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Evaluation of the Effect of Commercialization of Technology in Creating Sustainable Competitive Advantage of Knowledge-based Companies Emphasizing the Moderating Role of Environmental Factors

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Abstract

The present study aimed at designing a structural equation model of the effect of technology commercialization performance on creating sustainable competitive advantage of knowledgeable companies with an emphasis on the moderating environmental factors.

Research population includes 133 managers of knowledge based companies at the center for the growth and development of science and technology Park of East Azerbaijan University and based on the Cochran formula, the sample size was measured to be 99, and selection by stratified random sampling method, and the standard questionnaire is distributed among them. The research is applied in nature and the method is descriptive and survey. Then, the data were analyzed using smart pls software for partial least squares (PLS) path modeling. The results show that the technology commercialization performance has a positive effect on the competitive sustainable advantage of knowledge-based companies, as well as the role of variable moderating environmental factors (market turbulence, competitive intensity and technological turbulence) in the path between the technology commercialization performance and the sustainable competitive advantage of knowledge-based companies.

Keywords

technology commercialization performance, sustainable competitive advantage, environmental factors, knowledge-based companies

1. Introduction

The world is changing. New technologies emerge and the dynamics of trade shifts. Management systems must also shift to cope with the change. These shifts create a totally new paradigm for business. The most pronounced difference between the world today and the world of yesteryear is the rapid pace of technological change. This pace is combined with variation in the scope of technology deployment. Global competition is also relatively new. Competition among nations has intensified in the 1980s and 1990s compounded by the emergence of new countries on the "playing field." This contributes to a continuous shift in the balance of economic power. With the end of the Cold War, a new world order has emerged. Most countries now pursue free global trade, and trade blocs are becoming a defining feature of the time. Let us explore each one of these factors in greater detail (Khalil, 2000).

In Iran, science and technology parks have been established in order to achieve technological goals and sustainable development. Science and technology parks are also trying to create a basis for achieving sustainable growth and development and deepening the knowledge-based economy through the creation of small and medium-sized knowledge-based companies and by providing various facilities and support (Kr¨atzig, Oliver., Sick, & Nathalie, 2021).

Knowledge-based companies are the engine driving the knowledge-based economy. These companies play a role in the synergy of science and wealth, the development of a knowledge-based economy, the realization of scientific and economic goals, and the commercialization of research and development results in the Constitution, 44 areas of top technologies. The top documents of the country, including the communicated policy of the fourth, fifth and sixth development plans, as well as the country's twenty-year vision document, all consider the field of knowledge-based economy as one of the most important and influential areas in the country, and the development of this sector is a priority in the country's development plans. Have placed the realization of these goals depends on the creation and establishment of a knowledge base that is mainly guided by the presence of entrepreneurs who have central ideas. In fact, the driving engine of technological advancements is creative ideas that are formed in the minds of innovators and inventors, and with the serious pursuit of entrepreneurs, they are loaded in the form of a new business (Christopher & Jan-Åke, 2015). One of the challenges of knowledge-based companies in Iran is to improve the technology commercialization process.

Therefore, the main question of the present research is "why most of the domestic knowledge-based companies have difficulty in providing an optimal technology commercialization performance that can guarantee a stable competitive advantage for the company." Finally, this problem will be more tangible when the weakening and moderating effect of external environmental factors (technological disruptions, market and competitive intensity) is raised. With regard to past studies, paying attention to

operationalizing and measuring the performance of technology commercialization resulting from identifying the perceived results of each stage of technology commercialization in order to obtain a sustainable competitive advantage of knowledge-based companies can be the key to solving the problem of environmental influencing factors in the interaction between commercial performance Creating technology and competitive advantage is sustainable. Be At the same time, the innovation of the article is also in the simultaneous examination of three external moderators (technological disruptions, market and competitive intensity), as environmental influencing factors in the interaction between technology commercialization performance and sustainable competitive advantage.

1.1 Literature Review

1.1.1 Technology Commercialization Performance

The term technology commercialization (TC) generally includes activities that are able to generate capital returns from technological knowledge (Wang, Lyu, Cui, & Li, 2021). Commercialization of an innovation means performing a number of processes and developing technology. This work requires interactive assistance and appropriate complementary technologies and management alignments (Lin, Wang, & Kung, 2015). Technology commercialization strategy is critical for innovative companies, especially when they are internal innovators who are not only technology providers but also end product manufacturers (Sjåholm et al., 2021).

Technology commercialization is a process that begins with the acquisition of a new idea or technical development. Growth centers based on the marketing point of view defined the commercialization of technology as the basis for providing new products, promoting their acceptance and finally maintaining the market value of the product in the long term (Maury, 2018).

1.1.2 Sustainable Competitive Advantage

The holy grail of business success is achieving a sustainable competitive advantage, where a company outperforms its competitors and that advantage does not disappear quickly. Therefore, a central question in business research is to understand the causes of performance differences between firms and their stability. Firms compete with different resources and capabilities, and if some of these factors enable a firm to have higher prices or lower costs, or both, that firm will earn above-average profit flows. If it is difficult for competitors to imitate or replace basic resources or capabilities, this competitive advantage can be maintained over time (De Guimaraes, Severo, & de Vasconcelos, 2018).

Porter (1985) defines the consequence of sustainable competitive advantages based on long-term profitability and performance above the industry average in the long term (Dess & Beard, 1984). In fact, sustainable competitive advantage is the practical results of management decisions that achieve superior performance of the organization compared to its competitors in the long term (Wu, Liu, & Zhang, 2017).

1.1.3 Environmental Factors

Environmental factors describe the turbulence, instability and chaos of the environment and are characterized by the high level of change, complexity, uncertainty and capacity of the environment (Glazer & Weiss, 1993). Industries are often identified by their volatility; however, they only experience

these turbulent environments in some cases and to varying degrees. Environmental disturbances are defined as high levels of changes between cycles, which lead to the following:

Uncertainty and the inability to predict the actions of competitors and the changing needs of customers (Chakravarthy, 1997)

Dynamic and unstable conditions with discontinuity in growth rate and demand (Sharif, 1997)

The rapid development of technology in the industry (Chakravarthy, 1997)

Competitive advantages that are continuously created and destroyed (Chen, 2009)

Short barriers to enter and exit the industry, which changes the competitive structure of the industry continuously (Chen, 2009).

Therefore, based on the theoretical literature and the background of the research in this article, an attempt has been made to analyze a wide range of environmental factors, including three factors: market turbulence (demand structure and the rate of change in the composition of customers and their preferences), technological turbulence (the supply structure and the rate of technological changes in the industry is defined) and the intensity of competition (competition structure and the ability and willingness of competitors to change their marketing mix decisions in order to gain the advantage of competitive intensity) (Chakravarthy, 1997).

1.1.4 Knowledge based Companies and Science and Technology Park Companies

According to Article 1 of the Law on the Protection of Knowledge-Based Companies, a knowledge-based company and institute is a private or cooperative company or institution that aims to synergize science and wealth, develop a knowledge-based economy, and achieve scientific and economic goals (including the expansion and application of inventions and innovations). (And the commercialization of research and development results (including the design and production of goods and services) in the field of superior technologies and with a lot of added value is formed. Law on the Protection of Knowledge-Based Companies, 2019). The subject companies of this regulation include three categories, companies that produce knowledge-based goods and services, start-up companies, and industrial companies with knowledge-based activities. East Azerbaijan Science and Technology Park, by creating a suitable environment for the development of the activities of knowledge-based companies, has provided the necessary ground for the commercialization of their achievements and the attraction of domestic and foreign investments.

1.1.5 Technology Commercialization Performance and Sustainable Competitive Advantage

According to the resource-based view, organizational resources are important factors in creating competitive advantage. On the other hand, technology and its commercialization are considered one of the key resources and capabilities important for sustainable profitability and competitive advantage of organizations (Park & Ryu, 2015) and one of the types of organizational competencies (Zahra & Bogner, 2000) that have a positive impact on competitive advantage have (Chakravarthy, 1997). In fact, past research shows that technology and competitive solutions influence each other in a continuous cycle. Maintaining competitive advantage and organizational survival depends on maintaining and

strengthening the commercialization of technology. In other words, technology commercialization helps to provide competitive advantages to companies. The ability of knowledge-based companies to successfully commercialize technology can lead to better business performance. Successful is one of the most important prerequisites for the performance of knowledge-based companies that can lead to a competitive advantage over competitors.

H1: Technology commercialization performance has an impact on sustainable competitive advantage

1.1.6 Technology Commercialization Performance, Environmental Factors and Sustainable Competitive Advantage

Companies in rapidly changing, turbulent and unstable environments need access to new knowledge and rapid delivery of new solutions to maintain competitive advantage, which can be achieved through effective technology commercialization. technological, market and intensity of competition, competitive advantage is easily imitated by competitors or quickly fades in the eyes of customers and must be replaced with new advantages, in other words, past studies show that maintaining the sustainability of competitive advantage in a changing environment In a dynamic environment, products and services are easily removed from companies and it is difficult to achieve profits that are above the industry average. Product obsolescence is also faster in these environments, so companies can benefit from technology commercialization to create a sustainable competitive advantage. Competition as the most important weakening and moderating factor in creating competitive advantage through the effective performance of technology commercialization should be considered and based on the presented contents, the second hypothesis of the research is presented as follows:

H2: Environmental factors moderate the relationship between technology commercialization performance and sustainable competitive advantage.

1.2 Conceptual Model of the Research

According to the above, the present research follows the concept shown in Figure 1 in which the performance of technology commercialization leads to the achievement and creation of sustainable competitive advantage and this relationship is moderated by environmental factors.

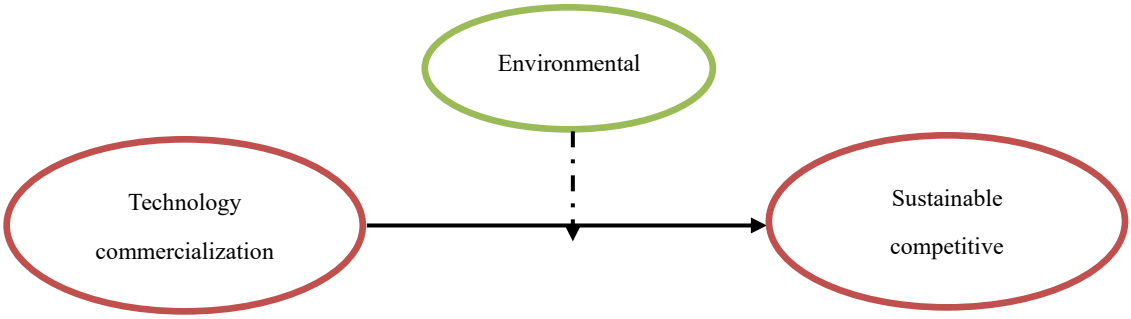

Figure 1. Conceptual Model

2. Method

In terms of the practical purpose of the current research, its method is descriptive and survey type. In terms of information collection, and according to the method of this research, a field research using a standard questionnaire tool, based on partial least squares structural equation modeling. The statistical population of the current research is 133 managers of knowledge-based companies located in the growth and development center of East Azerbaijan Science and Technology Park. Sampling was done with a simple random stratified method and the classes included companies in the growth stage (50 companies) and companies in the development stage (83 companies), of which 99 people were selected through the statistical formula for determining the sample size of the limited population. Cochran's were examined at the error level of 5% and the estimation accuracy of 0.05. The compiled questionnaire of the research was given to the members of different companies with a direct presence in the growth and development center of East Azerbaijan Science and Technology Park and was collected in a period of time.

Table 1. The Size of the Statistical Population by the Relevant Subgroups to Determine the Sample Size

Description	Number	Percentage	Number of Samples Selected
Companies in the Growth Stage	50	37.594	38
Companies in the Development Stage	83	62.406	61
Total Sum	133	100	99

The structural equation test is used to measure the relationship between the variables, the appropriateness of the conceptual model and its significance. Therefore, t-test was used to answer the hypotheses and determine the level of significance and relationships between variables. This analysis was done using Smart-PLS software.

In this research, a questionnaire containing 26 items was used to collect the required data, and the respondents were asked to indicate their level of agreement on a Likert scale with a rating of 1-5. In this questionnaire, number 5 means full agreement and technology commercialization performance in this research, four dimensions "number of new products", "faster time to new product", "number 1 means complete disagreement. The parameters of the questionnaire are from related studies. The former has been obtained. To measure the effective use of the patented invention and technical know-how" and "the future of the market" are considered. These dimensions include 12 items and are taken from the research

of Lin et al. (2015). Sustainable competitive advantage is measured with 5 items that are taken from the research of Giomaraes et al. (2018). To measure the environmental factors, 9 items taken from Teodosio et al. (2012) were used, and for the "market turbulence" dimension, and for the dimensions of "competition intensity" and "technological disruption" from Wu et al.'s research (2017).

3. Result

In the partial least square's method, before testing the hypotheses, it is necessary to examine the fit of the measurement models, the structural model, and the overall research model (Park & Ryu, 2015).

3.1 Evaluation of the measurement model

3.1.1 Reliability (Factor Loadings, Cronbach's Alpha and Composite Reliability)

The most basic criterion of reliability is the examination of factor loadings, which must be above 0.5 to be approved. In reflective models, the numbers displayed on the path between constructs and reagents represent the factor load. The results show that the variance between the structure and its indicators is greater than the variance of the measurement error of that structure. The factor loadings resulting from the implementation of the model, which indicates that all measures have appropriate factor loadings (Park & Ryu, 2015).

Table 2. Measures and Factor Loadings

Factor	***variables***	***Indicator code***	***indicator***	***Factor loading***
Technology Commercialization Performance	The Future of the Market	MF1	More market share of new products compared to other competitors	0/709
		MF2	More annual sales of new products compared to other competitors	0/703
		MF3	Life cycle of new products in the market	0/800
	Faster Time to get New Product	FT1	The speed of using concepts and techniques in new products	0/876
		FT2	The speed of entering the market until the recognition of customers	0/768
	Number of New Products	TNP1	Enrichment and introduction of changes in products	0/820

		TNP2	Designing products based on customer needs	0/695
		TNP3	Multiple product types with complete process	0/823
	Effective use of Patented Inventions and Technical Knowledge	PK1	The ability to integrate technologies with each other	0/647
		PK2	Professional technology, changeable and inimitable by competitors	0/679
		PK3	Number of new patents	0/760
		PK4	The ability to use different technologies in the new product	0/618
Sustainable Competitive Advantage	Sustainable Competitive Advantage	SAC1	Better income with new products/services in relation to competing companies	0/711
		SAC2	Lower operational costs during production and/or service delivery than competitors	0/721
		SAC3	Better profitability with new products/services compared to competitors	0/712
		SAC4	The degree of compatibility of new products/services with the knowledge and concepts of the environment biological	0/624
		SAC5	Produce and deliver our new products/services according to the social responsibility program	0/749
Environmental Factors	Market Chaos	MT1	Changing customer-centric product preferences in our industry over time	0/746

		MT2	The desire of our customers to search for new products	0/746
		MT3	Demand for new products and services from new customers	0/749
	Intensity of Competition	CT1	Many challenges in the field of promotion in our industry	0/798
		CT2	Compatibility of a competitor's topic with other competitors	0/677
		CT3	Competitive price as the turning point of our industry	0/796
	Technological Chaos	TT1	Rapidly technology transformation in our industry	0/828
		TT2	The difficulty of predicting technological advances in our industry	0/704
		TT3	The obsolescence of many emerging processes and technologies in our industry	0/665

In the case of Cronbach's alpha and composite reliability, values higher than 0.7 indicate acceptable reliability of measurement models. According to table 3, the reliability of the measurement model of this research is confirmed from the point of view of Cronbach's alpha and reliability.

Table 3. Cronbach's Alpha and Reliability

Variables	***Cronbach's Alpha***	***Reliability***	***Variables***	***Cronbach's Alpha***	***Reliability***
TNP	0/722	0/791	**SAC**	0/810	0/831
FT	0/789	0/808	**MT**	0/756	0/791
MF	0/793	0/781	**CI**	0/844	0/802
PK	0/802	0/771	**TT**	0/755	0/778

3.1.2 Validity (Convergent Validity and Divergent Validity)

Fornell and Larcker have introduced the Average Variance Extracted (AVE) measure to measure convergent validity (Fornell & Larcker, 1981). This criterion shows the degree of correlation of a structure with its indicators and they stated that its critical value is 0.5. All measurement models of this research have favorable convergent validity; because the average value of variance extracted for all structures is more than 0.5.

Table 4. Average Variance Extracted

Variables	*AVE*	*variables*	*AVE*
TNP	0/559	**SAC**	0/596
FT	0/678	**MT**	0/558
PK	0/559	**CI**	0/576
MF	0/545	**TT**	0/541

Divergent validity is another criterion for measuring the fit of measurement models in PLS method. Divergent validity is acceptable when the value of the square root of the variance extracted for each construct is greater than the shared variance between that construct and other constructs in the model. In PLS, this is checked by a matrix. In the output of the software, this matrix is presented in a section called differential validity and displayed in Table (5), which shows the approval of this criterion.

Table 5. Divergent Validity

Variables	*TNP*	*FT*	*MF*	*PK*	*SAC*	*MT*	*CI*	*TT*
TNP	0/744							
FT	0/511	0/823						
MF	0/575	0/511	0/738					
PK	0/658	0/600	0/657	0/747				
SAC	0/627	0/539	0/639	0/617	0/722			
MT	0/577	0/561	0/507	0/657	0/639	0/746		
CI	0/587	0/464	0/585	0/614	0/650	0/583	0/758	
TT	0/648	0/484	0/588	0/567	0/541	0/587	0/592	0/735

3.2 Structural Model Evaluation

3.2.1 Path Coefficients, Coefficient of Determination and Significant Coefficients

After examining the fit of the measurement model, the structural model has been examined. In the structural model, how the hidden variables are linked to each other is explained. The criteria of path coefficient, coefficient of determination and t statistic are used to evaluate the model. The numbers shown

on the path of the structures together are called path coefficient. These numbers represent the standardized beta in the regression or the correlation coefficient of two structures and are provided to check the direct effect of one variable on another variable. The numbers inside each circle represent the coefficient of determination (R2) of the main structure and its value is always between zero and one. it changes the larger the determination coefficient is, it shows that the regression line is better able to relate the changes of the dependent variable to the independent variable (Esfidani & Mohsenin, 2016). The implementation of the research conceptual model in Smart-PLS software was done in two stages. In the first stage, only the direct relationships between the variables were built in the form of a model, and in the second stage, the moderating factors were entered into the model built in the previous stage. All path coefficients and coefficient of determination of the overall research model are shown in Figure 2.

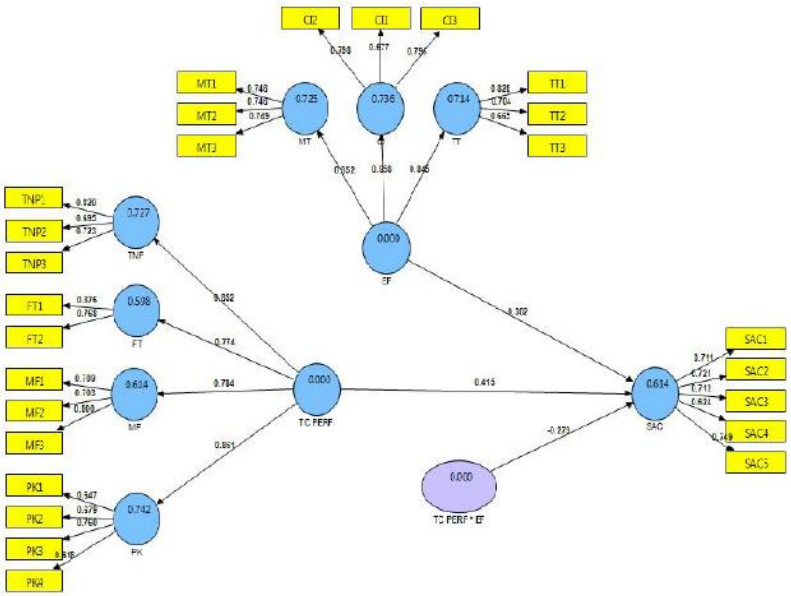

Figure 2. Path Coefficients and the Coefficient of Determination of the Overall Research Model

To test the significance of the hypotheses, the bootstrap test (BS) was used and the partial index of the t statistic value was used. The t value greater than 1.96 indicates the correctness of the relationship between the structures at the 95% confidence level, and as a result, the favorable conditions of the structural part of the model the t coefficients of the general research model are shown in Figure (3). According to the graph and the amount of significant coefficients, the t value must be greater than +1.96 or less than -1.96 in order to reject or confirm the hypotheses. , the value of the parameter between the two domains is not considered important in the model, and the values between these two values indicate the absence of a significant difference in the value calculated for the regression weights with a value of zero at the 95% level to determine the favorable or unfavorable status of the variable Also pay attention to the t-statistic.

If the t-statistic value is smaller than -1.96, the variable status is inappropriate, and if it is greater than +1.96, the variable status is appropriate.

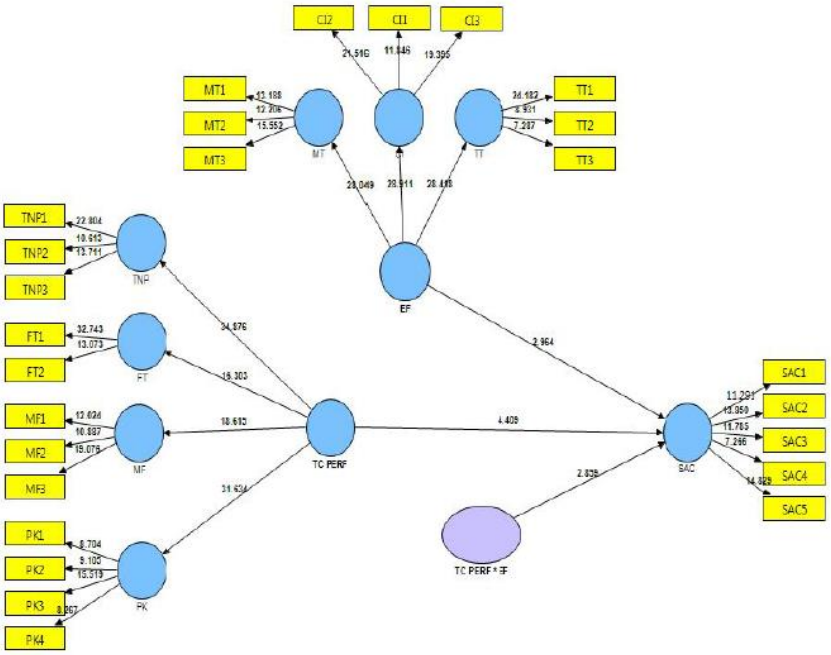

Figure 3. Research Model in a Significant Coefficients

3.2.2 Measures of Predictive Association (Q^2) and Effect Size (f^2)

Based on the predictive correlation criterion, the model should predict the indicators of the endogenous variables of the reflection. Q2 values above zero (positive values) indicate that the observed values are well reconstructed and the model has predictive ability. The effect size criterion can also be used to measure the effect size of an exogenous variable on an endogenous variable in a structural equation model.

Table 6. Predictive Correlation (Q2) and Effect Size (f2)

Variables	***Q^2***	***F^2***	***Variables***	***Q^2***	***F^2***
TNP	0/142	0/146	MT	0/249	0/165
FT	0/133		CI	0/141	
MF	0/117		TT	0/172	
PK	0/126		SAC	0/121	

3.3 GOF Criterion

This criterion considers both measurement and structural models and is used as a standard to measure the overall performance of the model (Esfidani and Mohsenin, 2016).

The GOF index = 0.5948 was obtained, which shows the high desirability of the model.

3.4 Test of Hypotheses

After examining the fit of measurement models, structural model and general model, research hypotheses were investigated and tested in two parts: t coefficients and path coefficients (β) were examined (Table 7). When the t-statistic value for testing a hypothesis at the 0.05 level is higher than at least 1.96, the hypothesis is confirmed. Path coefficient also shows the direct effect of one structure on another structure. The higher the path coefficient, the greater the predictor effect of the current variable compared to the dependent variable. Table 7 shows two models; In the first model, the effects of the research structures on each other are expressed without considering the moderating factors. In this model, the performance variables of technology commercialization, taking into account the standard coefficient of the path, caused about 0.415 of the changes of technology commercialization, and according to the value of t, the related hypothesis was confirmed at a confidence level above 95%. In the second model, the effects of the moderating factor were considered. Based on this model, it can be concluded that the change of environmental factors has a direct effect on the relationship between technology commercialization performance and sustainable competitive advantage of domestic knowledge-based companies.

Table 7. The Result for Summary of Hypothesis Testing

- ***Hypothesis***	***Model 1***			***Model 2***		
	B	t	Result	B	t	Result
Commercialization → Sustainable competitive advantage	0/443	5/224	Supported	0/415	4/409	Supported
The effect of the moderating variable of environmental factors on commercialization performance → Sustainable competitive advantage				0/279	2/859	Supported

3.5 Modulating Variable of Environmental Factors

In the present study, the significance coefficient of the moderator variable and the interaction term are both greater than 1.96, which indicates the confirmation of the moderating effect of environmental factors on the relationship between the two performances variables of technology commercialization and sustainable competitive advantage.

4. Discussion

Based on the results of the research hypotheses test, at a confidence level of 95%, technology commercialization performance has a positive effect on the sustainable competitive advantage of knowledge-based companies, as well as the variable moderating role of environmental factors (market turbulence, competition intensity, and technological turbulence) in the path between performance Commercialization of technology and sustainable competitive advantage of knowledge-based companies were confirmed

The general results of this research show that technology and its commercialization are considered a source, effective factor and main competence in obtaining and maintaining the competitive advantage of knowledge-based companies. In other words, the ability of knowledge-based companies to successfully commercialize technology can lead to better company performance and ultimately gain a competitive advantage over competitors. Therefore, it is suggested that the evaluation and monitoring of the technology commercialization performance of knowledge-based companies should be done continuously, and quantitative and operational indicators should be used as much as possible in the evaluation process.

In order to confirm the moderating role of environmental factors, the results of the research show that today, considering the development and variety of companies' products, as well as the intense competition between them, knowledge-based companies need effective performance in the commercialization process for their final success and sometimes even their survival. They have technology so that they can create a kind of competitive advantage for the company in a chaotic environment (technological and market chaos). In fact, not paying attention to environmental disturbances will cause knowledge-based companies to fail in identifying customer needs, retaining and attracting new customers, competitiveness with other companies, and the rate of progress and use of technology, development and finally commercialization. And maybe it is not far from the truth that in the current business world, negligence and failure to identify each of these factors will lead the company's fate to destruction. Therefore, it is suggested that although almost all knowledge-based companies face limited resources; But with the expansion of research and development, identify these factors that are vital for their organizational life in a deeper and more accurate way. Also, the confirmation of the negative moderating and weakening effect of technological and market turbulence on the relationship between technology commercialization and the competitive advantage of knowledge-based companies indicates the increase in the speed of the loss of the value of existing technologies in knowledge-based companies. Therefore, knowledge-based companies should take their technologies out

of their borders through commercialization before they become worthless. This will improve the performance of the company in terms of releasing more new products and customer satisfaction with new products compared to competitors in the same industry.

Finally, the following suggestions are presented for future researches:

The test of conceptual model relationships in specific fields of activity of knowledge-based companies that have different business environments and types of technology, such as information technology, agriculture, nano and bio-technology, pharmaceutical industry, food industry, chemical industry, high-tech industry and etc.

Comparison of conceptual model relationships in different life cycle stages of knowledge-based companies (pre-growth and development, growth and development)

Considering other moderators such as market novelty, competitor dynamics and customer dynamics in the conceptual model.

Ranking of factors affecting the successful commercialization of technology in knowledge-based companies. Evaluation of technology commercialization performance of knowledge-based companies.

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