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Examining the asymmetric effects of higher education on economic growth in Iran: Markov switching approach

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Abstract

The present study was conducted with the aim of investigating the asymmetric effects of higher education on economic growth in Iran. Playing the role of the educational system in creating and improving the capabilities of human capital, it is necessary to pay attention to the expansion of higher education for manpower in developing countries. In this research, the relationship between the education rate of higher education students and the literacy rate, as well as economic growth, was investigated and tested using the Markov switching approach and seasonal data (2001-2021). The results show a non-linear relationship between the education rate of master's students and economic growth, and the study of the effects of higher education on economic growth in different economic regimes showed that the education rate of senior students in the first and third regimes has a direct and significant effect on economic growth, and in the second regime, its effect on economic growth is reversed and negative. The literacy rate in all three regimes has a positive and significant effect on economic growth. Other studied economic variables, such as the unemployment rate, have a positive effect in the second and third regimes and a negative effect in the first regime. Also, the economic openness index in all three regimes has a positive and significant relationship with economic growth. The results of estimating the performance of the higher education system on economic growth with the Markov switching method show that the performance of the higher education system in the first and third regimes has a direct and significant effect on economic growth in Iran.

Keywords: higher education system, economic growth, Markov switching
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1 Introduction

Today, all governments, from industrialized countries to developing countries, consider education as one of their basic duties and impose heavy duties in their constitutions and fundamental laws to make education compulsory for everyone and a large percentage of the gross national product and The current and construction budget of the country is allocated to this important matter. Today, with the expansion of science and human experiences, as well as the

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development of technology and industry, the trend towards educational organizations has become a universal and universal thing. To such an extent that one of the important indicators of the growth of any society is considered to be the scope of education and upbringing duties. Since achieving economic growth and development is one of the most important goals that all economies strive for, however, achieving a high rate of economic growth requires knowing the potential of factors and facilities and their correct use. Changing the economic structure and human capital can have important and decisive effects on economic growth.

The higher education system in universities, by creating strategies for growth and development and organizing knowledge by creating opportunities for people in the society, provides the basis for the formation of innovation, creativity and competition by addressing the complex challenges of governance at the national and international levels. It provides in the development of countries [15], the supply of higher education services to the human force leads to the improvement of the level of skills and naturally increases the efficiency in the quantity and quality of the level of production by the workforce, which without a doubt, education Excellence can be considered an important factor in increasing the level of human capital. Therefore, one of the issues that should be addressed more in developing societies is the important and useful role of society members. In developing and even developed countries, they have come to the conclusion that what causes the development and progress of a country is not physical capital but human and social capital. Iran, as a developing country, currently has a surplus of labor force that can lead the country towards comprehensive growth and development. Therefore, due to the impact of economic growth on the education of people in society, it is very important to investigate the effect of education rate and literacy rate on economic growth in Iran. In general, it can be said that in open economies, improving the level of higher education can be effective through two channels: that improving the level of higher education increases the literacy rate, and from this channel, it increases the productivity of the labor force, reduces the unemployment rate, and increases production. and increasing economic growth. From another channel, the increase in the level of higher education leads to the skilling of unskilled labor and increases the migration of skilled labor, which reduces economic growth. Despite the importance of this issue, the relationship between these two variables has been discussed in a few studies in the country; In such a way that in studies like Sharif Karimi et al. [11] have investigated the linear relationship between higher education and economic growth in Iran. However, in Iran, there has been no study on the relationship between higher education and economic growth using a non-linear method, in the sense that in countries with an open economy, increasing the level of higher education to some extent has increased economic growth, and to some extent, with The increase in student immigration decreases the country's economic growth, which indicates the inverted U-shaped relationship between higher education and economic growth.

Therefore, considering the above contents and the importance of the effect of higher education on the economic growth of the country, it seems necessary to conduct the present research. Therefore, in this research, an attempt has been made to investigate the asymmetric effects of students' education rate and literacy rate by introducing other variables such as unemployment rate and economy openness index on economic growth using the Markov-switching approach with seasonal data during the period of 2002-2022.

In this research, the Markov-Switching model has been adopted to investigate the effect of students' education rate and literacy rate on economic growth, which is used to explain the behavior of variables that constantly change direction and their behavior changes from one state to another and back to the previous state. It comes back, it's convenient. In the Markov-Switching model, change is allowed at any point in time and in any number, while in structural change models, it is only possible to apply changes at specific times and exogenously; Therefore, the Markov-switching model is suitable for explaining data that show different behavioral patterns in different time periods.

In the present research, by stating and the necessity of the research problem in the introduction, in the second part, the theoretical framework of the subject under study and experimental studies are mentioned, in the third part, the econometric method and in the fourth part, with model estimation and analysis of the results and summary. And the conclusion is presented in the fifth section.

2 Theoretical framework of research and experimental studies

The growth of education in countries with open economies over the past 20 years has shown that their economies need to train more graduates in order to stabilize their market share and competitive position in the world economy, despite major challenges for graduate and higher education in developed countries. is developing, the main challenge of universities is the existence of high demand for entering higher education levels, and their other challenge is the imposition of severe financial restrictions by the governments, which leads to the lack of support of the government and universities for postgraduate education applicants. To improve the quality and direct it to the optimal path. The low elasticity of the labor market in order to attract post-graduate graduates in developing countries leads to

unemployment for graduates. It has attracted various sectors of the economy, including industry and mining, services, agriculture, oil and gas industries, etc., in the labor market, and in addition to financing the education sector by improving the quality of knowledge and skills of graduates, the efficiency of the higher education system to increase and improve its quality, the solution to increase the performance of educational systems on economic growth in countries that have been more exposed to globalization through logical interactions, has been the implementation of open economic policies, which has led to the reduction of problems in The labor market of higher education graduates has increased and the effects of post-graduate education and the higher education system on their economic growth have increased and higher education has been shown as an important and encouraging factor for their economic growth [5].

Examining the experiences and studies conducted in most countries on the labor market of graduates of the higher education system shows that with the increase in the degree of openness of the economy and its integration, the unemployment rate and, mainly, the unemployment rate of graduates of the higher education system have decreased. and the more important thing is that the unemployment rate of the graduates of the higher education system has been much higher than that of the low-educated and unskilled workforce, and the wages of this group of graduates of the higher education system have increased more than the wages of the regular workforce, which indicates The effects of the performance of the higher education system on economic growth in countries with an open economic system, and the root of this performance should be sought in the knowledge-based policymaking structure in various economic sectors. Virtual education can help to design a suitable model with the conditions that the growth of technology in developed and developing economies has placed on the performance of the educational system [4]. In today's era, the third level of formal education, i.e. academic and higher education, has gained great importance compared to previous decades, because it is an important factor in the competitive environment created among developed countries in the context of globalization based on a knowledge-based economy, and It is considered a knowledge for economic growth in these countries with an open economic system. The increasing interaction with the international economy leads to the creation of more job opportunities for the graduates and the adaptation of the educational system to the real needs of the labor market in different sectors of the economy and based on relative advantages in the macro economy. which results in improving the quality and skills of higher education graduates at high levels of education. According to the report of the World Economic Forum, the fourth industrial revolution requires changing the shape of the future of education and work to diversify talents, the consequences of which for education can include significant changes in the demand for knowledge, skills, and the expansion of facilities for education and learning [16], smart digital technologies such as artificial intelligence, Internet of Things, 3D printing, etc., by integrating in education, provide the possibility of meeting the demand of the global community in the path of economic growth and development.

Increasing the competition and flexibility of the labor market on the one hand and changing the institutions of the labor market such as the laws and regulations governing the market to increase the freedom of action of the economic enterprises can be seen as the effects of the open economic systems on the labor market which lead to by reducing the restrictions governing the behavior of companies in accepting and using production factors, the labor market environment becomes more competitive. In such a situation, due to rapid technological changes and rapid developments in various sectors of the economy, in open and globalized economies, due to the non-linearity and unpredictability of changes and developments in markets such as the labor market, unlike closed economies, it leads to deviation. It is working in the market objectives that the fall in investment motivation in the education sector. The growth of household income and the increase in the productivity of household members, in addition to depending on certain sources of income, are also dependent on access to productive assets and other sources of income, such as land, equal job opportunities in an open economy with competitive markets. Having an open economic system, constructive interaction in the international economy and attracting foreign investors in various sectors of the economy has increased the rate of return and productivity in education, which has increased the demand for private investment, the growth of the salaries of university professors and the improvement of the level. It has increased educational learners with higher motivation in the educational system, which causes more academic progress and shortens the duration of education. More demand for education increases its quality and vice versa. Conceptually, the open economic system represents the market performance of the economic system that governs the society, which is an important factor in economic integration in the interactions of the global economy, and with the existence of this economic system, the support policies of the governments are under pressure, and expanding the market of goods and services and increasing the sales of domestic products. Under such conditions, economic enterprises should use graduates, graduates and, in general, human capital at a high level to sell their goods and services.

In his study, Grant [8] examined the contribution of education to economic growth in OECD countries. The results of this study showed that increasing the share of education in the economy of OECD countries had a positive and significant effect on the country's gross domestic product.

Benos and Zotou [3] investigated the relationship between education and economic growth using the meta-regression method for a group of OECD countries. The results of this study provide evidence of the real effect of education on economic growth.

Abu Alfoul et al. [1] investigated the effect of education on economic growth in sub-Saharan Africa from 1989 to 2005. The results have shown that the quality of education in sub-Saharan African countries is much lower than in other developing regions. Evidence shows serious problems with the quality of education in sub-Saharan African countries.

Gyimah-Brempong et al. [9] in their study addressed the relationship between higher education and economic growth in Africa using panel data in the period 1960-2000. With the results obtained from this research, we realize that in African countries, all levels of human capital education, including higher education human capital, have a positive and significant effect on the growth rate of per capita income.

Karimi et al. [11] studied the relationship between women's education and economic growth in selected Islamic countries using annual data from 2000 to 2014 using a dynamic panel data model and modified least squares (FMOLS) and dynamic least squares estimation methods. (DOLS) have reviewed. According to the results, it can be seen that women's education had a positive and significant effect on the growth of GDP in these countries.

In their study, Asadzadeh et al. [2] investigated the role of women's employment and education on economic growth in Iran using the Gravitational Search Algorithm (GSA) and the Firefly Optimization Algorithm (FA) from 1380 to 1393. The results of their study have shown that the growth of the country's gross domestic product has been significantly affected by the growth of the economic activity rate of women in the labor market, and with the increase in the level of education of women as an intersection variable on their economic activity rate, it leads to an increase in the gross output. It has become the interior of the country. The relationship between education and economic growth in some developing countries in the period of 1990-2013, using the panel data method, is investigated by some researchers. The results show that the variable coefficient of education rate in elementary and high school has a positive and significant effect on economic growth. According to this conclusion, it can be said that with the growth of the number of middle school and high school graduates, the level of human capital and the rate of economic growth in developing countries have also increased, and two variables, the ratio of education and training costs and the ratio of R&D costs to gross production. internal have been positive and meaningful.

Naderi [13] investigated the effects of public education and higher education on economic growth in Iran using annual data from 1958 to 1963. The findings show that educational investment is more than physical investment. The external effects resulting from human capital concentration and public education have a much greater impact on Iran's economic growth.

Houshmand et al. [10], in an article entitled "Investment in education and its effect on the economic growth of selected developing countries", have discussed using the panel data method during the period of 1998-2010. The results of this article show that investment in education has had a positive and significant effect on economic growth in selected developing countries. Therefore, one of the important reasons for the low economic growth rate in developing countries can be considered to be low education costs and a lack of attention to the effects of education and training of human capital with skills. On the other hand, more importance should be given to the growth of the quantity and quality of educational systems by increasing educational costs.

Falihi [7] investigated the effects of higher education on economic growth in Iran by applying the dynamic system model and econometrics and using annual data (2010-2015) and reached these results that despite the increase in expenses in educational systems in The years under study, which resulted in the improvement of the level of human capital, and the improved quantity and quality of human capital, had a positive and significant, albeit insignificant, effect on economic growth, and the reason for the smallness of this effect can be found in the employment of graduates. The higher education system searches for activities not related to its specialized field, the effect of the graduates of the higher education system on the promotion of human capital and economic growth is greater than that of elementary, middle and high school levels. Therefore, paying more attention to increasing the productivity of the graduates of the higher education system and specializing the activities of the university graduates is necessary to increase the performance of higher education in the economic structure.

Nili and Nafisi [14] in a study investigated the relationship between human capital and economic growth, emphasizing the role of education distribution in Iran during the period of 1966-1996. The results of their study reveal that the increase in the years of education of employees causes a decrease in economic growth; Therefore, instead of higher education, focusing on raising the educational level of employees in primary and secondary levels will increase economic growth.

3 Markov switching approach

It is not possible to use linear models to model a time series whose behaviors in certain periods are particularly different from each other. In this situation, economists like Hamilton recommend using the Markov-Switching (MS) model. It has more advantages than other common models in time series analysis, for example, in determining business cycles and macroeconomic variables such as production, employment, etc., which show different behavior according to the conditions of prosperity and recession. In the Markov transition model introduced by Hamilton, regime transition is assumed to be exogenous. The main difference between Markov switching models and structural change models is that in Markov switching models, status changes are allowed at any point in time and any number of times; But in the patterns of structural change, it is possible to apply the change of situations at certain times and exogenously; Therefore, the Markov switching regime change model is more suitable for explaining the behavior of data that show different behavioral patterns in different intervals.

If we want to study the behavior of the stationary variable y_t, its value is determined by the first-order self-regression process during the period $(t = 1, 2, ..., T_1)$ will be as follows:

$$\begin{aligned} y_t &= c_1\rho_1 y_{t-1} + \varepsilon_t \\ \varepsilon_t &\sim N(0, \sigma^2) \end{aligned} \tag{3.1}$$

Now suppose that a mutation or structural change occurs in time T_1 for this variable, in this case the new model will be defined in this way with the aim of explaining the behavior of y_t for the period $(t = T_1 + 1, T_2 + 1, ..., T)$:

$$y_t = c_2\rho_2 y_{t-1} + \varepsilon_t \tag{3.2}$$

So, we can express the general equation as follows:

$$y_t = c_{st} + \rho_{st} y_{t-1} + \varepsilon_t \tag{3.3}$$

In addition, s_t contains the values 1 and 2 and indicates the changes before and after y_t, respectively. In other words, the period before the mutation $t < T_1$ is designated by $s_t = 1$ and the period after the mutation $t \geq T_1$ is designated by $s_t = 2$. But this fashion; has weaknesses such as the imprecise date of the mutation to use the virtual variable and the impossibility of predicting the behavior of the variable. Therefore, to solve these problems and the process of creating data, it is better to consider the probability condition for s_t. In the Markov switching model, the transmission mechanism is controlled by the unobservable state variable s_t [6].

This state variable follows a first-order Markov chain. In other words, the value of the state variable in period t depends only on its value in period t-1. The transfer models for the variable can be expressed as follows:

$$y_t = \begin{cases} c_1\rho_1 y_{t-1} + \varepsilon_t, & s_t = 1 \\ c_2\rho_2 y_{t-1} + \varepsilon_t, & s_t = 2 \end{cases} \tag{3.4}$$

Considering different assumptions for s_t, different models are created. when s_t takes the value of one for the period $(t = 1, 2, ..., T)$ and the value of 2 for the period $(t = T_1 + 1, T_2 + 1, ..., T)$; This model is a model with a structural change in time. When s_t is independent Bernoulli random variable, this model represents the quantum random transition model (1972). If s_t is considered as an index variable, so that its value is $s_t = 1$ for $\theta \leq c$ and $s_t = 2$ for $\theta > c$, (c is a threshold value), this model is called a threshold model. When s_t follows a Markov process, this model is called Markov switching model. Assuming that the variable y_t is modeled by the autoregressive process of order p and with regime m, we have $(MS(m)–AR(P))$:

$$\begin{aligned} y_t &= \sum_{i=1}^{m} \left[\sum_{j=1}^{p} ((\beta_{ij} y_{t-j}) + u_{it}) I_i(s_{t=i}) \right] \\ I_i(s_{t=i}) &= \begin{cases} s_t = i \to 1 \\ s_t \neq i \to 0 \end{cases} \end{aligned} \tag{3.5}$$

In the Markov switching model, the features y_t are jointly determined by the feature ε_t and the state variable s_t. State variables create permanent and frequent changes in the model pattern. To have the full dynamics of the

variables, the transition between states or regimes can be represented using a transition probability matrix. In the simple model that has only two regimes, this matrix is as follows:

$$y_t = \begin{bmatrix} Pr[s_t = 1|s_{t-1} = 1] & Pr[s_t = 1|s_{t-1} = 2] \\ Pr[s_t = 2|s_{t-1} = 1] & Pr[s_t = 2|s_{t-1} = 2] \end{bmatrix} = \begin{bmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{bmatrix} \tag{3.6}$$

where p_{ij} $(i, j = 1, 2)$ shows the transition probabilities $s_t = i$, so that $s_{t-1} = i$ and $p_{i1} + p_{i2} = 1$. As mentioned earlier, y_t is directly observable, but the state variable is unobservable and its value can only be inferred from the value of the realizations, which is expressed as $\xi_{it} = Pr[s_t = 1|\Omega_t, \theta]$ where $i = 1, 2$ and Ω_t represents the information set (set of observations available for period t) and θ represents the parameters vector for estimation. For inference, an iterative method should be used for the period $(t = 1, 2, ..., T_1)$, when the previous probability value $\xi_{it-1} = Pr[s_t = 1|\Omega_{t-1}, \theta]$ as data in The model is used. For this purpose, the probability density function is required under different situations, which can be checked as follows:

$$\eta_{it} = f(y_t|s_t = 1|\Omega_{t-1}, \theta) = \frac{1}{\sqrt{2\pi\sigma}} \exp\left[-\frac{(y_t - c_1 - \rho y_{t-1})^2}{2\sigma^2}\right] \tag{3.7}$$

And so we have:

$$\xi_{it} = \frac{\sum_{j=1}^{2} p_{ij}\xi_{it-1}\eta_{it}}{f(y_t|s_t = 1|\Omega_{t-1}, \theta)} \tag{3.8}$$

Using these results, we can obtain the logarithm of the conditional probability of the observed data for the given value:

$$\log f(y_1, y_2, ..., y_T|y_0, \theta) = \sum_{t=1}^{T} \log f(y_t|s_t = 1|\Omega_{t-1}, \theta) \tag{3.9}$$

To estimate θ, optimization is used to maximize the logarithm of the conditional probability by using the initial value ξ_{i0}. Assume that the Markov chain is ergodic. In this case, the unconditional probabilities of being in state j are used as initial values, which can be defined as follows:

$$\xi_j = Pr[s = j] = \frac{1 - p_{ii}}{2 - p_{ii} - p_{jj}} \tag{3.10}$$

After estimating the coefficients of the model and calculating the transfer matrix, the probability of the situation in each time period can be calculated based on the information of the entire sample (studies 1 to T), and this set of probabilities are known as smoothed probabilities. In addition, it is possible to calculate the probability of the state in each time period using the observations from 1 to t (the point under investigation), which is known as filtered probabilities.

In practice, the Markov transition model can be classified into different types according to which part of the regression model itself depends on the regime and is transferred under its influence. What is more interesting in economic studies includes the four modes of Markov switching models in the mean (MSM), breadth from the origin (MSI), coefficients of autoregression sentences (MSA) and heterogeneity in variance (MSH) or their combination [6]. The table below shows the different states of MS models using these symptoms.

Table 1: Summary of different modes of MS-AR model [12]

Description		**MSM**		**MSI**	
		Variable μ	Constant μ	Variable C	Constant C
Constant α_i	Constant variance	MSM-AR	Line AR	MSI	Line AR
	Variable variance	MSMH-AR	MSH-AR	MSIH-AR	MSH-AR
Variable α_i	Constant variance	MSMA-AR	MSA-AR	MSIA-AR	MSA-AR
	Variable variance	MSMAH-AR	MSAH-AR	MSIAH-AR	MSAH-AR

Considering the fact that some economic variables have a non-linear behavior based on economic theories and experimental observations, therefore, such variables can be modeled in a non-linear way using the models listed in Table 1.

4 Estimation of the model and analysis of the results

$$GDP_t = f(ES_t, Ed_t, UR_t, OP_t)$$

In the above equation, the dependent variable: (GDP_t) the growth rate of the gross domestic product at constant prices in 2013 and the independent variables: (ES_t) the education rate of master's students, (UR_t) the unemployment rate, (Ed_t) is the literacy rate and (OP_t) is the index of openness of the economy, and the data of all variables are collected from the central bank.

4.1 Stationary variables

Table 2: Results of Mann–Whitney test with Dickey-Fuller test (*, ** and *** indicate the significance level of 10%, 1% and 5%, respectively.)

Variable	Meaning on the surface		meaning with a difference	
	width from the origin	width with origin from the trend	width from the origin	width with origin from the trend
GDP	0.0136**	–	–	–
ES	0.6278	0.1336	0.009***	–
Ed	0.6734	0.7280	0.040**	–
UR	0.0015***	–	–	–
OP	0.7903	0.9845	0.001***	–

Considering that the null hypothesis of the above test indicates the existence of a single root in the variables, the results obtained from the Dickey-Fuller test, as it is known from Table 2, show that the significance level of all variables of the model except GGDP and UR with a single difference of 0.05 It has become smaller, which shows that these variables are not at a static level and are significant by differentiating them at different levels of confidence, and only GGDP and UR are at the significant level. Determining the optimal Markov switching model to investigate the effect of student education rate on economic growth.

Table 3: LR test results

statistics	Probability value
LR-test	$\chi^2(42) = 478.85[0.0000]^{**}$ approximate upperbound: $[0.000]^{**}$

As the results of table 3 show, the value of the LR test statistic is significant at the significance level of 1%; Therefore, it can be concluded that instead of linear models, it is better to use the nonlinear Markov-switching method to estimate the model. In the second step, to specify the model, the order of autoregression and the number of regimes of the Markov-switching model should be determined. According to the sample size, the MS model should be estimated for different degrees of autoregression (P) and the number of regimes (m). Akaike (AIC) and Henan-Queen (HQ), Schwartz (SC) and LR tests are used to determine the degree of the model, and all these criteria determine the optimal number of intervals: 4 intervals; Therefore, the MSIAH(3)-AR(4) model with 3 optimal regimes has been selected as the optimal model among several models, based on the lowest Schwartz criterion and the highest value of the likelihood test.

According to Table 4, the results of estimating the parameters of the model can be divided into three regimes. In addition, all coefficients are significant at the 1% level. The value of the width from the origin in the first regime is equal to 0.18768, in the second regime it is equal to -3.84356, and in the third regime it is equal to 2.3273.

Since in the estimated model, the variance of the disturbance component is a function of the state variable, therefore, the variance of the disturbance components related to the equations of the three different regimes is equal to 9.50017 e 007 in the first regime, 0.65720 in the second regime, and 0.64429 in the third regime. In fact, these numbers show that the observations of the third regime have more fluctuations than the first and second regimes. As shown, the coefficient of the education rate of students in the first regime is equal to 132.085, which indicates a direct and significant effect. The coefficient of the education rate of students in the second regime is equal to -88.3382, which shows the negative effect of the education rate. The coefficient of the education rate of students in the third regime is equal to 45.3731, which shows its direct and significant effect. The results related to the students' education rate show that in the first and third regimes, with the increase in the education level of the students, their productivity increases and with the increase in production, it leads to economic growth. In the second regime, with the increase in students' education, the economic growth is reduced, so that with the increase in students' education, their desire to immigrate increases, and as a result, their productivity in the host country decreases and economic growth decreases. Also, the coefficient of literacy rate in the first, second and third regimes is 20.6392, 1.9246 and 4.2532, respectively, which

Table 4: Summary of the estimation results of MSIAH(3)-AR(4) optimal model parameters

Variable	**Coefficients**	**Standard deviation**	**Statistic**	**t-probe**
$Constant_0$	0.18768	0.000	+inf	0.000
$Constant_1$	-3.84356	0.000	-inf	0.000
$Constant_2$	2.3273	0.000	+inf	0.000
D4ES (0)	132.085	0.000	+inf	0.000
D4ES (1)	-88.3382	0.000	-inf	0.000
D4ES (2)	45.3731	0.000	+inf	0.000
D4ES-1(0)	-379.864	0.000	-inf	0.000
D4ES-1(1)	106.262	0.000	+inf	0.000
D4ES-1(2)	-181.028	0.000	-inf	0.000
D4ES-2(0)	482.630	0.000	+inf	0.000
D4ES-2(1)	71.4780	0.000	+inf	0.000
D4ES-2(2)	208.605	0.000	+inf	0.000
D4ES-3(0)	-305.275	0.000	-inf	0.000
D4ES-3(1)	-193.719	0.000	-inf	0.000
D4ES-3(2)	-65.055	0.000	-inf	0.000
D4ES-4(0)	85.434	0.000	+inf	0.000
D4ES-4(1)	101.248	0.000	+inf	0.000
D4ES-4(2)	-20.4436	0.000	-inf	0.000
D4ED(0)	20.6392	0.000	+inf	0.000
D4ED (1)	1.9246	0.000	+inf	0.000
D4ED (2)	4.2532	0.000	+inf	0.000
D4ED-1(0)	-58.518	0.000	-inf	0.000
D4ED-1(1)	-1.1176	0.000	-inf	0.000
D4ED-1(2)	7.6447	0.000	+inf	0.000
D4ED-2(0)	66.954	0.000	+inf	0.000
D4ED-2(1)	7.552	0.000	+inf	0.000
D4ED-2(2)	-51.784	0.000	-inf	0.000
D4ED-3(0)	-40.076	0.000	-inf	0.000
D4ED-3(1)	-11.753	0.000	-inf	0.000
D4ED-3(2)	74.1768	0.000	+inf	0.000
D4ED-4(0)	11.9509	0.000	+inf	0.000
D4ED-4(1)	7.8961	0.000	+inf	0.000
D4ED-4(2)	-34.958	0.000	-inf	0.000
D4OP(0)	727.523	0.000	+inf	0.000
D4OP (1)	16.479	0.000	+inf	0.000
D4OP (2)	1056.46	0.000	+inf	0.000
D4OP-1(0)	-4677.09	0.000	-inf	0.000
D4OP-1(1)	-2624.13	0.000	-inf	0.000
D4OP-1(2)	-8187.17	0.000	-inf	0.000
D4OP-2(0)	10807.9	0.000	+inf	0.000
D4OP-2(1)	5926.22	0.000	+inf	0.000
D4OP-2(2)	16511.6	0.000	+inf	0.000
D4OP-3(0)	11257.4	0.000	+inf	0.000
D4OP-3(1)	-5194.62	0.000	-inf	0.000
D4OP-3(2)	-13847.6	0.000	-inf	0.000
D4OP-4(0)	4927.13	0.000	+inf	0.000
D4OP-4(1)	1790.42	0.000	+inf	0.000
D4OP-4(2)	4391.57	0.000	+inf	0.000
D4UR(0)	-1.66966	0.000	-inf	0.000
D4UR (1)	2.29376	0.000	+inf	0.000
D4UR (2)	1.14815	0.000	+inf	0.000
Sigma(0)	9.50017 e 007	0.000		
Sigma(1)	0.65720	0.000		
Sigma(2)	0.64429	0.000		
log-likelihood	81.12329			
AIC	-0.58675			
SC	1.31046			

indicates the positive effect of the literacy rate in the first, second and third regimes, in the sense that in an economy, the higher the literacy of the labor force, the simpler the labor force. become a skilled workforce is created, their productivity increases and leading to increased production and economic growth. The coefficient of unemployment rate in the first, second and third regimes is -1.66966, 2.29376 and 1.14815, respectively, which indicates its direct and positive effect in the second and third regimes and its negative effect in the first regime. In addition, the index

coefficient of the openness of the economy in all three regimes shows its direct relationship with the growth rate. According to what was said in the theoretical foundations section, the openness of the economy leads to an increase in economic growth through the import of technology and skilled labor. The value of the coefficients indicates that the nonlinear effects of students' education rate are significant in all three regimes, while these effects are positive in the first and third regimes and negative in the second regime.

The figures below show the estimated model disturbance sentences as well as the actual, fitted, one-period forecast, as well as fitted observations.

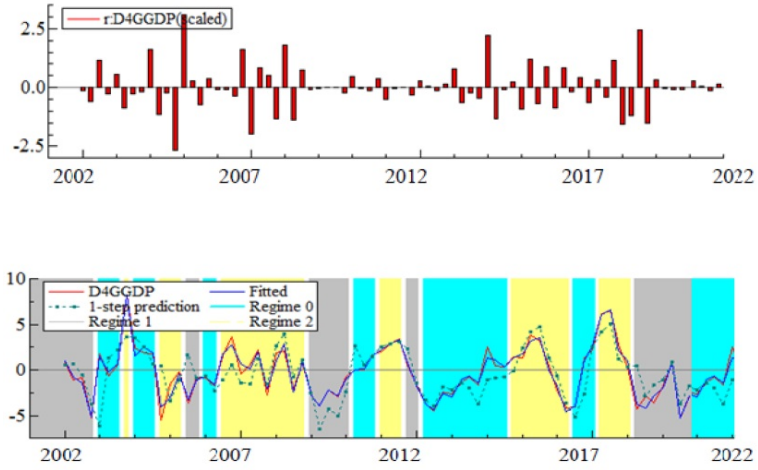

Figure 1: Model disturbance sentences and actual and estimated value status

In order to check the stability of each of the regimes, as well as the transition probabilities of each regime to another regime, the transition probability matrix of regimes and their results are given in the table below.

Table 5: Probability of transition from one regime to another

	The first regime	**The second regime**	**The third regime**
The first regime	0.19612	0.19623	0.28437
The second regime	0.29997	0.80328	0.0829
The third regime	0.50391	0.00048	0.63268
Course length	chapters 20	chapters 32	chapters 28

Considering that it is also specified in the table, the probability of the stability of the first regime is approximately 0.19, as well as the probability of transition from the first regime to the second regime is 0.19, and the probability of transition from the first regime to the third regime is 0.28. The probability of stability of the second regime is 0.80, as well as the probability of transition from the second regime to the first, which is approximately 0.30, and the probability of transition from the second regime to the third regime is 0.08. The probability of stability of the third regime is approximately 0.63, and the probability of transition from the third regime to the first regime is 0.50, and the transition from the third regime to the second regime is equal to 0.0004. The observations show the fact that the second regime is more stable than the first and third regimes. The breakdown of the seasons of each business cycle is presented in the table below.

According to the table 7, the results of the autocorrelation test show that the absence of autocorrelation cannot be rejected, so it can be concluded that the disturbance sentences are free of autocorrelation. The normality test also indicates that the distribution of the disturbance sentences of the estimated model is normal. The results of the heterogeneity of variance test also show that the variance of the disturbance sentences is the same. Therefore, the examination of the classical hypothesis tests shows the significance of the model estimates.

5 Summary and conclusion

This article aims to investigate the effect of the education rate of master's students on economic growth in Iran during the period of 2010-2017. In this regard, the main goal of this article is to empirically examine this issue, taking into account the features of the country's economy that are reflected in its data, as well as choosing and applying

Table 6: Business cycles by seasons

The first regime	2002:1-2002:1
	2003:1-2003:1
	2003:3-2003:3
	2007:3-2007:3
	2007:1-2007:1
	2005:4-2005:3
	2007:2-2007:2
	2009:2-2009:2
	2009:4-2009:4
	2013:2-2013:1
	2014:1-2014:1
	2015:4-2015:4
	2017:1-2017:1
	2020:1-2020:4
The second regime	2005:3-2005:2
	2008:1-2008:1
	2011:3-2011:1
	2012:4-2012:4
	2014:3-2014:4
	2016:2-2015:3
	2018:2-2018:4
	2019:3-2019:1
The third regime	2001:1-2001:4
	2001:2-2001:4
	2002:2-2002:2
	2004:4-2004:2
	2006:1-2006:1
	2007:2-2007:2
	2009:3-2009:3
	2012:1-2012:3
	2018:1-2018:4
	2021:1-2021:1

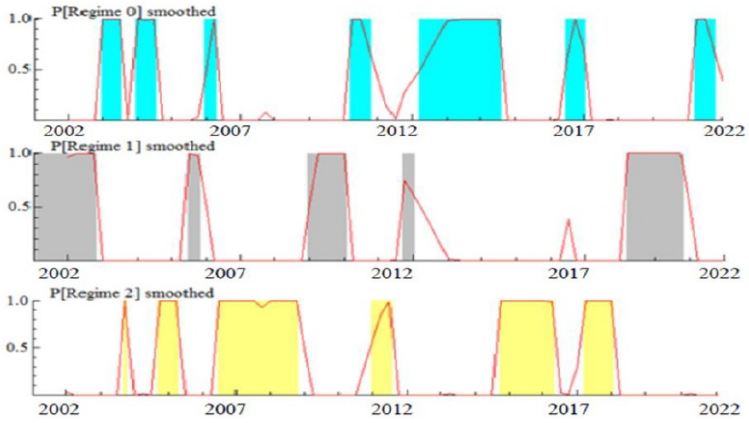

Figure 2: Status of regimes in the MSIAH(3)-AR(4) model

Table 7: Classical assumption tests of the MSIAH(3)-AR(4) model

Test type	**Test statistics**	**Probability value**
Autocorrelation test	$\chi^2(12) = 15.161$	0.2328
Normality text	$\chi^2(2) = 2.4996$	0.2866
Variance heterogeneity text	F(1,10)=0.0924	0.7673

the econometric method that matches the data conditions. For this purpose, we chose the Markov-switching model for this study by performing the LR test to ensure the existence of a non-linear relationship. Then, based on the optimal model selection strategy, MSIAH(3)-AR(4) was selected as the optimal model, and the main research model was estimated using this method. The results of the estimation of the Markov-Switching model showed that the education rate of senior students does not have the same effect on economic growth in Iran, or in other words, the nonlinear relationship (inverted U) between the education rate of senior students and economic growth in Iran was

confirmed during the period under review. Likewise, the results of estimating the education rate on economic growth with the Markov switching method show that the education rate of senior students in the first and third regimes has a direct and significant effect on economic growth, and in the second regime, its effect on economic growth is inverse and It is negative. The literacy rate in all three regimes has a positive and significant effect on economic growth. Observations show that other economic variables under investigation, such as the unemployment rate, have a positive effect in the second and third regimes and a negative effect in the first regime. Also, the economic openness index in all three regimes has a positive and significant relationship with economic growth.

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