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Production Technology in the Iranian Agricultural Sector

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Abstract: The objective of this study is to examine the contribution of technological change in the agricultural production of Iran. Several production function models were estimated using data from 1966/67 to 2000/01 to describe the production technology situation. The Translog production function was selected based on the ability to predict technological term. The results suggest that the production situation in the Iranian agriculture did not have a well-behaved production technology in 1980/81 to 1996/97, since the marginal product of labor was negative. Capital and land have become scare resources and gradually a binding constraint in the production. The estimated value of the technical change indicated a technical progress during the period of study. The result of the Pure Technical Change (PTC) has increased over time, although the Non-Neutral Technical Change (NNTC) was declining. The overall results suggest that policy makers should reduce the labor force in the agricultural sector and improve the capital-intensive methods in order to simultaneously increase the output and productivity in this sector and in the rural areas.

Key words: Technological change · Production functions · Return to scale · Marginal product · Agricultural labor

INTRODUCTION

Agriculture plays an important role in the Iranian economy. In 2003, it contributed 15 percent to the total gross domestic products and provided 23 percent of total employment [1, 2]. One of the main issues in the agricultural sector is the low labor productivity and the negative effect of labor on the production process [3-5]. Over-employment in the agricultural sector and its resultant diminishing return, along with an inappropriate combination of other production factors, has made a serious problem for the rate of output in recent years.

The trend of technical change was also found to be slow over time. The technological change has noteworthy effects on the quality and quantity of total production in the agricultural sector. This study therefore attempts to analyze technological change and its contribution to the production process of the Iranian agriculture.

MATERIALS AND METHODS

A production function can be expressed in many different mathematical forms. The production function prescribes a mathematical relationship between output and inputs. In its most general mathematical form, a production function can be expressed as:

$$Q = f(X_1, X_2, X_3,..., X_n) \quad (1)$$

Where, Q is equal to quantity of output and X_1, X_2, X_3... X_n are factors of production such as capital, labor, land or management. In this study, the production functions with the incorporation of technological term are specified in three functional forms. They are Cobb-Douglas, Transcendental and Translog.

The Cobb-Douglas (CD) production function is widely used to represent the relationship of an output to inputs. This major breakthrough in economics was originally proposed by Knut Wicksell and tested statistically by Douglas [6]. This study were influenced by the statistical evidence, which appeared to show that the labor and capital shares of the total output were constant over time in the developed countries. The CD production function can be expressed as:

$$Q = a X_1^{\beta_1} X_2^{\beta_2} .... X_n^{\beta_n} e^{\beta_t T} \quad (2)$$

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Where, Q is output, X1 to X_n are inputs, α and β's are estimated parameters. The time (T) is added to the function based on Solow approach to represent the technological change [7].

The second functional form that was applied in this study is transcendental production function [8]. For a Transcendental function, it is possible that the marginal products rise before they eventually fall. This function also permits a variable elasticity of production and variable elasticity of substitution over the range of input [9]. Therefore, it can be expressed as:

$$Q = aX_1^{\beta_1}...X_n^{\beta_n}e^{(d_1TX_1+.....+d_nTX_n)} \quad (3)$$

Where α and β's defined before and δ's are coefficients for technological term based on Solow approach [7]. The Transcendental function considers technological change as multiplicative relationships between time and inputs. The Equation (3) reduces to CD if δ_1 to δ_n vanish.

The third functional form is Translog production function [10-12]. In general the function can be expressed as:

$$Ln(Q) = a + \sum_{i=1}^{n}\beta_i LnX_i + \beta_t T + (1/2)[\sum_{i=1}^{n}d_{ii}(LnX_i)^2 + \beta_{tt}(T)^2] + \sum_{i=1}^{n}\sum_{j=2}^{n}d_{ij}((LnX_i)*(LnX_j)) + \sum_{i=1}^{n}d_{it}(LnX_i)*T \quad (i^1j) \quad (4)$$

Where; Q is output, X_1 to X_n are inputs, α, β's and δ's are estimated parameters. The Translog function is obtained by expanding the Taylor's series and omitting the term up from the third order to n^{th} order (i.e., expanding the Taylor series only up to the second order while there is a truncation error) [10, 11]. The Translog function does not impose any pre-specified restriction on the elasticity of the substitution among production factors. For example, while the CES function assumes constant return to scale, the Translog function has Variable Return to Scale (VRTS). The general form of the Translog function is flexible and it is possible to derive a variety of functional forms such as Homothetic, CD and Homogenous, with respect to the production form [13]. The Translog production function considers technological change as direct, square and interaction between inputs and time in the production function.

RESULTS AND DISCUSSION

The data from 1966/67 to 2000/01 were collected to estimate the three functional forms were obtained from the Statistical Center of Iran (SCI) and Management and Planning Organization of Iran (MPOI). The variables in the estimated equations were agricultural value added (total production), aggregate capital stock, both of which were converted into constant thousands Rial (1997=100), agricultural labor (thousands people), irrigated land and non-irrigated land (thousands hectare).

The first step of the analysis of this study is to check for the stationary test for all the economic variables involved in the econometric estimations. The unit root test is vital for the co-integration and causality test [14,15]. The stationary test carried out to avoid any spurious regressions in current study, examined by the use of the standard Augmented Dicky Fuller and Philips-Perron tests [16-18]. Based on the results of unit root test, not any problems had been reported. Hence, we can use the results derived from the models without any doubt on the spurious regression.

The CD and Transcendental were estimated by Least Square method. The Translog functional form with three share equation was estimated using Iterative Seemingly Unrelated Regression (ISUR). The three estimated equations are expressed as follows:

Cobb-Douglas

$$Ln(Q) = 14.60 + 0.06LnC - 0.77LnL + 0.050LnIRL - 0.053LnNIRL + 0.043T$$
(7.29***) (1.86*) (-3.76***) (0.59) (-0.81) (16.2***)

$R^2 = 0.99$, Adj-$R^2 = 0.99$

Trancendental

$$Ln(Q) = 22.60 + 0.21LnC - 1.35LnL - 0.30LnIRL - 0.26LnNIRL$$
(8.27***) (4.01***) (-5.16***) (-1.51) (-1.66)

$$-(4.20E\text{-}7)(C*T) + (9.16E\text{-}6)(L*T) + (2.88E\text{-}06)(IRL*T) + (1.13E\text{-}06)(NIRL*T)$$
(-2.93***) (4.76***) (1.73*) (1.20)

$R^2 = 0.99$, Adj-$R^2 = 0.99$

Translog

$$Ln(Q) = 1616.05 + 35.45LnC - 386.78LnL - 47.11LnLand + 0.268T$$
(2.4*) (3.12***) (-2.6*) (-2.05*) (0.35)

$$+0.113(LnC)^2 + 46.61(LnL)^2 + 0.5(LnLand)^2 + 0.0053(T)^2 - 4.22(LnC)(LnL)$$
(0.65) (2.7***) (0.42) (2.77***) (-3.15***)

$$-0.060(LnC)(LnLand) - 0.055(LnC)(T) + 5.35(LnL)(LnLand) + 0.026(LnL)(T)$$
(-0.18) (-3.7***) (2.19*) (0.28)

$$-0.0056(LnLand)(T) \quad (R^2=0.98 \text{ \& Adj-}R^2=0.97)$$
(-0.2)

Table 1: Elasticities and Return to Scale over the Different Time Periods (Calculated from the Translog Function)

Time	E_L	E_K	E_Z	E_T	RTS_{KZT} (labour is not included)	RTS_{LZT} (capital is not included)	RTS_{KLT} (land is not included)	RTS (all factors are included)
B R	1.33	0.57	0.02	-0.060	0.53	1.30	1.80	1.870
A R	-2.57	0.61	0.19	0.030	0.83	-2.35	-1.90	-1.740
W P	-3.51	0.60	0.13	-0.002	0.72	-3.38	-2.91	-2.780
A W P	-2.15	0.62	0.24	0.054	0.92	-1.85	-1.48	-1.230
O T	-1.12	0.60	0.13	-0.004	0.72	-0.99	-0.53	-0.400
1966/67-77/78	1.46	0.56	0.02	-0.060	0.52	1.42	1.96	1.987
1978/79-89/90	-3.28	0.60	0.12	-0.002	0.72	-3.16	-2.68	-2.564
1990/91-00/01	-1.58	0.63	0.25	0.060	0.94	-1.27	-0.89	-0.640

BR =Before the Islamic Revolution (1966/67 to 1977/78), AR = After the Islamic Revolution (1978/79 to 2000/01), WP = War Period (1980/81 to 1987/88), AWP = After War Period (1988/89 to 2000/01), OT = Overall Time (1966/67 to 2000/01)

The t-statistics are reported in the parenthesis. The * and ** are shown significant at the 5% and 10% levels. Where Q, C, L, IRL, NIRL, T and Land; are agricultural production, capital, labor, irrigated land, non-irrigated land, time and total land (irrigated land + non-irrigated land) respectively. The results show that 50%, 55% and 60% of the coefficients in CD, Transcendental and Translog, respectively, were significant at the 5% level. All coefficients have right signs and no autocorrelation problem was detected. The results of nonparametric test (Run-Test and Independent x^2) do not indicate any autocorrelation problem for Translog production function [19].

The Translog production function was the best estimated functional form based on the significance level, right signs, *Jarque-Bera* normality test, *Ramsey's RESET* test and *Likelihood ratio* test [9, 19, 20].

Based on Translog form, the Return To Scale (RTS) for before Iranian revolution (1966/67-1977/78) was positive and greater than one. For the period after revolution (1978/79-2000/01), the sign changed to negative. However, the RTS, without considering labor, was positive and increasing from 0.52 in the 1966/67-1977/78 to 0.94 in the 1990/91-2000/01, indicating the negative effects of labor in the agricultural production process. Table 1 presents both the E's and RTS in the different periods. The RTS's were negative, except for the RTS_{KZT} (when labour is not included) and RTS's for BR. Unfortunately, the RTS continuously decreased over the time, due to the negative role of the labour in the agricultural sector of Iran (Table 1).

The T (time) is included as one of the explanatory variables representing the rate of the exogenous technical changes. The three share equations (for K, L and Land) are obtained based on the mathematical derivatives of Translog form as follows:

Table 2: Decomposition Rate of the Technical Change (to PTC and NNTC) in the Agricultural Sector of Iran

Time	PTC	NNTC	Overall Technical Change
B R	0.30	-0.35	-0.046
A R	0.40	-0.38	0.021
W P	0.37	-0.37	-0.004
A W P	0.42	-0.38	0.042
O T	0.36	-0.37	-0.004
1966/67-77/78	0.30	-0.35	-0.046
1978/79-89/90	0.37	-0.37	-0.002
1990/91-00/01	0.43	-0.39	0.041

BR =Before the Islamic Revolution (1966/67 to 1977/78), AR = After the Islamic Revolution (1978/79 to 2000/01), WP = War Period (1980/81 to 1987/88), AWP = After War Period (1988/89 to 2000/01), OT = Overall Time (1966/67 to 2000/01)

$$E_i = \frac{\partial Ln(Y)}{\partial Ln(X_i)} = \beta_i + d_{ii}(LnX_i) + \sum_{j=1}^{n} d_{ij}(LnX_j) + d_{it}\ T \qquad (i^1 j) \qquad (5)$$

Hence, the equation for technology is expressed as follows:

$$E_t = \frac{\partial Ln(Y)}{\partial(T)} = \beta_t + \beta_{tt}T + \sum_{i=1}^{n} d_{it}(LnX_i) \qquad (6)$$

As shown by Equation (6), the rate of the technical change is conventionally defined as the partial derivative of the production function with regards to time. The E_T in Equation (6) can be further decomposed additively into the PTC ($B_t + B_{tt}T$) and the NNTC ($\Sigma_i \delta_{it} LnX_i$) components [21, 22]. The technical change is defined as non-neutral if the passage of time affects the marginal rate of the technical substitution between the inputs. The use of the flexible functional form and interaction of time with the inputs allows for the NNTC whereas, the PTC is presented by a simple time trend in the production function [22-24].

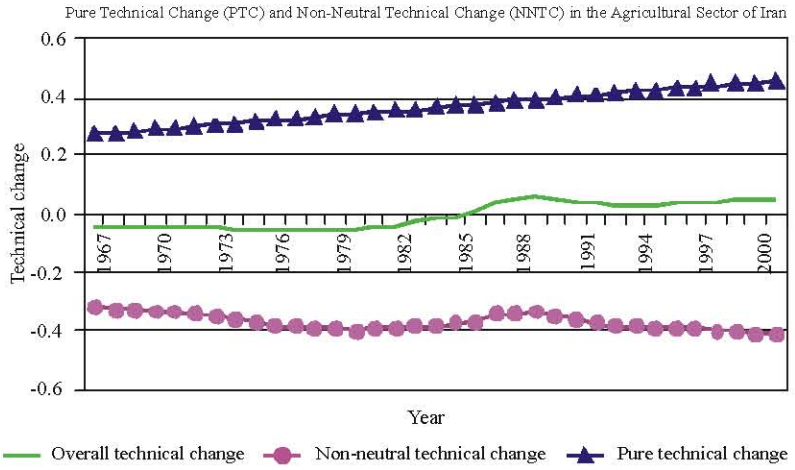

Fig. 1: Pure and Non-Neutral Technical Change in the Agricultural Sector of Iran (1966/67 to 2000/01)

The calculation of the rate of the technical change based on the estimation results, are shown in Table 2. The overall results showed that the PTC had progressed during the period of study, as well as during the war and the Islamic Revolution periods. In the Islamic Revolution category, the PTC increased significantly from 0.30 to 0.40 (before and after the Islamic Revolution) and the war category, from 0.37 to 0.42 (during and after the war period). The NNTC had a slight decrease, i.e., from 0.01 to 0.02 in each period. However, the overall technical change had increased over the different time periods because of the greater magnitude of the PTC (Table 2 and Figure 1). The increase in the overall technical change and an increasing MP_L are due to the prevailing capital intensive methods and the increase in the under cultivated land during that period [1, 2].

CONCLUSIONS

The findings of the study indicated the RTS was declining. However, if labor was not included in the calculation of the RTS, the RTS was positive and increasing over time. This suggests that the cause of the declining RTS was due to the negative effect of labor in the production process. It was shown also that the MP_L had decreased, while others such as MP_K, MP_Z and MP_T increased over the period of study. It is concluded that on the production surface of land and capital, production is on phase (stage) one or two, where the slope of the MP_Z and MP_K are positive. The improper combination of the labor and other inputs has remained unchanged. Thus the results suggested that policies should be formulated to reduce labor in the agricultural sector in order to increase output and productivity.

The mean of PTC and NNTC were 0.36 and -0.37, respectively. The PTC increased from 0.30 (1966/67-1977/78) to 0.43 (1990/91-2000/01), while the NNTC decreased from -0.35 (1966/67-1977/78) to -0.39 (1990/91-2000/01). The negative effect and decreasing rate of the NNTC component was an indication that the change had not taken place in the composition of inputs. The results confirmed that the value of overall technical change (PTC+NNTC) has experience a technical progress during the period of study from -0.046 (1966/67-1977/78) to 0.041 (1990/91-2000/01).

The magnitude of the technological change and its contribution to the production process of the Iranian agriculture were too slow. Therefore activities to develop and progress the use of new technological methods in the agricultural activities should be encouraged. Policies to boost the capital intensive farming practices, coupled with the improvement in the technological change to increase the output and productivity in the Iranian agricultural sector, are thus needed in the long-run. These policies assist farmers to increase income and productivity and consequently development in the rural areas.

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