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IMPACT OF TECHNOLIGIACAL INNOVATION, RESEARCH AND DEVELOPMENT ON THE DEFENSE ECONOMY – IRAN COUNTRY

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ABSTRACT

The Purpose. *This research is to investigate the relationship between the variables of technological innovation, research and development costs, economic growth, sales and export of weapons and military costs in Iran for the years 2000 to 2017.*

Design/Methodology/Approach. *In this study, we examine using Autoregressive Distributed Lag (ARDL) method to explore the estimating the impacts of technological innovation, research and development costs, economic growth, sales and export on military costs.*

Findings/Implications. *The results of this study showed that the impact of technological innovation and research and development costs on military costs is negative in short-term and long-term. Although the effect that these two variables have on military spending in the short-term is very close, in long-term the effect that research and development costs have on military spending is far greater and more significant. Also, the impact of economic growth on Iran's defense economy is much less than the variables of technological innovation and research and development costs. So that this effect will be less in long-term. But, the amount of arms sales and exports in the short-term has a positive effect on defense spending, but in long-term it becomes negative and increase in arms sales and exports can help Iran's defense economy.*

Originality. *The countries defense economy can always have positive effects on military and civilian research and development, scientific innovation and technological progress, in this condition that the country's macroeconomics can spend military spending on research and development and support innovation and inventions. Eventually adopt arrangements that use the innovations of the defense industry in the civilian sector, which will lead to economic growth. This is the experience of many developed countries that have been able to use the technological advances and innovations of the military sector in the civilian sectors as well, and to cause the economic progress and development of their country.*

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1. INTRODUCTION

Economics and its relationship to militarism, called defense economics, is a very important and complex issue that can be considered from different angles. The economy can both grow and be damaged by military activity.

Some countries have been able to gain significant foreign exchange through the production and sale of weapons. But in least developed countries (LDCs) and developing countries, the situation is very different. So that in the mentioned countries, the military expenses that are usually spent to provide security, analyze the economic power of the countries and affect their livelihood and development process.

It is clear that in order to achieve growth and prosperity in the country's defense economy sector and reduce military spending, as in other economic sectors, military spending must be directed towards research and development and support for technological innovations. This will increase productivity and efficiency in this sector and the reduction of costs also reduced the negative effects on the country's economic growth and can even help it.

But investment in research and development by non-profit businesses is essentially for production of new goods and services and for improving quality, that causes increase in productivity and efficiency, and ultimately reduces costs. It can be a good example for military sectors to invest in research and development, innovation and cooperation with leading civilian sectors by creating new equipment and advanced products and reducing dependence on foreign countries, increase productivity and efficiency in their organizations and even help by creating employment for educated people and economic growth.

As a result, the defense industry can always have a positive impact on civilian sectors in terms of scientific innovation and technological advancement, in condition that country's macroeconomics can drive military spending toward research and development and support innovation and invention, and ultimately uses defense industry innovations in the civilian sector, which will lead to economic growth. This is the experience of many developed countries that have been able to use the technological advances and innovations of the military sector in the civilian sectors as well, and to cause the economic progress and development of their country.

In this regard, the military expenditures of the Islamic Republic of Iran between the years 1979-2017 have been recorded in Figure 1. As it is known, Iran's military expenditures have had many ups and downs among the studied years. We see an increase in some years, such as the beginning of the imposed war; it has increased with a steep slope.

Therefore, it is clear that the country has paid more attention to military affairs, and due to the regional and trans-regional threats, this increasing in military spending will increase. Therefore, pay attention to the issues that can reduce these costs while maintaining the quality of military affairs should be on the agenda of government officials.

Figure 1.: Military expenditures of the Islamic Republic of Iran between the years 1979-2017
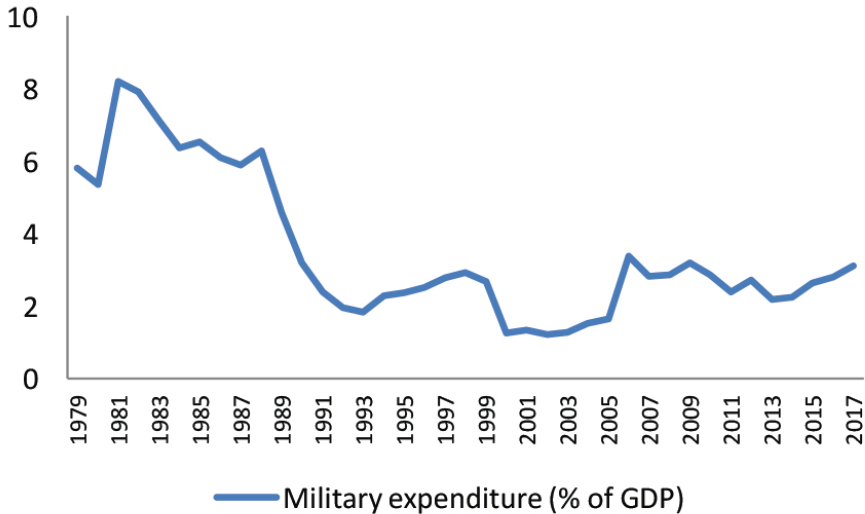
Source: Research results

Therefore, in this study, we will try to examine and analyze the impact of important factors such as research and development costs, the number of recorded inventions and innovations on defense costs in the form of defense economy.

2. LITERATURE REVIEW

Little research has been done on the effects of research and development and innovation on military spending, and most of them has been done on the impact of military spending on economic growth, some of that researches will be mentioned below:

Park (1995), in an article entitled "International Research and Development and Economic Growth of OECD Countries" using data from 10 member countries of this group, examined the research and development activities of the private sector and the public sector and concluded that Private sector research and development activities are more decisive in productivity growth, but government activities have indirect effects due to their foreign interests and can be considered as a factor influencing private sector productivity.

Yildirim and et al. (2005) in a study entitled "Military Expenditures and Economic Growth in the Middle East" between 1989 and 1999, using data panel method, concluded that military expenditures increased economic growth in these countries and Turkey.

Dunne and Nicolaido (2012), in a study examined the effect of defense spending on the economic growth of 15 EU member states during the period 1961-2007. Using combined data, they have concluded that increasing defense spending does not promote economic development.

Lin and et al. (2013), in a study entitled "Are Military Costs Consumed for Social Welfare? in OECD member". Between 1988-2005, in 29 countries of OECD member, they have concluded there is a positive relationship between military spending and two types of social welfare spending. (Education and health care costs). One reason is that OECD member states are more supportive of social welfare programs; therefore, when military spending increases (for example, military personnel), the government can also increase health and education spending.

Khalid and et al. (2015), in a research entitled "Defense Expenditures and Economic Growth in Developed Countries" between 2002-2010 using the GMM method in 67 developed countries of the world, concluded that military expenditures in this Countries have a positive and significant effect on economic growth.

Ajmair and et al (2018), in an article entitled "The Impact of Military Expenditures on Economic Growth of Pakistan" used ARDL approach for annual time series data from 1990 to 2015. The results showed that Pakistan military expenditures are insignificant (military burden for the country is statically insignificant) and number of persons in military are positively and significantly related with GDP growth in long-run. The error correction term is negative and significant which shows that short-run relationship exists among economic growth, military expenditures and number of army persons. In short run military expenditure and number of persons in military are positively and significantly related with GDP growth but in long-run only number of military persons affects economic growth positively and significantly.

Dimitraki and Win (2020), in an article entitled " Military Expenditure Economic Growth Nexus in Jordan: An Application of ARDL Bound Test Analysis in the Presence of Breaks "The relationship between military spending and economic growth during the period 1970-2015 using They examined the Gregory-Hansen convergence method and Autoregressive Distributed Lag (ARDL) test in Jordan. The results showed that during the period of short-term and long-term positive relationship between military spending and economic growth in the country.

3. THEORETICAL FOUNDATION

Defense Economics is a new branch of economic that studies the management of defense spending during periods of war and peace and analyzes the external effects of this expenditure on other sectors of the economy. In general, defense expenditures are considered as expenditures of public goods of an economy, but the defense economy analyzes the relationship between defense expenditures and economic variables through different channels (Ando, 2009). One of these variables is innovation and research and development.

But innovation in general is a kind of change that comes with something new that ultimately leads to practical outputs such as goods, services, methods, structures, or new markets. Innovation is essential for the survival and development of today's organizations, whether private or public, commercial or military, manufacturing or service.

3.1. Types of innovation and its importance in the defense industry

The most famous innovation expert - Schumpeter - believes in five types of innovation: product innovation, process, market, resources and organization. But the three most useful categories are: administrative innovation versus technical innovation; product innovation versus process innovation, and leapfrog innovation versus gradual innovation. The most famous of these classifications is the gradual-jump classification.

By definition, leapfrog innovations are those that have a completely new and different knowledge or technology base or, as a result, have major implications for industry performance and outcomes, but gradual innovations are accompanied by improvements and relative changes in technology or output results.

Gradual-gradual classification can be very important in the defense industry, because:

- **A**. Technology focuses on the activities of the defense industry, and in this industry, the rate of change in technology is usually high, and therefore, an important tool for progress in this industry is technological innovation. Also, the achievements of the defense industry are often manifested in the form of completely new products and technological innovations, or in the form of upgrading existing products or improving them, which can be considered equivalent to gradual and leapfrogging innovation compared to the proposed classification

- **B**. The result of the defense industry's work is mainly the provision of various military products (weapons and equipment) to the armed forces. For the Armed Forces as a user, the impact of new weapons and equipment or the same innovations on the significant improvement of defense (leap) or improvement of defense (gradual) strength is very important.

4. DATA, SPECIFICATION MODELS AND METHODOLOGY

4.1. Data

This study uses annual data series time to Iran from 2000 to 2017, Real Growth Domestic product (GDP) in billions of constant 2010 dollars, Military Expenditures (GDP%) (MEXPE), Technological Innovation (total patent application in the country i.e. both residents and non-residents) (INO), Research and development expenditure (% of GDP) (RD), Arms sales and exports (AEXPO).

In this study, the data are taken from the SIPRI Yearbooks for military expenditure and Arms sales and exports (Stockholm International Peace Research Institute, various years) and the data on GDP, Technological Innovation and Research and development expenditure are drawn from the World Bank Economic Indicators.

4.2. Econometric Methods

Following the, GDP measured is a linear function according to the following equation:

$$GDP_t = f(MEXPE_t, INO_t, RD_t, AEXPO_t) \tag{1}$$

To find the long-run relationship between Real Growth Domestic product, Military Expenditures, Technological Innovation, Research and development expenditure, Arms sales and the following log-linear form is proposed:

$$LnGDP_t = \alpha_0 + \alpha_1 LnMEXPE_t + \alpha_2 LnINO_t + \alpha_3 LnRD_t + \alpha_4 LnAEXPO_t + \mu_t \tag{2}$$

All the variables transformed to natural logarithms for the purpose of the analysis. We have used Eviews 10 to conduct the analysis.

5. ECONOMETRIC TECHNIQUES

In this section, we will describe and examine the tests; Augmented Dickey-Fuller Unit Root Test, Autoregressive Distributed Lags Test (ARDL).

5.1. Unit Root Test

First, the Augmented Dickey Fuller (ADF) tests are used to check whether each data series is integrated and has a unit root. The ADF test is based on the value of t-statistics for the coefficient of the lagged dependent variable compared with special

calculated critical values. If the calculated value is greater than the critical value, then we reject the null hypothesis of a unit root; the unit root does not exist, and our variable is stationary (Dickey and Fuller,1979).

5.2. ARDL Test

The Autoregressive Distributed Lag (ARDL) approach suggested by Pesaran et al. is applicable for variables that are I (0) or I (1) or fractionally integrated. The ARDL framework of Equation 3 of the model is as follows:

$$\Delta LnGDP_t = a_0 + \sum_{i=1}^{n} a_{1i}\Delta LnMEXPE_{t-i} + \sum_{i=1}^{n} a_{2i}\Delta LnINO_{t-i} + \sum_{i=1}^{n} a_{3i}\Delta RD_{t-i} + \sum_{i=1}^{n} a_{4i}\Delta LnEXPO_{t-i} + \lambda\ ECM_{t-1} + u_t \tag{3}$$

a0, a1, a2, a3 and a4 correspond to the long-run relationship in Equation. Where ECM tÐ1 is the error correction term which is gained from the following estimated cointegration equation:

$$ECM_t = LnGDP_t - a_0 + \sum_{i=1}^{n} a_{1i}\Delta LnMEXPE_{t-i} + \sum_{i=1}^{n} a_{2i}\Delta LnINO_{t-i} \sum_{i=1}^{n} a_{3i}\Delta LnRD_{t-i} + \sum_{i=1}^{n} a_4\Delta LnEXPO_{t-i} \tag{4}$$

6. EMPIRICAL ANALYSIS AND RESULTS

Before estimating the model, to prevent false regression, the unit root test should be performed and the stability of the variables should be examined. This test was performed using the generalized Dickie-Fuller (ADF) method and the results were recorded in Table 1. As it is known, all variables except Technological Innovation (INO) are not at the static level, so after once the difference of all variables became static at one level.

Table 1.: Augmented Dickey-Fuller Stationary Test Results

variable	level (0)		variable	level (1)	
	statistics T	prob		T statistics	prob
LnGDP	1.174722	0.6596	DLnGDP	-3.733709**	0.0013
LnMEXPE	-1.651525	0.4363	DLnMEXPE	-4.796001**	0.0019
LnINO	-3.821518**	0.0014			
LnRD	1.380309	0.5668	DLnRD	-4.844347**	0.0017
LnAEXPO	-2.175903	0.2209	DLnAEXPO	-4.607815**	0.0030

Notes: (**) and (***) indicate 5% and 1% significance level respectively
Source: Author's Estimation using Eviews 10.

Now, since not all variables are at the same static level (I (0) and I (1)), Bound Testing Approach is used to check the existence of a long-term relationship between the model variables. Therefore, the BOUND ARDL test is performed in this section and the results are shown in Table 2. In this regard, considering that if the computational statistic F is greater than the upper critical threshold value, regardless of the collective degree of variables it is possible to reject the null hypothesis that there is no long-term relationship. Conversely, if statistical F test is lower than the lower critical threshold value, the null hypothesis cannot rejected. Finally, if the test statistic is between the upper and lower thresholds, the result of the test is unclear. Now, according to the statistics obtained from this test, the computational statistic F is greater than the upper limit at the level of 5% (Pesaran and et al, 2001).

Therefore, the existence of a long-term relationship between the variables of the model is confirmed.

Table 2.: ARDL Bound Test Estimation Results

F-statistic	6.609875	
Significance	I (0) Bound	I (1) Bound
10%	2.01	3.1
5%	2.45	3.63
1%	4.84	3.42

Notes: (**) and (***) indicate 5% and 1% significance level respectively
Source: Author's Estimation using Eviews 10.

Now, according to the results, which indicates the existence of a long-term relationship between the variables of the model. By performing the ARDL test, we examine the long-term and short-term relationships between the variables, and the results of the test are given in Table 3.

Table 3: Error correction model (ECM) for short-run elasticity and The Long-run ARDL (3, 0, 0, 3, 0)

The Short-Run Diagnostic Test Results			The Long-run Estimation Results		
variable	Coefficient	prob	variable	Coefficient	prob
DLnINO	-0.38**	0.0539	LnINO	-0.47**	0.0002
DLnRD	-0.37**	0.0388	LnRD	-0.83**	0.0072
DLnGDP	-0.08**	0.0086	LnGDP	-0.005**	0.0011
DLnAEXPO	-0.12**	0.0076	LnAEXPO	-0.15**	0.0093
ECM(-1)	-0.92**	0.0023	C	23.7**	0.0000
		R^2: 0.98			Durbin-Watson:2.2

Notes: (**) and (***) indicate 5% and 1% significance level respectively
Source: Author's Estimation using Eviews 10.

According to the obtained results, the coefficients of all variables can be interpreted in the short and long-term. In the short-term, with a one percent change in the variables of technological innovations (number of patents registered by domestic residents), research and development costs and economic growth will be 0.38, 0.37 and 0.88 percent of Iran's military costs, will reduce. While the impact of sale and export of weapon on Iran's military spending is positive, a one percent change in this variable will increase military spending by 0.13 percent. But in the long-term, the effect of all variables on Iran's military expenditures was negative, with one percent change in technological innovation variables (number of patents registered by domestic residents), research and development costs, economic growth, sale and export of weapons, 0.47. 0.83, 0.85 and 0.15 will reduce Iran's military expenditures.

What is clear is that the impact of technological innovation and research and development costs on military spending is both short-term and long-term is negative. Although the impact that the two variables have on military spending in the short-term is very close, in the long-term the impact that research and development costs have on military spending is far greater and more significant. By using inventions and new research methods and resulting from research and development, military sector can reduce the costs of this sector and help Iran's defense economy. But the impact of economic growth on Iran's defense economy is far less than the two variables of technological innovation and research and development costs. So that this effect will be less in the long-term. Therefore, the effect of increasing economic growth and thus increasing the country's income and increasing the budget of the military sector on Iran's defense economy, although part of it to acquire and import modern technologies in the military sector and this will reduce military costs, but the effect It is far less important than using inventions and research and development on Iran's defense economy.

But, the sale and export of weapons in the short-term has a positive effect on defense spending because due to increased production for export and, with maintaining quality, more costs should be incurred in this sector, but in the long- term this effect is negative and increase in sale and export weapons can help Iran's defense economy because it can provide part of the cost of research and development and the cost of using inventions in the military sector.

But the main reason for the popularity of Error correction model (ECM) is that short-term fluctuations link variables to their long-term equilibrium values. Error correction coefficient, if displayed with a negative sign, will indicate the error correction speed and the desire for long-term balance. This coefficient shows how many percent of the imbalance of the dependent variable is adjusted in each period and is approaching the long-term relationship. Therefore, the error correction coefficient in this estimate is negative and interpretable, which shows that every year 0.92% of the short-term imbalance is adjusted to achieve the long-term balance. Obtained number for the Error correction model (ECM) indicates the high speed of short-term to long-term adjustment.

In order to investigate the stability of the model coefficients, Cumulative Sum of Recursive Residuals (CUSUM) and Cumulative Sum of Squares of Recursive Residuals (CUSUMQ) tests have been used. Stability test is used to determine the stability of the model and determine the presence or absence of structural failure. If the obtained statistical chart is in the range between these limits and does not cut them, it can be claimed that the model has the necessary stability and zero hypothesis is accepted based on the absence of structural failure.

In these tests, the zero hypothesis tests the stability of the parameters at a significance level of 5%. The results of the tests are shown in Figures 2. and 3. According to the results of these charts, the statistics of this test were located inside the straight lines, which mean that the coefficients were stable at a significant level of 5%. In other words, the zero hypothesis that the coefficients of stability at the 95% confidence level could not be rejected.
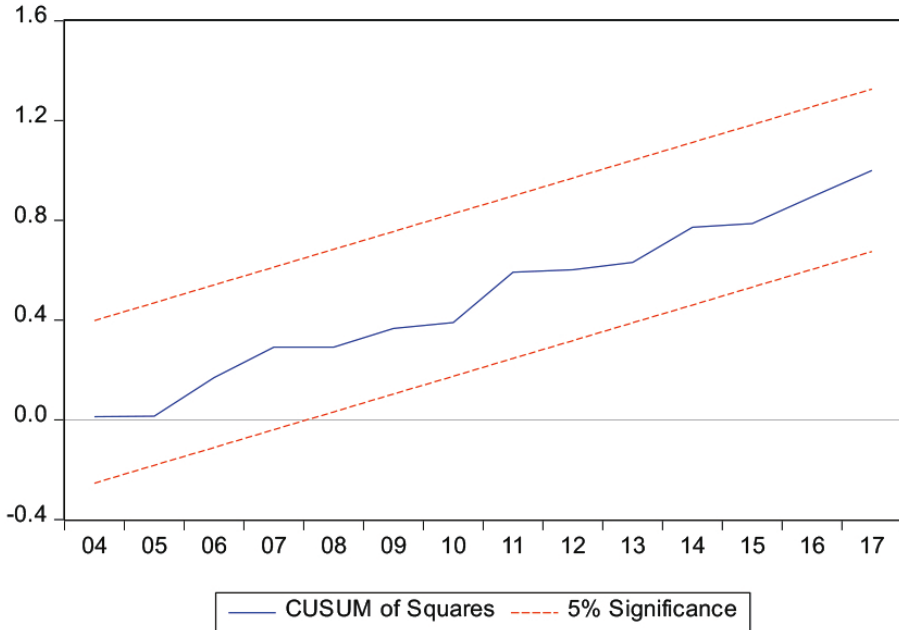
In other words, Figures 2. and 3. show that the estimated model has structural stability at the 5% level and no failure is observed.

Figure 2.: Test CUSUM
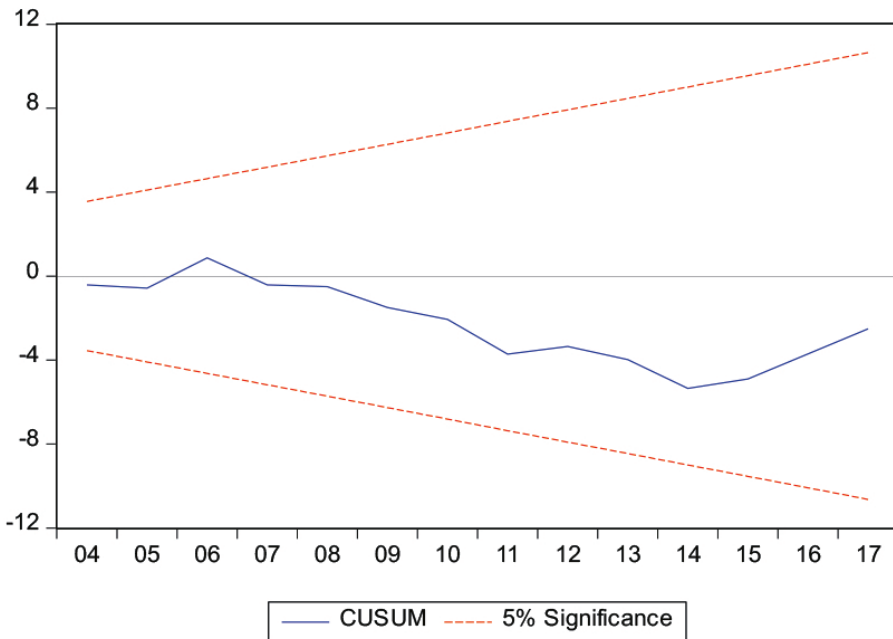
Source: Research results.

Figure 3.: Test CUSUMSQ

Source: Research results.

Diagnostic tests were also performed, including White, Breusch-Godfrey and Jarque-Bera. The results are shown in Table 4. The results, in turn, indicate that there is no problem of variance heteroscedasticity, self-correlation, and normal distribution of the disruption components.

Table 4.: Diagnostic tests

Test	Statistic	Prob
White	1.830508	0.3400
Breusch-Godfrey	1.453870	0.4075
Jarque-Bera	0.253545	0.880934

Source: Research results.

7. DISCUSSION AND CONCLUSIONS

What is clear is that in order to achieve growth and prosperity in the country's defense economy and reduce military spending, as in other economic sectors, military spending must be directed towards research and development and support technological innovation, which will increase productivity and efficiency in this sector and the reduction of costs have reduced the negative effects on the country's

economic growth and can even help it. Therefore, in this study, by conducting a self-explanatory test with wide interruptions (ARDL) the relationship between the variables of technological innovation, research and development costs, economic growth, sales and export of weapons and military costs in the period of 2000-2017 were examined .In addition, the data used in this study used the statistical information of the World Bank and the Stockholm International Peace Research Institute (SIPRI) and the EVIEWS 10 software was used to estimate the proposed equation. Based on the results, what is clear is that the impact of technological innovation and research and development costs on military spending is negative in both short-term and long-term. Although the impact that the two variables have on military spending in the short-term is very close, in the long-term the impact that research and development costs have on military spending is far greater and more significant. By using inventions and new research methods and methods resulting from research and development, can reduce the costs of this sector and help Iran's defense economy. But the impact of economic growth on Iran's defense economy is far less than the two variables of technological innovation and research and development costs. So that this effect will be less in the long-run. Therefore, the effect of increasing economic growth and thus increasing the country's income and increasing the budget of the military sector on Iran's defense economy, although part of it to acquire and import modern technologies in the military sector and this will reduce military costs, but the effect is less important than using inventions and research and development on Iran's defense economy. But, the rate of sale and export of weapons in the short-term has a positive effect on defense spending because due to increased production for export and, of course, maintaining quality, more costs should be incurred in this sector, but in long-term this effect is negative and increase the rate of sale and export of weapons can help Iran's defense economy.

Because it can provide part of the cost of research and development and the cost of using inventions made in the military sector. The Error correction model in this estimate is also negative and interpretable, which shows that 0.92% of the short-term imbalance is adjusted every year to achieve the long-term equilibrium. The high number obtained for the Error correction model (ECM) indicates the high speed of short-term to long-term adjustment. The results of Cumulative Sum of Recursive Residuals (CUSUM), the Cumulative Sum of Squares of Recursive Residuals (CUSUMQ) also indicate the stability of the model and the absence of structural failure.

But, the results of this study clearly show that investing in research and development and the use of technological innovations can affect the production of new military goods and services and increase quality, and by creating new equipment and advanced products and reducing dependence on foreign countries, productivity and efficiency increase in military organizations and even help create employment for educated people who are prone to economic growth.

For this reason, the country's defense economy can always have positive effects on military and civilian research and development, scientific innovation and technological progress, in this condition that the country's macroeconomics can spend military spending on research and development and support innovation and inventions. Eventually adopt arrangements that use the innovations of the defense industry in the civilian sector, which will lead to economic growth. This is the experience of many developed countries that have been able to use the technological advances and innovations of the military sector in the civilian sectors as well, and to cause the economic progress and development of their country.

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