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Studying the Effect of Energy Factor on Iran's Agriculture Sector and Total Economy Production

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Abstract

Energy is an indispensable input for economic activity. Although capital and labor have widely been used as the production factors of many countries production function, but there is little body of literatures which has used the energy as a production factor in Iran. To the importance of energy factor in production process, in this study, the energy factor is entered in the long-run Iran's agriculture sector and total economy production functions. Also, the Cobb-Douglas production function and Auto-Regression Distributed Lag (ARDL) approach are used for estimating the long-run production functions. Results show that the production elasticities of labor, capital and energy factors of Iran's agriculture sector are 0.36, 0.23 and 0.32, respectively. Beside, the production elasticities of labor, last year capital and energy factors of Iran's total economy are 0.55, 0.46 and 1.17, respectively.

Key words: Energy, Production Function, Labor, Capital, ARDL.

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1- Introduction

The concept of technical production function is central to economic analysis and is defined in the literature as a physical relationship between inputs and outputs of an economic process. The study of production function has a number of important direct and indirect implications for macro-theorist. First, it provides a link between the input markets and the commodities markets and thus has a key role to play in any generalization of the economy. Secondly, it is an input into the study of aggregate investment and, clearly, the choice of production technology influences the nature of investment function. Finally, it provides a basic ingredient to the study of income distribution because one can work back to the distribution of the proceeds of production from the production function itself. Energy is an indispensable input for economic activity. Economic growth will be hindered if a stable source of energy is not secured (Tanabe, 2004). In addition, nowadays, the main portion of world commercial transactions was dedicated to energy carriers and these transactions have found a special position among the commercial activities. Further, since the commencement of the industrial revolution and the formation of industries, energy carries have been known as one of the important production factors. Although capital and labor have widely been used as the production factors of many countries, there is little body of literatures which has used the energy as a production factor in Iran. To the importance of energy in production process, in this study, the effect of energy factor on Iran's agriculture sector and total economy production is investigated using the data extracted from the balance sheets of Iran's Ministry of Power and statistical yearbooks related to the years 1981-2005.

2- Energy usage trend of Iran's agriculture sector

2-1- Oil Products

In this section, the usage trend of various main oil products in the agriculture sector during the years 1996-2005, is investigated. The trend of oil products usage and their proportion in total energy provisions of agriculture sector during the years 1996-2005, have been shown in table1:

Table1: Trend of oil products energy carrier's usage of Iran's agriculture sector

Energy carrier	Gasoline		Fuel oil		Kerosene		Gas oil	
Year	Usage (1000liter)	Proportion (%)	Usage (1000liter)	Proportion (%)	Usage (1000liter)	Proportion (%)	Usage (1000liter)	Proportion (%)
1996	14521	0.12	24190	0.16	335269	3.16	4052693	17.92
1997	11057	0.09	54013	0.35	156436	1.54	3987969	16.69
1998	17123	0.13	285575	2.06	174861	1.77	4196231	18.23
1999	17630	0.12	63168	0.44	146114	1.58	3888037	16.89
2000	18943	0. 12	115100	0.78	180957	1.97	3770757	15.53
2001	14157	0.08	11580	0.08	178236	1.99	3648245	14.53
2002	15710	0.09	*	*	93971	1.08	3437736	13.28
2003	14138	0.07	*	*	80255	1.02	3670545	13.99
2004	15161	0.07	4103	0.03	79113	1.02	3617581	13.23
2005	13445	0.06	*	*	73969	0.99	3729991	13.00

*Unavailable data, Source: Energy balance sheet related to the year 2005.

Also, the average proportions of gasoline, fuel oil, kerosene and gas oil in the total energy provisions of this sector during the same years are 0.09, 0.56, 1.61 and 15.33 percent, respectively. Therefore among the oil products of energy provisions, gasoline and gas oil have the lowest and highest proportions, respectively.

2-2- Electricity

In this section, the trend of electricity energy usage in the agriculture sector during the years 1996-2005, is studied. Table 2 indicates the trend of electricity energy usage and its proportion in total energy provisions of agriculture sector during these years.

Table2: Trend of electricity energy usage of Iran's agriculture sector

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Usage(10^6kwh)	5731	6009	6782	8019	9147	11079	12435	13858.6	15489.1	16469
Proportion(%)	8.2	8.19	8.73	9.47	10.12	11.40	11.83	12.06	12.44	12.39

Source: Energy balance sheet related to the year 2005.

Table2 states that the annual growth of electricity usage of Iran's agriculture sector during the years 1996-2005 has been 12.54 percent, and its average proportion in total energy provisions of this sector during the same years has been about 10.48 percent. Also, the trend of oil products, electricity and total energy usage at 10^6 barrels crude oil during the years 1985-2005, has been shown in table3.

Table3: Energy usage trend of Iran's agriculture sector (10^6 barrels crude oil)

Year	Oil Products	Electricity	Total
1988	25	1.8	26.8
1989	26.4	2	28.4
1990	27.5	2.2	29.7
1991	29.6	2.3	31.9
1992	31	2.1	33.1
1993	28.6	2.4	31
1994	28.8	3	31.8
1995	27.7	3.2	30.9
1996	27.4	3.4	30.8
1997	26.1	3.5	29.6
1998	29.2	4	33.2
1999	25.6	4.7	30.3
2000	25.4	5.4	30.8
2001	23.9	6.5	30.4
2002	22	7.3	29.3
2003	23.4	8.2	31.6
2004	23.1	9.1	32.2
2005	23.7	9.7	33.4

Source: Energy balance sheet related to the year 2005

Table3 demonstrates that oil products proportion in total energy usage has reached from 93.28% in 1988 to 70.96% in 2005, which indicates the decreasing trend of oil products proportion in energy usage and its substitution with other energy carriers like electricity. And electricity proportion in the used energy provisions of agriculture sector has increased from 6.72 % in 1988 to 29.04% in 2005, which indicates the increasing trend of electricity proportion in energy usage.

Totally, tables 1-3 indicates that the oil products energy usage of Iran's agriculture sector have substituted with the electricity energy usage.

Moreover, the proportion of Iran's agriculture sector in total country used energy during the years 1980-2005, has been shown in figure1.

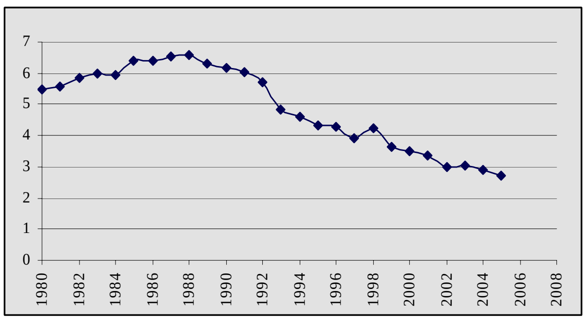


Fig1: Iran's agriculture sector proportion in total country energy usage (%)

Source: Energy balance sheet related to the year 2005.

This figure exhibits that until the Iran-Iraq war, Iran's agriculture sector proportion in total energy usage has had an increasing trend, but after this war through the other economic sectors emersion and increasing their energy usage, the Iran's agriculture sector proportion in total energy usage has had decreasing trend.

3- Energy usage trend of Iran's total economy

In order to study the per capita energy usage trend, the available data of energy balance sheet was used. Table 4 presents the energy usage trend of Iran's households and commercial, industrial, transportation, power plants, refineries and total economy at 10^6 barrels crude oil during the years 1981-2005.

Table 4: Energy usage trend of Iran's various economic sectors (10^6 barrels crude oil)

Year	Households, Commercial		Industrial		Transportation		Agriculture		Power plants		Refineries		Total
	Usage	%	Usage	%	Usage	%	Usage	%	Usage	%	Usage	%	
1990	122.5	26	112.9	24	96.2	20	29.7	6	103.1	21	15.9	3	480.3
1991	139.2	26	123.3	23	104	20	31.9	6	112.1	21	18.5	3	529
1992	166.6	29	130.6	23	110.7	19	33.1	6	116.8	20	21.4	4	579.2
1993	191.2	30	121.6	19	122.1	19	31	5	142.9	22	30.3	5	639.1
1994	212	31	125.5	18	144.6	21	31.8	5	146.9	21	30	4	690.8
1995	213.6	30	133.8	19	141.9	20	30.9	4	158.5	22	31.6	4	710.3
1996	229.8	32	117	16	147.9	21	30.8	4	162.4	23	33.5	5	721.4
1997	240.3	32	130.7	17	153.2	20	29.6	4	174.1	23	34.5	5	762.4
1998	244.8	31	117.4	15	161.2	21	33.2	4	181.2	23	41.6	5	779.4
1999	251.7	30	133.7	16	170.3	21	30.3	4	198.3	24	43.8	5	828.1
2000	270.9	31	136.5	16	183.4	21	30.8	4	212	24	43.1	5	876.7
2001	277.2	31	137.5	15	194.3	21	30.4	3	225.9	25	42.7	5	908
2002	309.3	32	143.5	15	208.9	21	29.3	3	243.8	25	45.6	5	980.4
2003	314.2	30	157.4	15	220.8	21	31.6	3	256.9	25	52.7	5	1033.6
2004	342.4	31	168.5	15	234	21	32.2	3	281.3	25	59.5	5	1117.9
2005	379.3	31	188.2	15	254.3	21	33.4	3	305.7	25	59.8	5	1220.7

Source: Energy balance sheet related to the year 2005.

Table 4 shows that the proportions of energy usage in Iran's various economic sectors except the industrial and agriculture sectors during 1990-2005 are increasing. And it indicates that Iran's energy usage instead of generation sections has shifted to consumption sections.

4- Literature Review

Tatom (1979) perused the effect of energy prices on U.S. capital formation during the years 1972-1977. He found that the large increase in the cost of energy sources from 1972 to 1977 has had profound effects on productivity investment, and the long-term growth path of the U.S. economy. In addition to a direct loss in productivity of about 6.5 percent, a reduction in the desired capital-labor ratio has further aggravated productivity growth. Since 1975, growth in the capital stock has barely kept pace with growth in the labor force available to the private sector. This development represents a significant departure from the trend growth in the capital-labor ratio, a trend which contributed significantly to overall economic growth in the United States prior to 1973.

Hope and Singh (1995) studied the effect of price increasing in electricity and oil products, on the industrial sector, households, and macroeconomic variables of Malaysia, Ghana, Zimbabwe, Indonesia, and Turkey in decade of the 1980's. Results indicated that almost in all these countries the energy consumption pattern has changed to the fuel substitution, and generally this substitution is towards to their domestic energy sources.

Fetini and Bacon (1999), through the Input-Output table usage, have investigated the effect of energy prices adjustment with the world prices level, on Iran's households welfare and price of other goods by supposing the other production factor's fixed wages and fixed price. Results stated that except the energy related sections, just 8 sections of 43 sections have experienced a price increasing more than 20%, and half of these 8 sections have related to the constructive materials, and have not directly consumed by the households.

Kiyani and ranjbari (2001) studied the long-run relationship among the Iran's energy, labor and capital factors of agriculture sector using the co-integration and Auto-Regressive Distributed Lag (ARDL) models for estimating the Cobb-Douglas form of production function during the years 1967-1999. Results showed that in the agriculture sector, there is a long-run relationship among the production and energy, labor and capital factors. Also, the energy factor's coefficient is positive and meaningful -like the other coefficients- with the considerable effect on the agriculture sector's production.

Abbasi Nejad and Vafi (2004) investigated the energy efficiency and productivity of Iran's economic sectors. They estimated the energy price elasticity of industrial and transportation sectors using TSLS method during the years 1971-2000. Results demonstrated that, the energy consumption index of the tree industrial, agriculture and transportation sections has experienced an increasing trend, and the energy efficiency have had an increasing trend. Also, the energy dotted elasticity index -which shows the percentage changes in energy consumption annual growth per the percentage changes in value added- almost for all years is more than one. In this mean that energy productivity of various economic sectors has experienced a decreasing trend during the studied period.

Arman and Zare (2005) searched the "Granger causality relation" between the Iran's energy consumption amount and the economic growth. Also, using the "Tuda" and "Yamamutu" methods, they studied the Granger causality relation between the Iran's marginal energy consumption and various energy carriers' consumption with the Iran's economic growth during the years 1976-2002. Results indicated that there is the one-side causality from the economic growth to the consumption of natural gas and solid fuels. Therefore it is possible to reduce the energy carriers' consumption without the economic growth reduction.

Although capital and labor have widely been used as the production factors of many countries production function, but there is little body of literatures which has used the energy as a production factor in Iran. This lack is the most motivation of this research.

5- Methodology

Harrod-neutral technical change is a condition that must be placed on production to achieve a steady state. The Cobb-Douglas form is the only form that reduces to Harrod neutrality even when inputs productivity grows over time. So although Cobb-Douglas is a restrictive form, it allows one to envision a number of flexible mechanisms by which technical progress augments growth, in a model consistent with steady state (Cobb and Douglas, 1928). The relation 1 represents the augmented Cobb-Douglas production function consist of labor, capital and energy inputs:

$$Y = \alpha_0 . L^{\alpha_L} . K^{\alpha_K} . E^{\alpha_E} \tag{1}$$

The variables are described as follow:

Y: Value added at current price (milliard Rials).

L: labor in complete employment level (1000 persons).

K: Capital stock at current price (million Rials).

E: Consumed energy including oil products and electricity (million barrels crude oil).

α_L , α_K and α_E : are the production elasticity of labor, capital and energy factor, respectively.

* Due the fact that the current price affects the quantity of value added and capital stock, we consider the *Y* and *K* at current price.

In addition, the logarithmic form of Cobb-Douglas production function is as fallow:

$$\ln Y = \ln \alpha_0 + \alpha_L \ln L + \alpha_K \ln K + \alpha_E \ln E \tag{2}$$

In order to study the long-run and short-run relationship between depended and independent variables of model, usually the cumulative methods like Engel-Granger and Error correction (ECM) are used. But because these methods have disadvantages -such as: limitation in apply, bias in small samples and inability in testing statistical hypothesis- more suitable methods are suggested to analyze the long-run and short-run relationship between variables such as ARDL approach (Pesaran et. all, 1977). In this method, the equality of variables cumulative degree is not essential while in Engel-Granger method, it is necessary (yusefi, 2000). Other advantages of ARDL are the simultaneously estimation of long-run and short-run patterns and removing the resulted problems of variables elimination and autocorrelation. Therefore in this method the estimators are efficient and unbiased because of avoiding some problems like autocorrelation and inter-production (Sidiki, 2000). These priorities encouraged the ARDL method application to this research. The augmented ARDL model is shown as follow:

$$\alpha(L,P)y_t = \alpha_0 + \sum_{i=1}^{k} \beta_i(L,q_i)x_{it} + u_t \quad ; \quad i = 1,2,..., k \tag{3}$$

So that α_0 , y_t and *L* are intercept, dependent variable and lag factor respectively. And *L* is explained as follow:

$$L^j y_t = y_{t-j} \tag{4}$$

Thus:

$$\alpha(L,P) = 1 - \alpha_1 L^1 - ... - \alpha_p L^p \tag{5}$$

$$\beta_i(L,q_i) = \beta_{i0} + \beta_{i1}L + \beta_{i2}L^2 + ... + (\beta_{iqi}L_i^q) \tag{6}$$

Therefore the dynamic ARDL model for production function will be in this form:

$$\ln Y_t = \alpha_0 + \sum_{i=1}^{m} \beta_i \ln Y_{t-1} + \sum_{i=1}^{n} \gamma_i \ln L_{t-1} + \sum_{i=1}^{o} \lambda_i \ln K_{t-1} + \sum_{i=1}^{p} \omega_i \ln E_{t-1} + \gamma_0 \ln L_t + \lambda_0 \ln K_t + \omega_0 \ln E_t + u_{it} \quad (7)$$

So that *m*, *n*, *o* and *p* are numbers of the best lags for the variables lnY_t, lnL_t, lnK_t, and lnE_t respectively.

For estimating the long-run relationships the two-step following method can be used: In the first step; the existence of long-run relation between considered variables will test. So that if the total estimated coefficient related to the dependent variable lags be smaller than one, the dynamic pattern will tend to long-run balance. Thus, for co-integration test, performing the following hypothesis test is essential (Noferesti, 1999):

$$H_0 : \sum_{i=1}^{m} \beta_i - 1 \geq 0$$

$$H_1 : \sum_{i=1}^{m} \beta_i - 1 < 0 \quad (8)$$

And the quantity of *t* statistic for this test is estimated as follow:

$$t = \frac{\sum_{i=1}^{m} \hat{\beta}_i - 1}{\sum_{i=1}^{m} S\hat{\beta}_i} \quad (9)$$

By comparing the calculated *t* statistic with the critical quantity offered by Banejee and Dolado in considered significance level, we can test the existence or non- existence of long-run balance among pattern variables. If the existence of long-run relationship between variables of model will proved, in the second step the estimation and analysis of long-run coefficients and drawing a conclusion about their quantity will be performed. There will be following relations for model variables in long-run relationship:

$$Y_t = Y_{t-1} = ... = Y_{t-m} \ , \ L_t = L_{t-1} = ... = L_{t-n}$$
$$K_t = K_{t-1} = ... = K_{t-n} \ , E_t = E_{t-1} = ... = E_{t-p} \tag{10-13}$$

Therefore the long-run relations can be presented as follow:

$$\ln Y_t = \delta_0 + \delta_L \ln L_t + \delta_K \ln K_t + \delta_E \ln E_t + u_{2t} \tag{14}$$

Also, the existence of co-integration among a set of economic variables provides the application of error correction models (Noferesti, 1999).

So that, the ARDL error correction equation can be written like this:

$$\Delta \ln Y_t = \Delta\alpha_0 + \sum_{i=1}^{m} \hat{\beta}_i \Delta \ln Y_{t-i} + \sum_{i=1}^{n} \hat{\gamma}_i \Delta \ln L_{t-i} + \sum_{i=1}^{o} \hat{\lambda}_i \Delta \ln K_{t-i} + \sum_{i=1}^{p} \hat{\omega}_i \Delta \ln E_{t-i}$$
$$+ \theta ECT_{t-1} + u_{3t} \tag{15}$$

And the error correction term ECT_{t-1} is as follow:

$$ECT_{t-1} = \ln Y_t - \hat{\alpha}_0 - \hat{\beta}_1 \ln L_t - \hat{\gamma}_1 \ln K_t - \hat{\lambda}_1 \ln E_t \tag{16}$$

In relations 15 and 16, Δ is the first order difference factor and $\hat{\beta}_i$, $\hat{\gamma}_i$, $\hat{\lambda}_i$ and $\hat{\omega}_i$ are respectively the estimated coefficients from relation No.6. Also, θ is the coefficient of error correction term which, measures the modify rate. In addition, the number of best lags for each variable can be specified through the Akaike information, Schwarts Bayesian and Hannan-Quinn criterions. In this research, the optimal lag number in short-run coefficients estimation is calculated by the Schwartz-Bayesian criterion which economizes in the lag numbers determining. In addition, the Microfit 4.1 software is applied for the production functions estimation.

6- Results and Discussion

Usually only the two labor and capital factors are used in production function estimation, and the important energy factor is disregarded. In this research, the effect of energy factor on production is considered alike the two other factors. Also, the Iran's agriculture sector and total economy long-run production relations is estimated using the time series data aggregated from the Iran's Statistics center related to Iran's agriculture sector and total economy value added, labor and capital. Table 5 states the results of dynamic estimated ARDL (1,0,0,0) model of Iran's agriculture sector and total economy.

Table5: Results of estimated dynamic ARDL (1,0,0,0) model

	ARDL(1,0,0,0) for the Agriculture sector			ARDL(1,0,0,0) for the Total economy		
Predecessor	**Coefficient**	**S.E**	**t Ratio**	**Coefficient**	**S.E**	**t Ratio**
Ln (Y-1)	1.68	0.12	14	1.65	0.13	12.69
Ln L	0.36	0.15	2.4	0.55	0.21	2.62
Ln K	0.23	0.09	2.56	0.11	0.12	0.92
Ln (K-1)	*	*	*	0.46	0.13	3.54
Ln E	0.32	0.15	2.13	1.17	0.42	2.79
Intercept	22.31	10.5	2.12	2.86	1.17	2.44
R^2=0.99 , D.W =2.38				R^2=0.99 , D.W =1.86		

Source: Research findings

Considering the above table and relation No.9, the calculated *t* statistics of Iran's agriculture sector and the total economy are equal to 5.67 and 5 respectively, which are more than the absolute of offered critical quantity by Banerjee and Dolado 5% significance level (equal to -3.91). Thus we can't reject the existence of long-run relationship among the model variables. Also, the above table shows that, the Iran's agriculture sector long-run production elasticities for the labor, capital, and energy variables are respectively, 0.36, 0.23, and 0.32, and there is a positive and meaningful relationship between the current value added and the last year one of Iran's agriculture sector. Beside, the Iran's total economy long-run production elasticities for labor, last year capital stock and energy variables are respectively 0.55, 0.46, and 1.17 and there is a positive and meaningful relationship between the current value added and the last year one of Iran's total economy. Also, because the process of affect of capital on production is time consuming, the current capital doesn't have the meaningful relationship with the value added of Iran's total economy. The results of estimated long-run coefficients of Iran's agriculture sector and total economy production function has presented in below table.

Table6: Estimated Long-run Coefficients

	Agriculture sector			Total economy		
Predecessor	**Coefficient**	**S.E**	**t Ratio**	**Coefficient**	**S.E**	**t Ratio**
Ln L	0.32	0.13	2.46	7.05	6.97	1.01
Ln K	0.29	0.13	2.23	4.59	2.32	1.98
Ln E	0.23	0.11	2.09	1.47	1.81	0.81
Intercept	-241.73	286.53	-0.84	-36.18	29.39	-1.23

Source: Research findings

Table 6 indicates that, there is a positive and meaningful relationship among the labor, capital, and energy variables and Iran's agriculture sector value added in long-run. Beside, in the long-run, only capital has meaningful relationship with Iran's total economy value added, and other variables have just the positive relationship with Iran's total economy value added. And it states that in long-run labor and energy are substituted with capital stock.

On the other hand, the error correction model engages the short-run fluctuations in their long-run quantities. Table7 illustrates the error correction model of Iran's agriculture sector and total economy production function.

Table7. Error Correction Representation

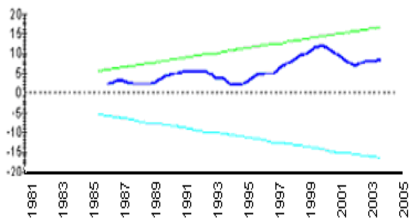
	Agriculture sector			Total economy		
Predecessor	**Coefficient**	**S.E**	**t Ratio**	**Coefficient**	**S.E**	**t Ratio**
dLnL	0.51	0.22	2.32	0.55	2.21	0.25
dLn K	0.32	0.19	1.68	0.11	0.12	0.92
dLn E	0.36	0.09	4.00	1.17	0.42	2.79
dIntercept	22.31	10.5	2.12	2.86	1.17	2.44
ecm(-1)	-0.09	0.04	-2.25	-0.07	0.03	-2.33
	R^2=0.88 , D.W =2.38			R^2=0.86 , D.W =1.82		

Source: Research findings

Notice to the table7 obtained results, in short-run, there is a positive and meaningful relationship between labor and energy variables, and the Iran's agriculture sector value added in 5% significance level. And there is a positive and meaningful relationship between the capital and Iran's agriculture sector value added in 10% significance level. Also, in the short-run, only energy factor and Iran's total economy value added have a positive and meaningful relationship in 5% significance level and other variables have just positive relationship with Iran's total economy value added and it states that in short-run labor and capital are substituted with energy. In addition, for the Iran's agriculture sector and total economy, *ecm(-1)* static is meaningful with the expected negative sign which, it states that respectively, 9% and 7% of dependent variable inequality (Iran's agriculture sector and total economy value added in each year), will be adjust after one period.

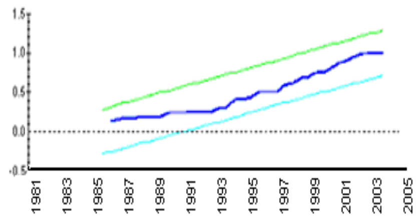
Beside, the stability of estimated coefficients during the studied period has tested by Cumulative sum of recursive residuals (Cusum) and Cumulative sum square of recursive residuals (Cusum Square). Figures 2-5 illustrates the results of these two tests:

Fig2. Plot of Cusum of Iran's agriculture sector



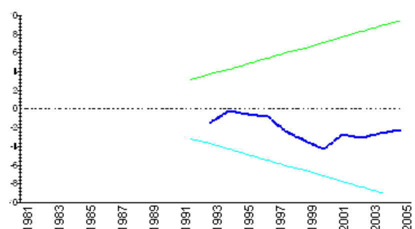
Source: Research findings

Fig3. Plot of Custum Square of Iran's agriculture sector



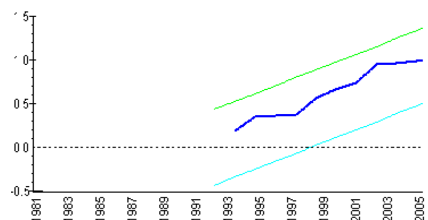
Source: Research findings

Fig5. Plot of Cusum Square of Iran's total economy



Source: Research findings

Fig5. Plot of Cusum Square of Iran's total economy



Source: Research findings

According to above figures, the estimated model coefficients of Iran's agriculture sector and total economy are stable. Because their "Cusum"s and "Cusum Square"s are located between the two up and down straight lines.

* In above figures the straight lines represent critical bounds at 5% significance level.

7- Summary and Conclusions

Although capital and labor have widely been used as the production factors of many countries production function, but there is little body of literatures which has used the energy as a production factor in Iran. This lack was the most motivation of this research. In this study the Cobb-Douglas production function and Auto-Regression Distributed Lag (ARDL) approach were used to estimate the long-run production functions. Results showed that the production elasticities of labor, capital and energy factors of Iran’s agriculture sector are 0.36, 0.23 and 0.32, respectively. Beside, the production elasticities of labor, last year capital and energy factors of Iran’s total economy are 0.55, 0.46 and 1.17, respectively. Thus, undoubtedly we can affirm that the most important production factor of Iran’s total economy and -with the less stress- of Iran’s agriculture sector is energy factor.

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