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The Estimation of Total Factor Productivity of Agricultural Sector in Iran

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Abstract

Agriculture represents that fundamental sector of the world economy that has to supply food for all mankind. Beside, today growing population of world has increased the need for agricultural products and consequently increased the pressure on based resources that is required for those products such as labor and capital. In order to feed the growing population, agricultural production is to be increased. This can be achieved either by increasing the area under cultivation or by increasing total factor productivity (TFP) of agriculture sector. Increasing the total factor productivity (TFP) of agricultural sector is becoming the key issue to feed the increasing population from the limited resources. The purpose of this study is to estimate the TFP growth rate of Iran's agriculture sector using Auto-Regressive distributed Lag (ARDL) approach. Also, in contrast to the conventional agricultural production functions which are just based on labor and capital inputs, in this research we estimate TFP derived from a Cobb- Douglas production function included the energy factor. Results showed that the elasticity of labor, capital and energy variables in Iran's agriculture sector production function is 1.04, 0.16 and 0.70, respectively. Also, the growth rate estimation of TFP indicated that the contribution of TFP growth rate in economic growth rate of Iran's agriculture sector (4.43%) is just 0.33%. Finally, we concluded that TFP of Iran's agriculture sector must be increase in order to satisfy its total economic growth.

Keywords: Total factor productivity, Auto-regressive distributed lag, agriculture, Labor, Capital, Energy.

Introduction

The agricultural products represent the main alimentary source for 6.7 billion people (FAO United Nations, 2009). In addition, results from the empirical studies provide strong evidence indicating that agriculture is an engine of economic growth especially in developing countries (Tiffin, 2006). Therefore agriculture represents that fundamental sector of the world economy that has to supply food for all mankind.

Beside, today growing population of world has increased the need for agricultural products and consequently increased the pressure on based resources that is required for those products such as labor and capital. In order to feed the growing population, agricultural production is to be increased. This can be achieved either by increasing the area under cultivation or by increasing total factor productivity (TFP) of agriculture sector (Tsakok and Gardner, 2007).

Not excepted the other world, agriculture is very important sector in Iran in order that this sector contributed 11 percent of the GDP in 2004 and employed a third of the labor force. In addition benefiting from 123,580 square kilometers of land suitable for agriculture, the agricultural sector is one of the major contributors to Iran’s economy. It accounts for almost 13% of Iran’s GDP, 20% of the employed population, 23% of non-oil exports, 82% of domestically consumed foodstuffs and 90% of raw materials used in the food processing industry (Iran’s Ministry of Agricultural Jihad, 2009). On the other hand, roughly one-third of Iran’s total surface area is suited for farmland, but because of poor soil and lack of adequate water distribution in many areas, most of it is not under cultivation. Only 12% of the total land area is under cultivation but less than one-third of the cultivated area is irrigated; the rest is devoted to dry farming (Iran’s Ministry of Agriculture Jihad, 2009). Therefore, according to the lack of Iran’s cultivatable land, increasing total factor productivity (TFP) of agriculture sector has the key role in order to satisfy the Iranian food security and economic growth.

As the lack of cultivatable land in Iran and consequently the importance of increasing total factor productivity (TFP) of its agriculture sector in order to satisfy the Iranian food security and economic growth, in this research we estimate the total factor productivity (TFP) growth rate of Iran's agriculture sector.

Methodology

B.1. Cob-Douglas Production Function

In order to investigate the total factor productivity (TFP) of agriculture sector, estimating the production function is mandatory. In addition, despite energy is an indispensable input for economic activity, the conventional agricultural production functions are just based on labor and capital inputs and economic growth will be hindered if a stable source of energy is not secured (Tanabe, 2004). Therefore, the approach we use in this study to determine the total factor productivity (TFP) is derived from a Cobb-Douglas production function included the energy factor:

$$Y_t = \alpha_0 . L_t^{\alpha_L} . K_t^{\alpha_K} . E_t^{\alpha_E} \qquad (1)$$

Where Y_t refers to agriculture sector value added in time t (milliard Rials), L_t refers to labor in time t (1000 persons), K_t refers to capital stock in time t (million Rials) and E_t refers to consumed energy in time t (million barrels crude oil equivalent).besideα_L, α_K and α_E are parameters that measure the respective elasticity of capital, labor and energy with respect to output.

B.2. Auto-Regressive Distributed Lag (ARDL) Approach

Recently, the Autoregressive Distributed Lag (ARDL) approach to co-integration and error correction models (ECMs) was proposed by Pesaran, Shin and Smith (2001) as an alternative to Johansen's multivariate co-integration test (Johansen and Juselius, 1990). ARDL approach allows for causal inference based on ECMs and is a very good alternative to conventional ointegration tests because it bypasses the need for potentially biased pre-tests for unit root. The ARDL technique is invariant to mixed orders of integration. Thus, the determination of the existence of long-run relationships does not require that the variables be of the same order of integration (Morley, 2006). These priorities encouraged the ARDL approach to estimate the Cob-Douglas production function. The augmented ARDL model is shown as follow:

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

Whereα_0, y_t and L are intercept, dependent variable and lag factor respectively. And L is explained as follow:

$$L^j y_t = y_{t-j} \qquad (3)$$

Thus:

$$\alpha(L,P) = 1 - \alpha_1 L^1 - \dots - \alpha_p L^p \qquad (4)$$

$$\beta_i(L,q_i) = \beta_{i0} + \beta_{i1}L + \beta_{i2}L^2 + \dots + \left(\beta_{iq} L_i^q\right) \qquad (5)$$

Therefore the dynamic ARDL model for Iran's agriculture sector production function will be in this form:

$$lnY_t = \alpha_0 + \sum_{i=1}^{m} \beta_i \ln Y_{t-i} + \sum_{i=1}^{n} \gamma_i \ln L_{t-i} + \sum_{i=1}^{o} \rho_i \ln K_{t-i} + \sum_{i=1}^{p} \omega_i \ln E_{t-i} + \gamma_0 \ln L_t + \rho_0 \ln k_t + \omega_0 \ln E_t + u_{it} \qquad (6)$$

Where m, n, o and p are numbers of the best lags for the variables ln Y_t, ln L_t, ln K_t, and ln E_t respectively.

For test the existence of long-run relation between variables the sum of estimated coefficients related to lags of dependent variable must be less than one. Thus, for co integration test, performing the following hypothesis test is essential (Greene, 2002):

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

$$H_1 : \sum_{i=1}^{m} \beta_i - 1 < 0 \qquad (7)$$

The quantity of t statistic for co-integration test is as follow:

$$t = \frac{\sum_{i=1}^{m} \hat{\beta}_i - 1}{\sum_{i=1}^{m} s\hat{\beta}_i} \qquad (8)$$

By comparing the above calculated t statistic with the critical quantity offered by Banejee, Dolado and Master (1992) in considered significance level, we can test the existence long-run balance among the variables.

Also, the existence of co-integration among a set of economic variables provides the application of error correction models (Greene, 2002). Therefore, the ARDL error correction equation can be written like this:

$$\Delta lnY_t = \Delta\alpha_0 + \sum_{i=1}^{m}\hat{\beta}_i \Delta \ln Y_{t-i} + \sum_{i=1}^{n}\hat{\gamma}\Delta_i \ln L_{t-i} + \sum_{i=1}^{o}\hat{\rho}_i \Delta \ln K_{t-i} + \sum_{i=1}^{p}\hat{\omega}_i \Delta \ln E_{t-i} + \theta ECT_{t-1} + u_{2t} \quad (9)$$

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

$$ECT_{T-1} = \ln Y_t - \hat{\alpha}_0 - \hat{\beta}_1 \ln L_t - \hat{\gamma}_1 \ln K_t - \hat{\rho}_1 \ln E_t \quad (10)$$

Where Δ is the first order difference factor and $\hat{\beta}_i$, $\hat{\gamma}_i$, $\hat{\rho}_i$ and $\hat{\omega}_i$ are respectively the estimated Coefficients from relation 5. Also is the coefficient of error correction term which measures the modify rate to the long-run.

B.3. Total Factor Productivity

The concept of TFP and the idea that anything else not explained by traditional inputs of production, i.e., land, labor, natural resources and physical capital, falls under TFP, has been discussed in the literature on economic growth from the early 1930s (Griliches, 1995), yet many analysts remain uncertain as to what it really is. Lipsey and Carlaw (2001) summarize the different interpretations of TFP in the literature into the following:

a) TFP as a measure of all improvements in technology and increases in efficiency over long periods of time. This interpretation is what they refer to as the “conventional” view.

b) TFP as a measure of externalities and other free gifts associated with economic growth.

c) TFP as a measure of our ignorance, of what we do not know.

Although Lipsey and Carlaw subscribe more closely to the second interpretation of TFP in view of their study of long-run technological change, they, nonetheless, acknowledge that, “TFP clearly means different things to different informed observers”. Therefore, in this research we estimate the TFP growth rate using the follow equation:

$$\varphi_t = \frac{\partial TFP}{\partial t} = \dot{Y}_t - \left(\frac{\partial Y_t}{\partial L_t}.\frac{L_t}{Y_t}.\dot{L}_t\right) - \left(\frac{\partial Y_t}{\partial K_t}.\frac{K_t}{Y_t}.\dot{K}_t\right) - \left(\frac{\partial Y_t}{\partial E_t}.\frac{E_t}{Y_t}.\dot{E}_t\right)$$
$$= \dot{Y}_t - (\alpha_L.\dot{L}_t) - (\alpha_K.\dot{K}_t) - (\alpha_E.\dot{E}_t) \quad (11)$$

Where $\dot{Y}_t$, $\dot{L}_t$, $\dot{k}_t$ and $\dot{E}_t$ are the growth rate of agriculture sector value added, labor, capital and energy, respectively. Also α_L, $\alpha_k$and α_E are parameters that measure the respective elasticity’s of capital, labor and energy with respect to output and will calculated from estimation of Cob-Douglas production function using ARDL approach .

Results and Discussion

According to the importance of estimation productivity in order to optimum allocation of resources, several researches have been carried out such as: Wu et al. (2001) studied the productivity growth and its components in Chinese agriculture after reforms. They concluded that TFP grew at 2.4% annually with technical change augmenting the growth by 3.8% while efficiency change reduced productivity growth by 1.3%. For all provinces, 288 out of a total of 442 cases experienced productivity growth while the rest showed productivity regression during this post-reform period. Wizarat (2002) worked to compute TFP of the large-scale manufacturing sector of Pakistan for the period 1955-91. She found that for the period under study role of TFP in economic growth of Pakistan remained negative. IMF (2002) estimated TFPG for the period of 1961-2001. It found that TFPG remained negative in 1960s but positive afterwards. Polyzos and Arabatzis (2005) studied the labor productivity of the agricultural sector in Greece. In this research, an effort was made to classify and concisely present the factors that shape labor productivity in the agricultural sector in Greece; these were empirically calculated by using cross-section statistical data, statistical significance and the impact of each factor on the formulation of productivity figures. The results have shown that there is a positive relation between certain factors and productivity, while others appeared statistically insignificant, i.e. of limited significance, and others seemed to negatively affect the level of productivity. Nkamleu et al. (2008) investigates empirical relationships between the rates of growth and total factor productivity growth, physical input accumulation, as well as institutional and agro-ecological change using an international panel data set on 26 African countries and covering the period 1970-2000. The analysis employs the DEA approach to calculate the TFP indices. Their results suggest a positive evolution of the total factor productivity during the study period. The positive

Performance of the productivity of the agricultural sector is due to positive technological progress rather than technology absorption. Majeed et al. (2010), empirically analyses the relationship between Trade Liberalization (TL) and Total Factor Productivity (TFP) growth in large scale manufacturing (LSM) sector of Pakistan during the period 1971-2007. They concluded that the estimated coefficients of openness are negative and statistically significant which implies that the TL policy of the government has not yet brought about any epoch-making economic results 7 particularly for the growth rate of TFP in LSM sector. Ilias et al. (2010) explored the determinants of manufacturing value added in Pakistan. They reported that TFP is the most significant determinant of manufacturing value added in Pakistan both in the short-run and long-run.

Beside in the light of the findings of this study they strongly recommend that the Government of Pakistan should introduce such policies which could enhance the level of TFP and control the price level of investment. This action would help the manufacturing sector of Pakistan to exhibit a sustainable growth. The labor augmenting total factor productivity may be increased through education and training of the labor force working in manufacturing sector.

According to the lack of cultivatable land in Iran and the importance of increasing TFP of Iran's agriculture sector, in this section we estimate the total factor productivity (TFP) growth rate of Iran's agriculture sector.

C.1. Estimation of Iran's agriculture sector production function

Though there is no requirement to run the unit root test in ARDL application for long run and short run relationship, but, we run the test of stationary. The statistics of ADF test showed that LnE is stable at level and LnL, LnK and LnY variables are stable at 1st order of difference.

Also, the optimal length of the distributed lag determined based Schwartz-Bayesian criterion, which economizes in the lag numbers determining. Table1 states the results of dynamic estimated ARDL (1, 0, 0, 0) model of Iran's agriculture sector production function.

Table1. Results of dynamic ARDL (1,0,0,1) model

Repressors	Coefficient	S.E	T-Ratio
C	-6.2144	4.0266	-1.5433
Ln Y_{t-1}	0.3399	0.1530	2.2209**
Ln L	0.7132	0.3316	2.1509**
Ln k	0.1062	0.0356	2.9843***
Ln E	0.2595	0.1093	2.3743**
Ln E_{t-1}	0.2170	0.1303	1.6655*
R^2=0.9889			
Test Statistic		LM Version	
Serial correlation		25.94(0.11)	
Functional Form		8.53 (0.18)	
Heterscedasticity		43.76(0.09)	

* , ** and *** significant at 1%, 5% and 10% level, respectively.

Table1 shows that according to LM version of test statistics, functional form of Iran's agriculture sector production function is acceptable. Also, the existence of serial correlation and heteroscedasticity hypothesizes will be rejected. Beside the calculated t statistics for existence of long-run co-integration between the variables of Iran's agriculture sector production function is equal to -4.4, which according to critical quantity offered by Banerjee, Dolado and Master at 5% significance level (-3.91), the existence of long-run relationship between the variables of model can't be rejected.

Table2 illustrates the results of estimated long-run coefficients of Iran's agriculture sector production function:

Table2. Estimated Long-run Coefficients

Regresses	Coefficient	S.E	T-Ratio
C	-8.543	5.2215	-1.6421
Ln L	1.0395	0.3798	2.737**
Ln k	0.1571	0.0454	3.4581**
Ln E	0.7041	0.0707	9.9601**

Table2 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 we can interpret that 1% increase in labor, capital and energy variables will increase the Iran's agriculture sector value added equal to 1.04%, 0.16% and 0.70%, respectively. On the other hand, error correction model engages the short-run fluctuations in their long-run quantities. Table3 indicates the ECM model of Iran's agriculture sector production function.

Table3. Error Correction Representation

Regresses	Coefficient	S.E	T-Ratio
d C	-6.0751	4.515	-1.3289
d Ln L	0.6981	0.3280	2.128**
d Ln k	0.0.9892	0.3351	2.952***
d Ln E	0.2459	0.1046	2.3501**
ECT (-1)	-0.6402	0.1462	-4.3789***
R^2=0.8501			

According to the above table, in short-run, there is a positive and meaningful relationship between labor, capital and energy variables, and the Iran's agriculture sector value added. In addition, ECT (-1) static is meaningful with the expected negative sign which states that 64% of dependent variable inequality (Iran's agriculture sector value added in each year), will be adjust after one period. Also, the structural stability of estimated coefficients verified using CUSUM test which figure1 illustrates its graphical form:

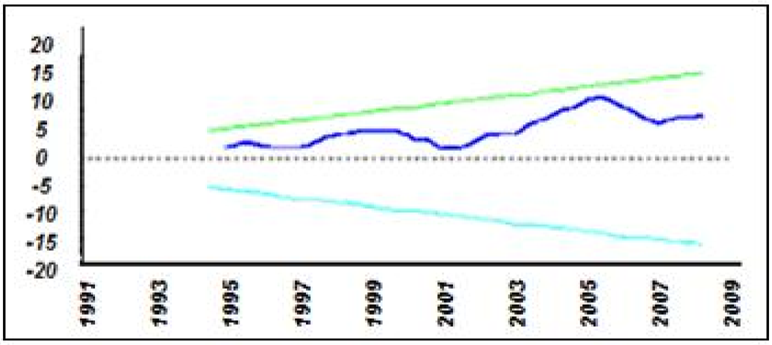

Fig1. Plot of Cusum test of Iran's agriculture sector production function

Estimation TFP growth rate of Iran's agriculture sector

According to elasticity of labor, capital and energy variables (1.04, 0.16 and 0.07) and using equation 11 we estimated the TFP growth rate. Table 4 illustrates the TFP, value added, labor, capital and energy growth rate of Iran's agriculture sector during 1978-2010:

Table4. TFP growth rate of Iran’s agriculture sector

year	TFP growth rate	value added growth rate	labor arowt rate	capital growth rate	Energy growth rate
1978	0.055	0.067	-0.012	0.072	0.019
1979	0.014	0.061	-0.012	0.057	0.072
1980	0.021	0.037	-0.012	0.058	0.027
1981	-0.048	0.019	-0.012	0.052	0.101
1982	-0.041	0.071	-0.012	0.031	0.171
1983	-0.092	0.046	-0.012	0.057	0.201
1984	0.018	0.073	-0.012	0.016	0.093
1985	-0.017	0.079	-0.012	0.02	0.15
1986	0.138	0.048	-0.009	0.012	-0.118
1987	-0.044	0.025	0.002	0.015	0.091
1988	-0.005	-0.006	0.002	0.001	-0.005
1989	-0.034	0.043	0.002	0.011	0.105
1990	0.042	0.11	0.002	0.021	0.089
1991	-0.039	0.056	0.001	0.056	0.121
1992	0.043	0.103	0.011	0.026	0.063
1993	0.023	0.01	0.012	0.025	-0.042
1994	-0.028	0.021	0.018	0.009	0.041
1995	-0.003	0.037	0.049	-0.001	-0.015
1996	0.007	0.033	0.014	0.022	0.011
1997	0.018	0.01	0.008	0.016	-0.027
1998	-0.01	0.099	0.021	0.005	0.122
1999	-0.044	-0.068	0.013	0.057	-0.066
2000	0.03	0.035	-0.018	0.036	0.025
2001	-0.041	-0.023	0.013	0.047	-0.004
2002	0.079	0.136	0.037	0.076	0.009
2003	-0.034	0.05	0.043	0.065	0.041
2004	-0.038	0.003	-0.011	0.332	-0.002
2005	0.062	0.092	0.014	0.099	-0.005
2006	0.007	0.032	0.014	0.077	-0.009
2007	0.019	0.044	0.014	0.07	-0.013
2008	0.018	0.042	0.013	0.072	-0.017
2009	0.018	0.04	0.013	0.065	-0.021
2010	0.017	0.039	0.013	0.061	-0.024

According to the above table the average annual growth rate of TFP of Iran’s agriculture sector during the years between Iran Islamic revolution (1978) and Iran-Iraq war (1990) is very low (=0.53%) and after that it growths annually 0.511% in average. Also, , the average annual growth rate of TFP of Iran’s agriculture sector during the years 1978-2010 is equal to 0.33%. On the other the growth rate of TFP of Iran’ agriculture sector as a measure of externalities and other free gifts associated with economic growth of Iran’s agriculture sector, indicates that the contribution of TFP growth rate in economic growth rate of Iran’s agriculture sector (4.43%) is just 0.33%. Beside, the average annual growth rate of TFP, value added, labor, capital and energy of Iran’s agriculture sector during 1978-2010 are 0.33%, 4.43%, 0.59%, 4.96% and 3.59%, respectively. Consequently, we can conclude that TFP of Iran’s agriculture sector must be increase in order to satisfy its total economic growth and food security.

Also, figure 2 shows the graphical form of TFP growth rate of Iran’s agriculture sector during 1978-2010:

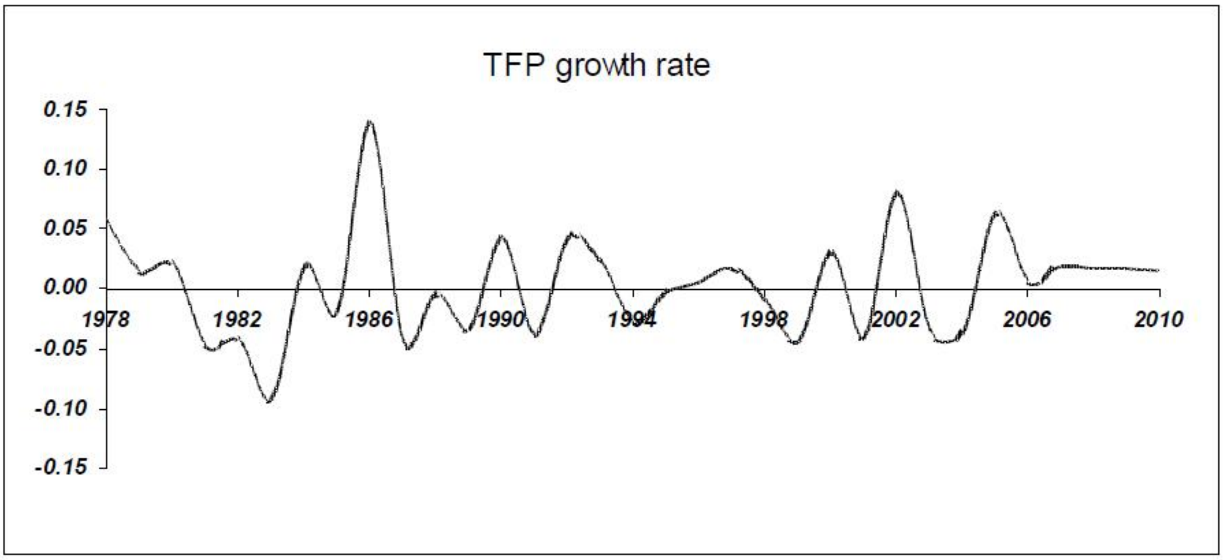

Fig2. TFP growth rate of Iran's agriculture sector during 1978-2010

Conclusion

According to the lack of cultivatable land in Iran and consequently the importance of increasing total factor productivity (TFP) of its agriculture sector in order to satisfy the Iranian food security and economic growth, in this research we estimated the TFP growth rate of Iran's agriculture sector using Auto-Regressive distributed Lag (ARDL) approach. We concluded that 1% increase in labor, capital and energy variables will increase the Iran's agriculture sector value added 1.04%, 0.16% and 0.70%, respectively. Beside, the average annual growth rate of TFP, value added, labor, capital and energy of Iran's agriculture sector during 1978-2010 were 0.33%, 4.43%, 0.59%, 4.96% and 3.59%, respectively which indicated that the contribution of TFP growth rate in economic growth rate of Iran's agriculture sector is just 0.33%. Therefore, agriculture sector policy makers must adopt the programs which increase the TFP of Iran's agriculture sector and consequently satisfy the total economic growth.

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