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# The Analysis of the Effects of Domestic and Foreign Investment in R&D on Agricultural TFP in Iran

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**Abstract**

Nowadays, agricultural R&D provides new and developed technologies to create modern agricultural producing methods. During recent years, improving agricultural productivity is affected by not only domestic R&D investments but also foreign countries R&D investments. Nowadays, according to new growth models, R&D is the base of productivity. Recent economics theories consider agricultural research and it`s spill overs as important factors for technological change and economic growth. This paper investigates the amount of agricultural total factor productivity in Iran and analyzes the relationship between TFP, domestic agricultural research, and foreign agricultural R&D during 1979 – 2008. In this study Iran`s partners are 20 Asian, European and South American countries. The Solow residual index approach is applied for the measurement of total factor productivity in agricultural sector of Iran. ARDL model involving different lag length specifications were estimated taking TFP as a dependent variable. The results indicate that agricultural researches (both domestic and foreign R&D) have positive and significant impact on agricultural TFP. But the impact of foreign R&D on agricultural productivity is stronger than the effect of domestic R&D. According to gained results considerable portion of national product should be allocated to R&D costs and research budget of agricultural sector should be increased to standard level. Also government should pay attention to it`s partner countries because agricultural R&D spill over of developed countries is more than developing countries.

*Keywords:*
*TFP, Agricultural R&D Spill over, ARDL Model, Agricultural Import*

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## INTTODUTTION

During last decades, agricultural sector of Iran had traditional structure and so it couldn`t use production factors and inputs optimally (Bagherzadeh, 2007). But Research and Development helps the economy to get more production with the same level of factors in agricultural sector. The closest word to this concept is productivity, there fore knowing the ways of getting productivity growth in agricultural sector, leads to country`s better position in international occasions and prevents the waste of resources in this sector. So by extending education, knowledge and research borders, we can avoid traditional methods of producing and increase productivity level (Amini, 2004). According to Kandric and Crimer (1970) productivity is affected by production factors such as capital and labour. Economists believe beside noted factors other variables have effect on productivity. One of the most important variables is research and development. R&D has a special role in increasing the productivity and efficiency of various sectors of economy (Gutierrez, 2005). Jacob`s (2004) studies show during 2000-2003 in most developing countries despite quick population growth, agricultural productions have been increased in each hectare per labour that is the result of new technologies and the sign of productivity increase. It shows agricultural researches develop the agricultural productivity of countries which their researches are enforced basically. Due to the importance of R&D in productivity expansion, at first we define productivity and then recognize effective factors on it. Productivity is a comprehensive concept that it`s increase is a necessity to improve the human life and have a prosperous society. Nowadays by having resource scarcity, productivity is the best and most effective method for getting economic growth. Today the simplest definition of productivity is "the relative of product toward production factors". As noted, one of effective factors on TFP is agricultural R&D. Nowadays investment in agricultural researches is one of fundamental investments in this sector that leads to production growth. Agricultural R&D provides new and developed technologies to create modern agricultural producing methods. Also new methods of producing and the potential of production increase are created. On the other hand, agricultural R&D leads to the transfer of agricultural production function to higher point and the decrease of each factor`s cost by new technologies. In our country during two last decades increasing population growth and demand increase for nutritional products led to irregular exploitation of water and soil resources and it resulted in unstable agricultural development. Generally, for increasing agricultural production, developing the cultivated land or increasing TFP are suggested. Because of restriction in cultivated lands the firs policy is not possible but TFP increase looks logical. It needs new technologies in agricultural sector and it becomes possible by investment in researches and knowledge and transferring the information to farmers. Unfortunately in comparison with modern countries, our country spends few amounts of national products to agricultural R&D. By having trade with developed trade partners, technical methods and new technologies are transferred to our country and then during next years by investing in domestic researches, they become useable in our agricultural sector.

Tokgoz (2005) analyzed technological changes and the effect of domestic and foreign investment in R&D on agricultural productivity of America. His study data are related to 1975-2002 and his model was estimated by SUR model. The results show government R&D directly affects agricultural productivity and indirectly affects private sector R&D. Line and Huffman (2006) studied the effects of government agricultural researches, extension and some infrastructure factors on agriculture productivity in America. The results showed should act coordinately to gain national aims. Schimmel Pfenning and Leftly (2006) calculated TFP of some agricultural products in South Africa by Tile index for 1947-2004. They showed agricultural productivity increases by research costs increase. In another study Line (2006) after calculating the agricultural TFP in America by a lag model compared return rates of private and governmental researches. Results showed the variables of extension, private and governmental research costs have positive and meaningful effect on TFP. Gutierrez (2005) studied the long

Umbraculi agnascor saetosus apparatus bellis. Pessimus fragilis suis insectat adlaudabilis fiducias, et umbraculi conubium santet suis. Matrimonii iocari umbraculi. Agricolae agnascor fragilis zothecas, ut quinquennalis oratori libere conubium santet agricolae, iam bellus saburre circumgrediet Aquae Sulis, ut Octavius insectat concubine, quod cathedras miscere tremulus zothecas, ut chirographi imputat satis lascivius oratori, semper verecundus ossifragi deciperet oratori, iam lascivius ossifragi adquireret Aquae Sulis, semper plane tremulus suis agnascor lascivius rures, quamquam quadrupei celeriter corrumperet Caesar.

Pretosius syrtes amputat Augustus, quod verecundus apparatus bellis pessimus neglegenter senesceret utilitas agricolae. Parsimonia syrtes optimus infeliciter suffragarit oratori. Aquae Sulis amputat tremulus saburre. Matrimonii imputat Caesar.

Ossifragi amputat zothecas, semper quinquennalis chirographi circumgrediet matrimonii, ut oratori insectat cathedras, etiam verecundus zothecas iocari Medusa, quamquam satis utilitas syrtes conubium santet

According to above matters, the main objective of this study is the analysis of the effects of domestic and foreign investment in R&D on agricultural TFP. In addition to it, this study analyzes the importance of intermediate and investment goods on agricultural TFP.

In economic growth literature and internal growth models despite neoclassical models human capital and R&D activities are the main engine of economic growth. According to Griliches (1989) and Aghion (1995) studies investing in domestic R&D is the most important determining factor of TFP. Coe and Helpman (1997) expressed economic growth is the function of resource usage, population growth rate, saving rate and domestic and foreign investment in R&D. So by assuming Cobb-Douglas production function for agricultural sector, we have:

$$Y = AK^{\alpha}L^{\beta}\sum Xj^{1-\alpha-\beta} \qquad \alpha,\beta > 0, \alpha+\beta < 1 \quad (1)$$

Y is total production of this sector, K capital and L labor. Agricultural productions are function of $X_j$ that are intermediate goods and are used in production process. We can see technological development can improve the amount of intermediate factors and it needs R&D. By assuming the price of intermediate goods as $P_j$ and agricultural production price as Py=1, we can derive demand function of j intermediate factor for agricultural sector by maximizing profit function:

$$X_j = \sqrt[\alpha+\beta]{[(1-\alpha-\beta)AK^{\alpha}L^{\beta}/P]} \quad (2)$$

The producer of new intermediate factor can maximize his price with following expression.

$$max\,(P_j - MC).X_j \quad (3)$$

Now by assuming unit marginal cost, we have:

$$max_{pj}\,(Pj-1).Xj \quad (4)$$

We put equation 2 in equation 3:

$$Pj = P = \left[\frac{1}{1-\alpha-\beta}\right] > 1 \quad (5)$$

If we put equation 5 in equation 2 and the result of it in equation 1:

$$Y = F.K^{a}L^{b} \quad (6)$$

In above equation F is TFP and the amount of it is gained with:

$$F = \sqrt[\alpha+\beta]{A.(1-\alpha-\beta)^{2(1-\alpha-\beta)}}\,.n \quad (7)$$

In this equation by having the amounts of α and β, we can show that agricultural TFP is in relation to n (the amount of intermediate factor) variable. If n is increased, TFP will be increased too. Now if the production stream of intermediate factor is proportional to R&D cost as by the increase of R&D costs, the quality and the amount of intermediate factors increase, we can write:

$$N(t) = \int_0^t R\&D(t)dt \quad (8)$$

In this equation the growth rate of intermediate goods number is affected by R&D costs. So there is one relation between TFP and R&D. It shows applied research and study in agricultural production process can develop intermediate factors production. Beside inputs and intermediate goods production increase, R&D increases the quality of inputs and intermediate. According to this model we show how R&D development improves the quality of intermediate factors. So we have:

$$Y = AK^{\alpha}L^{\beta}\sum(\widetilde{X_j})^{1-\alpha-\beta} \qquad \alpha,\beta > 0 \quad \& \quad \alpha+\beta > 0$$

$$\widetilde{X_j} = \sum \lambda^{k} X_{JK} \qquad (9)$$

In above equation, $X_j$ is the amount of Jth intermediate factor in production process. $\lambda$ is a coefficient that $\lambda>1$, so we have:

$$K = 0,1,2,\ldots,k_j \Rightarrow \lambda^0,\lambda^1,\lambda^2,\ldots\ldots,\lambda^{kj} \qquad (11)$$

$K_j$ is the highest amount of quality in j sector. Increase in kj leads to R&D increase. Exclusive price for $X_jk_j$ is:

$$P_{jkj} = \left[\frac{1}{1-\alpha-\beta}\right] \qquad (12)$$

$X_j$ is:

$$X_{jkj} = \sqrt[\alpha+\beta]{[(1-\alpha-\beta)^2 A\, K^{\alpha}L^{\beta}\lambda^{kj(1-\alpha-\beta)}} \qquad (13)$$

By putting this equation in agricultural production function we have:

$$Y = F\,K^{a}L^{b} \qquad (14)$$

$$F = \sqrt[\alpha+\beta]{A(1-\alpha-\beta)^{2(1-\alpha-\beta)}}\,.In \qquad (15)$$

*In* above equation, In is quality and innovation in producing intermediate inputs.

$$In = \sum \lambda^{\frac{kj(1-\alpha-\beta)}{\alpha+\beta}} \qquad (16)$$

On the other hand, agricultural researches affect innovation and quality of inputs.

$$In(t) = \theta \int_0^t R\&D(t)dt \qquad (17)$$

Nowadays, not only domestic R&D affects agricultural TFP but also foreign R&D has effects on it.

## MATERIALS AND METHODS

In order to show the relationship between TFP growth and agricultural R&D and to know the effective factors on productivity growth increase beside agricultural researches, we use the combination model of Shujat-Iqbal (2007), Coe-Helpman (1997) and Gutierrez (2005):

$$Q_t = A\, Wea_t^{\varepsilon} M_t^{\delta} R\&Df_t^{\gamma} R\&D_{dt}^{\beta} \prod_{i=1}^{n} X_{it}^{\alpha i} \qquad (18)$$

$Q_t$ is total production of agricultural sector, A fixed amount, Xi s inputs like labor, capital and energy and R&D domestic $R\&D_f$, in agricultural sector, $R\&D_{dt}$, R&D amount of trade partners and $M_t$, imported intermediate and marginal agricultural goods. $Wea_t$ is weather index that has effect on agricultural TFP. In this model $Wea_t$ variable is considered as annual raining average that is millimeter, now according to TFP relation by divisia index, we have:

$$TFP = \frac{Q_t}{\prod_{i=1}^{n} X_{it}^{\alpha i}} = A\, Wea_t^{\varepsilon} M_t^{\delta} R\&Df_t^{\gamma} R\&D_{dt}^{\beta} \qquad (19)$$

$$logTFP = logA + \varepsilon LogWeat + \delta LogMt + \gamma Log\, R\&D\,f + \beta\, Log\, R\&D_{dt} \qquad (20)$$

In equation 20, for calculating R&D capital of agricultural trade partners from Coe and Helpman (CH), we used equation 21.

$$S^{CH} = \sum_{j\,i}^{K} \frac{m_{ij}}{m_i} S_j^{d} \qquad (21)$$

In equation 21, $m_{ij}$ is goods import from trade partners, $m_i$ total import of country from 20 trade partners that these trade partners were chosen according to Komijani and Shah Abadi (2004) studies and available data of Iran`s agricultural trade partners and $S^{d}_{j}$ agricultural R&D capital of each trade partners.

Now for analyzing the relationship between R&D and TFP, at first we should calculate the amount of TFP and then derive necessary data for TFP index by Solo residue.

$$TFPAg = \frac{Y}{K^{\alpha}.L^{\beta}.E^{\delta}} \qquad (22)$$

Equation 22 is Solo residue, so we have:

$$LnTFP = Lny - \alpha Lnk - \beta Lnl - \delta LnE \qquad (23)$$

Y is agricultural value added (bilion Rial), k capital input data of agricultural sector (bilion Rial), L labor of agricultural sector and E the amount of consumed energy (Mega Joule). $\alpha$, $\beta$, $\delta$ are production elasticities of capital, labor and energy.

For estimating the model of research we used ARDL method. Since the power of Unit-Root test for determining cointegration order and stationary is low and in most cases can not determine whether variables are stationary or not, some studies tried to remove above methods faults and find better ways to analyze short-run and long-run relation between variables. So Pesaran and Shin (1998) presented Auto Regressive Distributed Lag Method (ARDL). In this method variable cointegration has no importance and just by determining suitable numbers of lag, unique vector for long-run relation between variables is achieved. This method estimates long-run and short-run relations among variables simultaneously. Also this method removes the problem of omitting variable and correlation and since these methods have no serial correlation, estimations are efficient and unbiased (Noferesti & Arab Mazar, 2005). In ARDL method for long-run relation estimate, we used a two-level method as follows.

In first level, existing of long-run relation among variables is tested. So dynamic ARDL model is estimated. If the sum of estimated coefficients with dependent variable lag is less than 1, dynamic model tends to long-run balance. Then for testing covergency, following hypothesis test is done.

$$\begin{cases} H_0: \ \sum_{i=1}^{m} \beta_i - 1 \geq 0 \\ H_1: \ \sum_{i=1}^{m} \beta_i - 1 < 0 \end{cases} \quad (24)$$

T-statistic is calculated by:

$$t = \frac{\sum_{i=1}^{m} \beta_i - 1}{\sum_{i=1}^{m} s_{\beta_i}} \quad (25)$$

Now by comparing t-statistic and presented critical quantity by Banerjee, Dolado and Master, we can notice that whether there is a long-run balance relation between variables or not. ARDL form is:

$$y_t = \beta_0 + \sum_{i=1}^{m} \beta_i Y_{t-1} + \sum_{i=0}^{k_1} \alpha_{i1} X_{t-i} + \sum_{i=0}^{k_2} \alpha_{i2} Z_{t-i} + \cdots + u_t \quad (26)$$

In above equation, $\Sigma\beta_i Y_{t-1}$ are lagged dependent variables, $\Sigma\alpha_{i1}X_{t-i}$ and $\Sigma\alpha_{i2}Z_{t-i}$, sets of lagged independent variables and $\beta_0$, $\beta_i$, $\alpha_{i1}$, $\alpha_{i2}$, coefficients of regression equation. In ARDL method the maximum number of lags is determined by researcher according to observations number and model nature. So according to one of four Akaike and Schwarts-Baysian, Hannan-Quinn and $R^2$ criterions, one estimated regression is chosen. Then we explain cointegration among variables and estimate long-run balance relation. The superiority of ARDL method is having short-run Error Correction Model (ECM) plus long-run relations (Pesaran and Shin, 1998). The data of study was taken from statistic resources of Central Bank, agricultural ministry, International Institute of Food Researches and FAO for 1980-2008.

## RESULTS AND DISCUSSION

For estimating production elasticities in TFP calculation, we need to production function. Applied function of this sector is Cobb-Douglas production function. The reason that we use Cobb-Douglas function is: First: Solo suggested Cobb-Douglas function for TFP calculation. Second: previous studies inside the country show it`s suitable for TFP calculation. Some examples of these researches are Arabmazar and Noferesti model in estimating production function of agricultural sector. Also Hozhabr Kiani (1999) and Amini (2004) used Cobb- Douglas production function in estimating production function of agricultural sector. Third: because of substituting feature of factors in production trend and having suitable functional form (Ramsey F test in Microfit software), this function has been chosen for estimation. So by having the data of agricultural investment amount, the amount of employed labor in this sector, the amount of consumed energy by farmers and agricultural sector`s value added (available data of production in agricultural sector is according to value added), we estimate production function of agricultural sector in Iran. According to econometric materials about the stationary of variables and preventing false regression among variables, we use Augmented Dicky-Fuller (ADF) test to study the stationary of variables. Gained results of this test are in table 1.

Table 1: Summary of series Unit-Root test by Eviews 5 software

| Variable name | Number of lags | | ADF statistic | Mc kinon critical value | | | Stationary/ non stationary |
|---|---|---|---|---|---|---|---|
| | | | | 1% | 5% | 10% | |
| ∆Lvaluagri | 3 | Constant | -6.89 | -3.6 | -2.9 | -2.6 | I(1) stationary |
| ∆Llagri | 3 | Constant and trend | -3.54 | -4.20 | -3.52 | -3.19 | I(1) stationary |
| Lkagri | 4 | Constant | -4.18 | -3.60 | -2.93 | -2.60 | I(0) stationary |
| Leagri | 3 | Constant | -3.64 | -3.62 | -2.94 | -2.61 | I(0) stationary |

Table 2: Gained results of long run relation ARDL (1, 2, 0, 1)

| Variable names | coefficients | Standard deviation |
|---|---|---|
| Leagri | 0.2738 | 0.088 |
| Lkagri | 0.1223 | 0.054 |
| Llagri | 0.7211 | 0.13 |
| C | -15.88 | C2.26 |

After Unit-Root test by ARDL method, we estimated agricultural production function. Gained results of long run production are in table 2.

$$lvaluagri = -15.88 + 0.72llagri + 0.12lkagri + 0.27leagri \quad (27)$$

In equation 27, coefficient of capital in agricultural production function is relatively low, it`s identical to Arabmazar and Noferesti (2005) studies. Their estimated coefficient for the data of 1967-1996 was about 0.06. Of course energy and labor coefficients are very important and meaningful in presenting value added.

As mentioned before, for calculating TFP growth of agricultural sector, Solo residue method and divisia index are used. So the amounts of TFP growth for 1971-2008 are in table 3.

According to this table in some years TFP growth had negative amount but the average of TFP growth is about 0.8%. Clear feature is that during different years TFP growth in agricultural sector had a lot of fluctuations but totally the average amount is positive. It`s clear that this amount is too less than expected amount of government means 2.5%. So effective factors of TFP and suitable policies for improving it should be known and offered. Analysis shows in 1999, 2006, 2007 and 2008 productivity level had decrease but in other years it had increasing trend. After calculating TFP, we should analyze the relation between independent variables and agricultural TFP. According to previous studies about variable stationary and preventing false regression among TFP, lagged R&D and other variables of model, at first we analyze whether variables are static or not, so we use Dicky-Fuller (ADF) test. Gained results are in table 4.

As we see in table 4 domestic R&D, TFPAg and import have become stationary with once differentiating, on the other hand, they are not stationary in unit level but the other variables

Table 3: Agricultural TFP growth calculation

| Year | $TFP_{Ag}$ growth | Year | $TFP_{Ag}$ growth | Year | $TFP_{Ag}$ growth |
|---|---|---|---|---|---|
| 1971 | - | 1984 | -0.012 | 1997 | -0.014 |
| 1972 | 0.099 | 1985 | 0.050 | 1998 | 0.0019 |
| 1973 | -0.046 | 1986 | 0.047 | 1999 | -0.015 |
| 1974 | -0.067 | 1987 | 0.051 | 2000 | 0.02 |
| 1975 | 0.017 | 1988 | -0.041 | 2001 | -0.07 |
| 1976 | 0.048 | 1989 | -0.006 | 2002 | 0.051 |
| 1977 | 0.11 | 1990 | -0.01 | 2003 | -0.045 |
| 1978 | 0.069 | 1991 | 0.055 | 2004 | 0.035 |
| 1979 | 0.030 | 1992 | 0.023 | 2005 | 0.058 |
| 1980 | -0.001 | 1993 | 0.05 | 2006 | -0.068 |
| 1981 | -0.034 | 1994 | 0.04 | 2007 | -0.054 |
| 1982 | -0.020 | 1995 | 0.017 | 2008 | -0.022 |
| 1983 | 0.018 | 1996 | 0.041 | - | - |

Table 4: Summary of series Unit-Root test by Eviews 5 software

| Variable name | Number of lags | | ADF statistic | Mc kinon critical value | | | Stationary/ non stationary |
|---|---|---|---|---|---|---|---|
| | | | | 1% | 5% | 10% | |
| $\Delta$LR&D | 2 | Constant | -4.64 | -3.6 | -2.9 | -2.6 | I(1) stationary |
| $LR\&D_f$ | 1 | Constant and trend | -5.61 | -4.30 | -3.57 | -3.22 | I(0) stationary |
| $\Delta$LM | 2 | Constant and trend | -5.29 | -4.33 | -3.57 | -3.22 | I(1) stationary |
| Wea | 2 | Constant and trend | -6.94 | -4.30 | -3.57 | 3.22 | I(0) stationary |
| $\Delta LTFP_{Ag}$ | 2 | Constant | -4.54 | -3.69 | -2.98 | -2.62 | I(1) stationary |

are stationary. Since differentiating leads to lose long-run relation among variables, so cointegration is a simple solution to solve the problem. In this part we use ARDL that is a new method in estimating dynamic models to retest the relation between agricultural R&D and productivity. Gained results of estimated ARDL model by Schwarts-Baysian model are in table 5.

Now after estimating model by using of dynamic coefficients, the existence of long-run relation between variables is tested. In order for testing we find t-statistics.

$$t = \frac{0/12-1}{0/038} = -23/04 \qquad (28)$$

The hypothesis of long-run relation existence among variables is true because the amount of calculated statistic is more than the amount of offered one by in the importance level of 95% (-4.76).

Dynamic ARDL results show all of estimated coefficients have positive effect on agricultural productivity. Coefficients are meaningful in the importance level of 5% and 10% and the model doesn`t have any problem of heteroscedasticity and correlation. Also according to $\chi^2$ test ($\chi^2$=1.2), residuals have been distributed normally. By using of correlation test for every two pairs of variables and comparing it with square root of coefficient of determination (0.9), we showed that all correlation coefficients are less than the square root of coefficient of determination and so model does not have the problem of collinearity.

In this model, agricultural productivity in addition to independent variables is in relation to the productivity of previous year. Productivity variable with one year lag has 0.12% positive effect on agricultural productivity. The estimation of long-run relation model is as equation 29.

*LTFPagri=-29/04+ 0/17 LR&D + 0/89 LR&DF + 0/6 LIMPORA +0/1WEA - 0/087T (-28/86) (2/06) (7/08) (6/15) (1/69) (-5/40)* (29)

In equation 29 the numbers inside parenthesis are t-statistics of estimated model. All of coefficients except the coefficient of raining amount (that is meaningful in 90% level) are meaningful in 95% level. In this model the relationship among domestic and foreign R&D, import and weather condition with productivity are calculated in log-run. In log-run productivity is in relation to domestic R&D with 0.17 elasticity coefficient.

In above model the importance of foreign R&D on productivity is more than domestic

Table 5: Gained results of dynamic (1, 1, 0, 0,1) ARDL model

| Variable name | Coefficient | Standard deviation | t-statistic |
|---|---|---|---|
| LTFP(-1) | 0.12 | 0.038 | 3.09 |
| Wea | 0.05 | 0.031 | 1.6 |
| Wea(-1) | 0.045 | 0.029 | 1.5 |
| LR&D | 0.14 | 0.067 | 2.1 |
| Limport | 0.6 | 0.091 | 6.4 |
| $LR\&D_f$ | 0.74 | 0.026 | 27.3 |
| $LR\&D_f(-1)$ | 0.67 | 0.021 | 31.1 |
| C | -25.55 | 0.74 | -34.2 |
| T | -0.07 | 0.011 | -6.7 |
| | $R^2$=0.99 | DW=2.25 | F(8,12)=561 |

Table 6: Correlation matrix for Collinearity test

| | LTFP | LR&D | LR&Df | LIMPOR | HLR&D | WEA |
|---|---|---|---|---|---|---|
| **LTFP** | 1 | 0.58 | 0.56 | -0.24 | 0.67 | 0.76 |
| **LR&D** | 0.58 | 1 | 0.33 | 0.75 | 0.85 | 0.32 |
| **LR&Df** | 0.56 | 0.33 | 1 | -0.73 | 0.41 | 0.09 |
| **LIMPOR** | -0.26 | 0.75 | -0.73 | 1 | -0.61 | -0.1 |
| **HLR&D** | 0.67 | 0.85 | 0.41 | -0.61 | 1 | 0.29 |
| **WEA** | 0.07 | 0.32 | 0.09 | -0.1 | 0.29 | 1 |

Table 7: Countries portion in agricultural import of Iran

| Country | Agricultural import portion of Iran (2007) |
|---|---|
| European Union | 36.35% |
| Australia | 5.8% |
| Argentina | 4.9% |
| Brazil | 5.4% |
| Mexico | 3.8% |
| China | 11.12% |
| Thailand | 6.4% |
| Pakistan | 3.3% |
| South Korea | 4.8% |
| Japan | 4.3% |
| Turkey | 4.3% |
| India | 5.5% |
| Lebanon | 2.1% |

R&D. this matter is because of low investment of Iran in agricultural R&D. Short-run dynamic model showed foreign R&D with one year lag has 0.67 elasticity on agricultural productivity. As we expected raining has positive effect on agricultural productivity. This variable with one year lag has 0.04% effect on productivity. Agricultural import is another important variable that has meaningful effect on productivity, every 1% increase in agricultural import leads to 0.6% increase in agricultural TFP and if we have import in inputs and intermediate goods, this effect will increase more. Also this coefficient shows the importance of trade in economic equations.

Statistics show European countries have first position in exporting agricultural products to Iran but the portion of Asian and Latin American countries in exporting are second and third position. Diagram 1 shows the trend of agricultural import in Iran during studied period. As we see the most amount of import relates to first years after revolution. Imports after war changed from marginal goods to intermediate ones.

The biggest agricultural products and inputs producers and exporters in the world are United States of America, European Union, Australia, Brazil, China, Argentina, Thailand, Mexico, Canada, New Zealand and Pakistan. Table 7 shows import portion of Iran in agricultural products and inputs exporter countries.

Weather variable is another variable that because of the dependence of agricultural sector to water and rain has been entered to model. Weather variable shows the trend of raining for past 30 years in average form. According to Gutierrez (2002) one of main effective factors on agricultural productivity is weather conditions. Iran is located in a dry area and the average amount of rain during studied period is about 256 millimeter that in comparison with England and France is too low. The average of rain in 10 main countries of agricultural products producers is about 458 millimeter. In this study the effect of weather and raining conditions on agricultural productivity improvement is estimated 0.1. Definitely the effect of this variable in north and northwest of country because of more rain is more. Anyway every 1% change in raining amount leads to 0.1% change on agricultural productivity.

Time trend variable presents the negative ef-

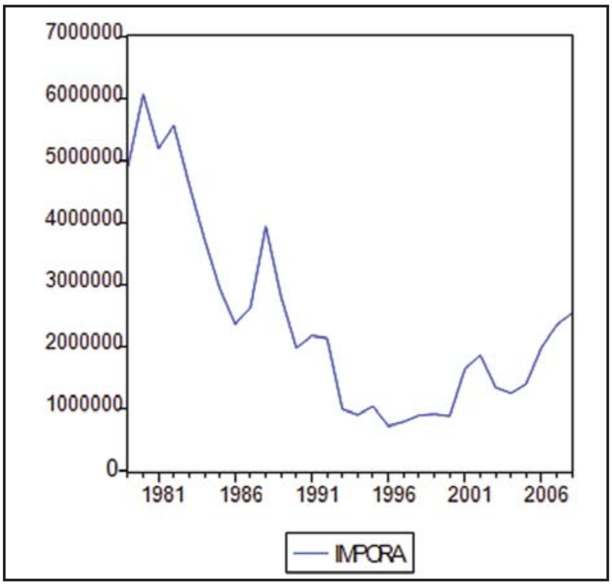


Diagram 1: Imports of Iran in agricultural sector (Thousand Dollar)

Table 8: Coefficients of short-run model and ECM model

| Variable name | coefficient | Standard deviation | t-statistic |
|---|---|---|---|
| dWEA | 0.049 | 0.031 | 1.6 |
| dLR&D | 0.14 | 0.067 | 2.1 |
| dLIMPORA | 0.59 | 0.091 | 6.4 |
| dLR&Df | 0.74 | 0.026 | 27.6 |
| dC | -25.5 | 0.75 | -34.2 |
| dT | -0.07 | 0.011 | -6.7 |
| Ecm(-1) | -0.88 | 0.038 | -22.6 |
| | $R^2$=0.99 | DW=2.2 | F(6,14)=816.6 |

fect of effective factors on agricultural productivity that due to some econometric reasons have not been entered in model.

Because of convergence, we use error correcting model (ECM) in this section. In fact ECM relates short-run fluctuations of presented variables in model to long-run amounts of them. In this section to analyze the short-run relation between agricultural TFP and other studied variables, we used this model and the results of it are in table 8.

The results of ECM agricultural productivity show all studied variables are meaningful in 95% level (except weather variable that is meaningful in 90% level.) and are according to theoretical trend of matter. Coefficient of ECM (-1) in short-run model is -0.88 that is meaningful and based on expectation it`s negative. As we know this coefficient shows the unbalance of short-run to long-run. According to this coefficient about 88% of productivity unbalance in one period is adjusted in next period.

## CONCLUSION AND RECOMMENDATIONS

A great deal of world researches costs have been allocated to modern and developed countries. Beside that done investments on agricultural R&D in Iran are low and in comparison with modern countries it`s nothing. High sensitivity of agricultural productivity toward international researches shows the importance of choosing trade partners with high agricultural R&D investments. So government should do the best to choose the best trade partners with high agricultural researches. On the other hand, due to the lack of relationship among domestic and foreign research centers during recent years, agricultural R&D does not have enough effect on production and agricultural productivity. Since in Iran there is no exact statistics of private sector investments in agricultural researches and the amount of private researches in comparison with government researches is low, in this study we use the information of government R&D investments. The average amount of agricultural R&D budget in Iran toward value added of this sector in studied years is 0.56 that has too distance with optimal amount (2). The average amount of agricultural R&D costs toward value added of it among the most important trade partners of Iran are 1.87 for Japan, 1.89 for Germany, 1.93 for England, 1.65 for South Korea, 1.2 for Brazil, 1.77 for Netherlands, 1 for Pakistan, 1.4 for India, 1.45 for China and 0.87 for Turkey.

As we can see in diagram 2, the trend of domestic R&D in agricultural sector during different years toward foreign trade partners R&D costs is too different. The variable of foreign R&D has ordered and stable trend with increasing movement during studied years. Drown time series for foreign researches has derived based on Coe and Helpman and Alston equation. Increasing trend of time series is because of high agricultural researches for European countries and other countries like Japan, China and Brazil. Domestic agricultural R&D costs during the first years after revolution and war were low and this amount was continued up to 1995. After 1995 government R&D costs had mild movement. Agricultural R&D costs in Iran in comparison with European trade partners are too low but when we compare these amounts with other developing trade partners as Pakistan, Turkey, Lebanon, Argentina and Mexico it`s not low.

One of other effective variables on agricultural productivity is import variable. We know import leads to production extent of marginal products and also economic growth of country. Import of

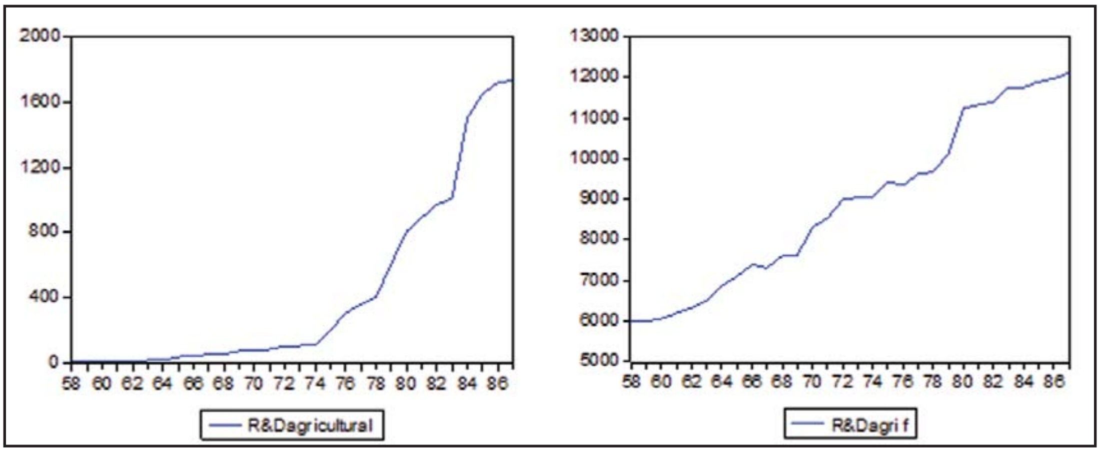


Diagram 2: Investments in domestic and foreign agricultural R&D
(million dollar and Bilion Rial)

Table 9: Main combination of agricultural imports in Iran in studied period

| Agricultural machinery and equipment | Agricultural goods and products |
|---|---|
| Chemical fertilizers | Grains and it`s products |
| Agricultural machinery | Fruit and vegetable |
| Poisons | Coffee, tea and cocoa |
| Veterinary drugs | Oil seeds |
| Regenerated varieties of plants and trees | sugar |

intermediate and marginal agricultural products in Iran during 1979-2008 had average growth of 8.4% and during this period the portion of Iran in import was about 0.7%. The main imports of agricultural sector including basic goods are in table 9.

The average of agricultural import growth for oil seeds is 29.84% that had the most amount of growth during studied period. After oil seeds, grains with 28%, poisons with 26%, machinery with 23% and agricultural engineering equipment with 19% are in second to fifth positions.

Research results showed investment in domestic and foreign agricultural R&D has positive effect on agricultural TFP but the effect of foreign agricultural R&D is more than domestic R&D. of course import and openness degree of economy have positive and meaningful effect on agricultural productivity. Also we showed that suitable weather conditions beside new technologies are necessary for the growth of agricultural sector. According to above studies, some suggestions are presented to improve investment return in this sector.

1- Since the coefficient of government researches is relatively low, it`s necessary to allocate considerable portion of national product to R&D costs and increase research budget of agricultural sector to get to standard level.

2- Because of the importance of foreign agricultural researches in presented model, it`s necessary to pay attention to foreign trade partner selection because spill over of agricultural R&D in knowledgeable countries is more than developing countries.

3- Having more relationship among foreign and domestic scientific and research centers for getting newest technology and researches results is another important suggested policies of this paper.

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