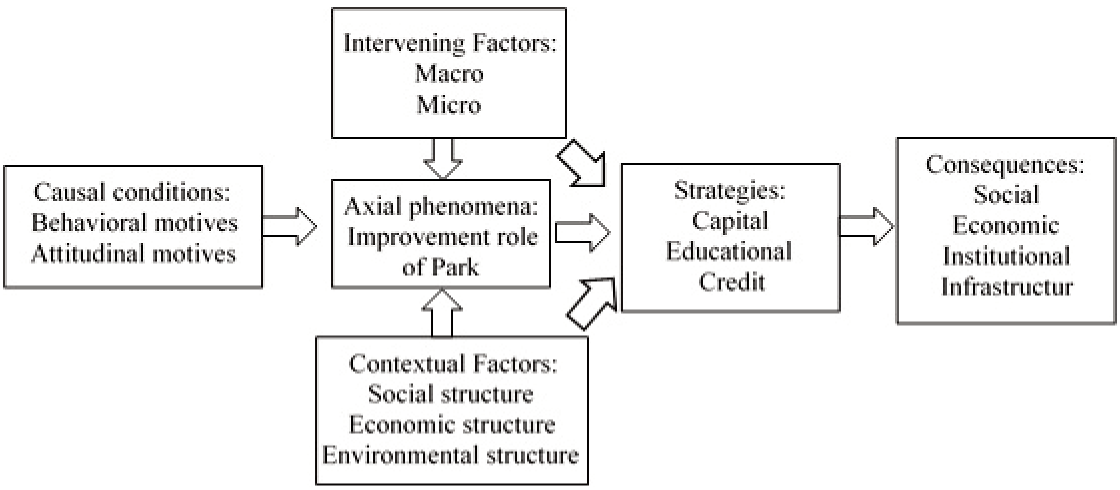

Figure 2. Axial Coding Model of Improvement of the Role of the Park in Agricultural Technology Development.

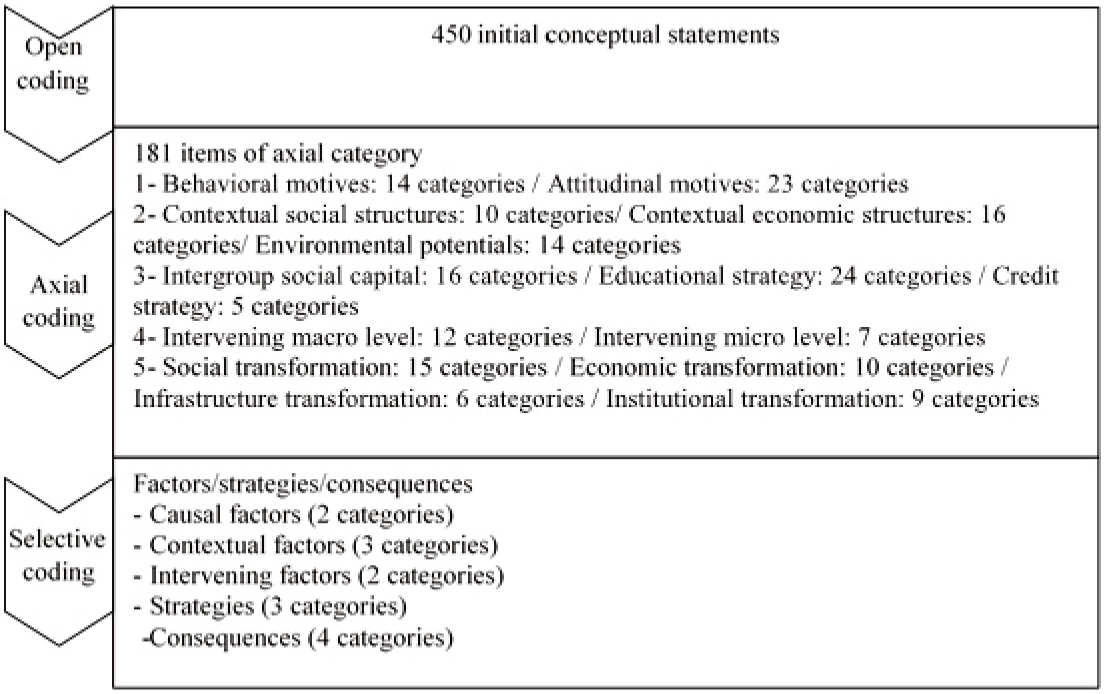

Figure 3. Data Reduction Process in the Three Coding Stages.

cupational attributes were examined, including variables such as age, work experience, major, education level, number of scientific articles, and others. The detailed results are presented in Table 2.

The Pearson correlation coefficient has been used to investigate the correlation between the improvement of the role of the park in agricultural technology development and research variables. The results are presented in Table 3.

The correlation coefficient between the variables was analyzed to explore the relationships between the research variables influencing the mechanisms of improving the park's role in agricultural technology development. The results indicated that all correlations were significant at the 0.01 level.

Based on the fitness indicators presented in Table 4, it can be concluded that the structural model designed for the park's role in agricultural technology development is acceptable in terms of fitness and the examination of correlations between the structures.

Therefore, based on the fitted model of the research, it can be concluded that the structures used to analyze the model for improving the park's role show an acceptable correlation with the causal infrastructure. The t-values and the fitted model are presented in Figures 4 and 5.

Table 5 shows the results from the hypotheses testing for the causal correlation between the research variables.

Table 6 presents the direct, indirect, and total effects of independent variables on dependent variables. Based on the results of the path analysis for improving the park's role, the most direct impact on its improvement comes from the adopted strategies. Therefore, focusing on educational and credit strategies can be effective in enhancing the park's role. This aligns with the findings of Zarinjooee et al. (2021), who concluded that science and technology parks are crucial for research and innovation strategies, smart specialization, technology diffusion through entrepreneurship, and the knowledge economy.

The second variable influencing the improvement mechanisms is intervening factors, which impact the improvement process at both macro and micro levels. Research by Momeni Beshbousgheh et al. (2020) sup-

Table 2

Investigation and Description of the Personal and Occupational Attributes of the Respondents.

Variable	Items	Frequency	Percentage	Cumulative percentage	Descriptive statistics
Age	Under 40	25	27.8	27.8	Mean=46.65
	40-50	38	42.2	70	Median=45
	50-60	20	22.2	92.2	Mode=50
	Above 60	7	7.8	100	SD=8.33
	Total	90	100		Minimum=35
					Maximum=66
Education level	Master's degree	4	4.4	4.4100	Mode=Ph.D.
	Ph.D.	86	95.6		
	Total	90	100		
Managerial position	No	32	35.6	-	Mode=Yes
	Yes	58	64.4		
	Total	90	100		
Major	Development and promotion	6	6.7	-	Mode=Horticulture
	Economy	3	3.3		
	Agronomy	10	11.1		
	Horticulture	12	13.3		
	Machinery	5	5.6		
	Irrigation	9	10.0		
	Wood and paper	7	7.8		
	Medicinal plant	8	8.9		
	Fisheries	5	5.6		
	Forestry	11	12.2		
	Grassland	41	4.4		
	Soil science	9	1.1		
	Animal husbandry	90	1.0		
	Total		100		
Managerial experience	Less than 5 years	26	44.8	44.8	Mean=7.74
	50-10 years	17	29.3	74.1	Median=6
	10-15 years	9	15.5	89.7	Mode=2
	Above 15 years	6	10.3	-	SD=5.2
	No response	32	-	100	Minimum=2
	Total	90	100		Maximum=18

ports this finding, indicating that organizational and cultural factors are the most influential on the success of science and technology parks. Contextual and causal factors also contribute to the improvement mechanism. Keshavarz et al. (2021) found that organizational culture, organizational capability, support mechanisms, organizational policy, personality traits, environmental infrastructure, and demographic characteristics ranked highest in influencing success. Information technology infrastructure, patents, intellectual property, and government support policies were also among the key indicators.

In analyzing the indirect effects of causal factors on improvement strategies, contextual and intervening factors are found to play a significant role. Intervening factors affect contextual factors and strategies, and ultimately, contextual factors influence the strategies. The coefficient of determination (R^2) is used to assess how much of the variance in the dependent variable is explained by the causal model presented in the path analysis. The R^2 value of 0.47 indicates that the model explains approximately 47 percent of the changes in the dependent variable. The error coefficient (e value), calculated from R^2, shows that the causal model does not account for 53 percent of the variance in the dependent variable.

CONCLUSIONS

Table 3

Investigation of the Correlation Between the Improvement of the Role of the Park in Agricultural Technology Development and Research Variables.

Predictor variable	Dependent variable	r
Age	Mechanisms to improve the role of science and technology park in the development of agricultural technology	-0.103*
Education level		0.151**
Working experience in the business		0.128*
Average monthly income		0.072
Amount of loans received		-0.140**
The amount of initial capital		0.198**
Behavioral motives		0.224**
Attitudinal motives		0.148**
Social structures		0.382**
Economic structures		0.268**
Environmental potentials		0.216**
Inter-group social capital		0.190**
Educational strategy		0.584**
Credit strategy		0.115*
Macro intervening factors		0.312**
Micro intervening factors		0.172**
Social consequences		0.107*
Economic consequences		0.190**
Infrastructure consequences		0.216**
Institutional Consequences		0.127*

**p<0.01, *p<0.05

Table 4

Fitness Indicators of the Structural Model of the Improvement of the Park's Role in Technological Development.

Fitness index	Proposed criterion	Reported value
$\frac{x^2}{df}$	≤3	2.04
NFI	≤ 0.90	0.94
NNFI	≤ 0.90	0.95
CFI	≤ 0.90	0.98
GFI	≤ 0.90	0.96
IFI	≤ 0.90	0.92
RMR	≤0.05	0.038
RMSEA	≤0.10	0.052

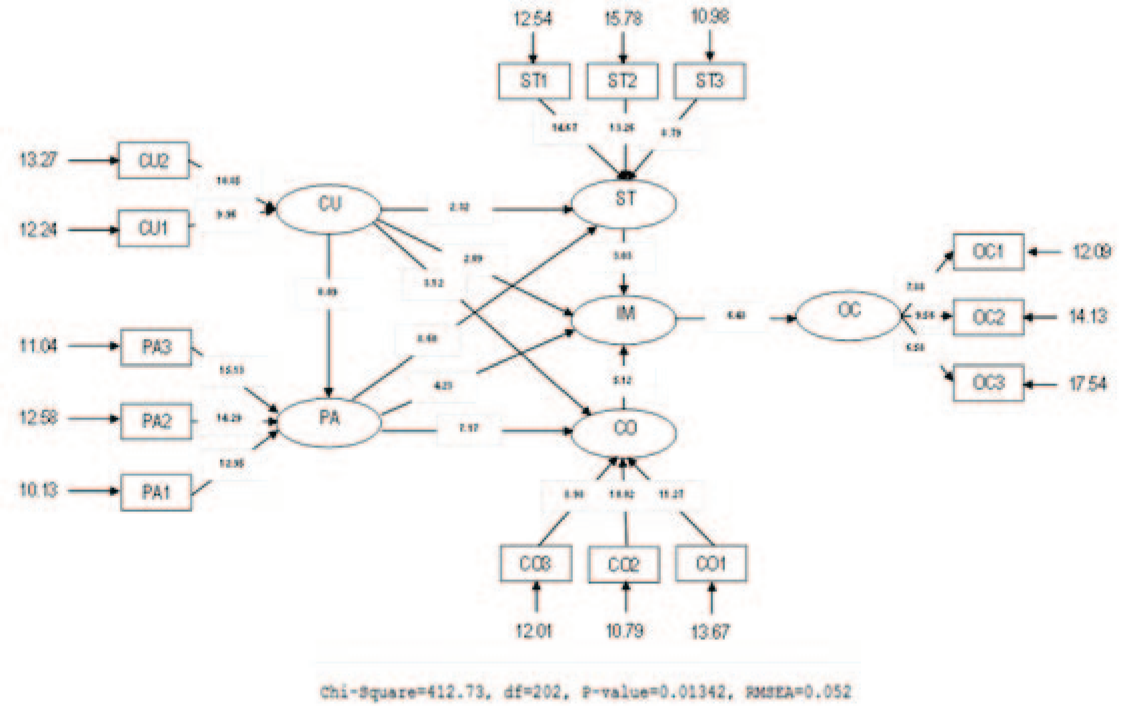

Figure 4. t-values of the Model of Improvement of the Role of the Park in Agricultural Technology Development. CU: Causal, PA: Intervening, ST: Sterategies, IM: Improvment, CO: Contextual, OC: Consequences

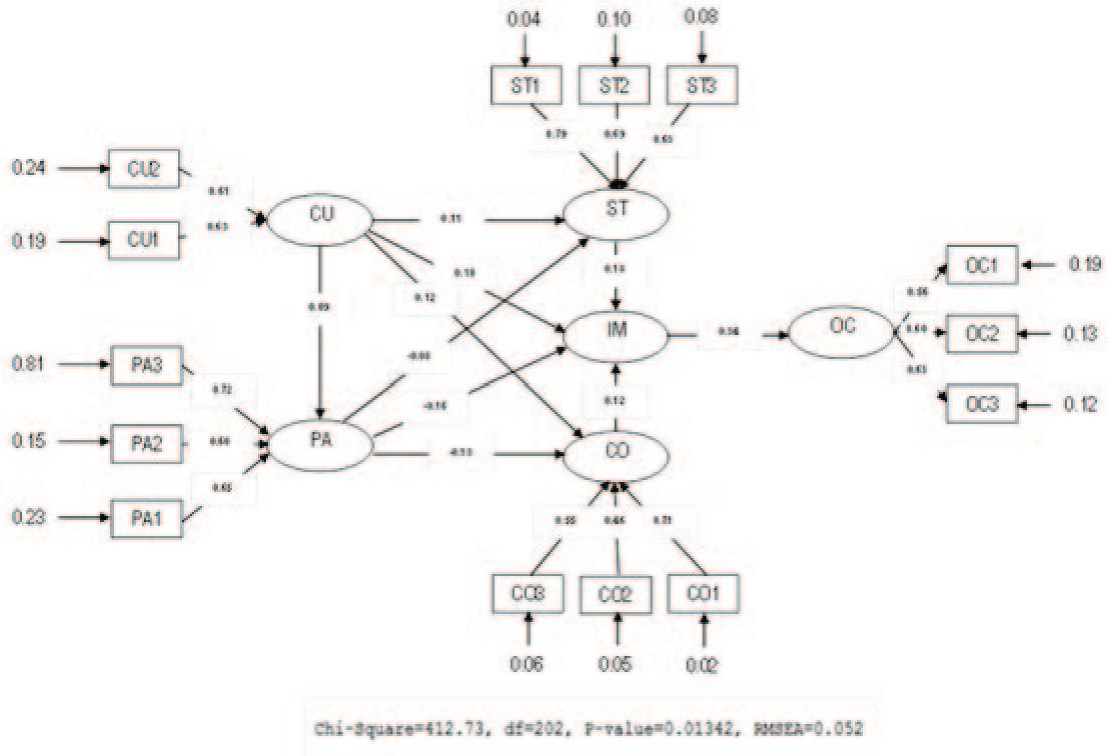

Figure 5. Fitted Structural Model of Improvement of the Role of the Park in Agricultural Technology Development.

Table 5

A Path Analysis of the Effects of Research Structures.

Variable's effect	On the variable	Path coefficient	t	Standard error	Hypothesis
Causal factors	Improvement	0.10	2.32**	0.12	Confirmed
Contextual factors	Improvement	0.12	2.09**	0.11	Confirmed
Intervening factors	Improvement	0.16	2.44**	0.18	Confirmed
Strategies	Improvement	0.18	8.69**	0.09	Confirmed
Improvement	Consequences	0.34	6.67**	0.04	Confirmed

**$p<0.01$, *$p<0.05$

Table 6.

Separation of the Direct, Indirect, and Total Effects of the Model of Improvement Role of the Park in Agricultural Technology Development.

Independent variable	Dependent variable	Direct effects	Indirect effects	Total effects
Causal factors		0.10	-	0.10
Contextual factors	Improvement of the role	0.12	-	0.12
Intervening factors	of the park	-0.16	-	-0.16
Strategies		0.18	-	0.18
Causal factors	Strategies	-	0.11	0.11
Causal factors	Contextual	-	0.12	0.12
Causal factors	Intervening factors	-	0.09	0.09
Intervening factors	Contextual factors	-	-0.13	-0.13
Intervening factors	Strategies	-	-0.08	-0.08
Contextual factors	Strategies	-	0.12	0.12
Total	0.24	0.23	0.47	

In this research, the three-stage process of open, axial, and selective coding was used to analyze the data obtained from the interviews. After examining the data, labeling events, and extracting concepts, each concept was compared to identify similarities and differences. In total, 6 categories and 181 concepts were identified, along with the characteristics of each category based on the data content and respondents' indications.

Behavioral Motivators: 14 items were examined. The results showed that the most important behavioral motivator for managers is gaining social acceptance, followed by income generation from technology and providing employment for youth.

Attitudinal Motivators: The most important attitudinal motivator is investment in the younger generation to promote entrepreneurial spirit, followed by personal experience in running a company and availability of sufficient financial resources.

Social Structures: The greatest challenge in improving the park's role is the reluctance of educated individuals to work in science and technology park companies. The next priorities include attracting governmental and non-governmental organizations to promote public motivation and exchange knowledge with other businesses.

Economic Structures: The most important economic structure for improvement is the supply of production inputs at low cost and high quality, followed by addressing economic motivations among company managers, and comparing production costs to large-scale businesses.

Environmental Potentials: The most important environmental potential is mandatory government guidelines supporting knowledge-based companies, followed by specialized human resources and proximity to markets and input sources.

Effective Intergroup Social Capital: Establishing interdepartmental collaborations for company development has the greatest impact, followed by fostering cooperation between managers and academic/research centers and using educational institutions to improve entrepreneurial motivations.

Educational Strategies: The most important educational need is training for company management and startup skills, followed by basic training in innovation and creativity, and training on utilizing banking facilities.

Credit Strategies: The most significant issue is the inflexibility of banking regulations, followed by cumbersome loan application procedures and delays in credit facility disbursements.

Macro-Intervening Factors: The creation of service institutions to facilitate company development is the most important, followed by ensuring economic security, investment for managers, and access to appropriate equipment.

Micro-Intervening Factors: High risk-taking among managers is the most important factor, followed by the freedom to choose investment locations.

Social Consequences: The most important social consequence is the improvement of work values and successful activities, followed by increased dignity, social identity, and motivation of managers.

Economic Consequences: The primary economic consequence is the improvement of rural household living standards, followed by the creation of new employment opportunities and better economic conditions.

Infrastructure Consequences: The most significant infrastructure consequence is the establishment of network communication between companies, followed by the development of information and communication technology for managers and the creation of information systems for managing companies.

Institutional Consequences: The most important consequence is identifying and removing structural obstacles to small business development, followed by creating growth centers and compiling suitable ranking indicators for small businesses.

Indicators for Improvement: The most important indicator for improving science and technology parks is providing laboratory and workshop services to technological units, minimizing administrative costs, and investing in technological development.

The design of strategies to improve the park's role in agricultural technology development is influenced by three causal variables: intervening and contextual factors. The adopted strategies have the most direct impact, followed by intervening factors. Contextual and causal factors also influence the improvement mechanisms. In investigating the indirect effects of causal factors on improvement strategies, background factors and intervening factors play significant roles. Intervening factors affect contextual factors and strategies, and ultimately, contextual factors influence the strategies. Planners of science and technology parks and knowledge-based companies in agriculture are advised to consider the designed model to foster the development of new agricultural technologies. Focusing on the factors influencing the improvement of science and technology parks—such as causal factors (behavioral and attitudinal motives), contextual factors (social, economic, and environmental structures), and intervening factors (macro and micro)—will facilitate the advancement of agricultural technology development.

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AUTHOR CONTRIBUTIONS

Homyoon Dinarany: Writing– Original draft, formal analysis. Tahmasb Maghsoudi: Writing–original draft, Writing–review and editing, project administration, analysis and interpretation of results. Saeed Mohammadzadeh: Conceptualization, visualization. Azadeh N. Noorivandi: Validation, consulting and supervision on data collection, methodology, analysis and interpretation of results.

CONFLICT OF INTERESTS

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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