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The role of technical progress in agricultural growth: a study of agricultural sector of Iran

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Abstract

Agriculture has a multifunctional role in economic development in developing countries; besides providing food for growing population, it is a major source of economic growth. Furthermore, growth originating from agriculture is known to be twice as effective in poverty reduction as growth originating from other sectors. Technical progress is a major factor in stimulating agricultural growth. This paper aims to investigate the role of technical progress in agricultural growth. For this purpose, an endogenous growth model applied to the agricultural sector of Iran. The results show that growth in physical capital and material inputs have had the main role in growing the agricultural sector of Iran. Technical progress, found to be the second significant source of the growth. The effect of growth in employed labour on the value-added growth was not significant. The path of technical change found to be neutral, with global innovation spill-over and human capital indices affecting it significantly.

Key Words: technical progress, economic growth, endogenous growth model

Introduction

Agriculture contributes to development in different ways; as an economic activity, as a livelihood, and as a provider of environmental services. These contributions make agriculture a unique instrument for development in developing countries (World ban 2008). Although only around 10% of the total land area of Iran is actually suited for cultivation (and less than one-third of the cultivated area is irrigated), agriculture 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, and 90% of raw materials used in the food processing industry. The natural and organizational condition, contributed to low crop yields in agriculture and poverty in rural areas, chronically. Furthermore, after the 1979 revolution, many agricultural workers claimed ownership rights and forcibly occupied large, privately owned farms where they had been employed. The legal disputes that arose from this situation remained unresolved so far, and many owners put off making large capital investments that would have improved farm productivity. However, progressive government supports during the 1990s, improved agricultural productivity slightly. Construction of several dams in different parts of Iran has facilitated the irrigation of agricultural lands, helping Iran toward its goal of re-establishing national self-sufficiency in food production. Due to its climatic diversity, Iran produces a wide range of agricultural products, from cereals and pulses to citrus fruits and sugar cane. Wheat and barley, however, play a very important role in Iran's agriculture, having a very large portion of the cultivated lands. During 2005, wheat accounted for about 53% of the cultivated lands in Iran. Pistachio, raisins, dates and saffron are the first four agricultural export products, from the viewpoint of value. In addition to the above-mentioned products, Iran also exports some other important agricultural products such as medical and industrial plants, decorative flowers and plants, as well as livestock products.

Iran's agriculture experienced average 3.5% annual value added growth in the period of 1971 -2005. In the same period, the growth rate of employed labour in agriculture has been only 0.77%. The Annual physical capital growth rate in agriculture, in the same period is 3.9%, and total factor productivity (TFP) growth is 4.7% (table 1).

Theoretically, agricultural output growth can be explained by changes in inputs use (mainly capital and labour) and technical progress (Barro 1997). Technical progress is an increase in the amount of output produced from the same inputs. Technical progress includes technological, organizational and institutional progresses, in addition to improvement in a constraint such as regulation, prices, or qualities of inputs. Technical progress is one of the most important sources of economic growth. The general objective of the current study is an investigation of effect and the share of technical progress in value-added growth for agricultural sector of Iran. For this purpose, a corrected endogenous empirical growth model with direct presence of technical progress equation in the system.

Table (1). Annual average growth[1] rate of Value-added (constant price), labour, capital (constant price), and TFP in agricultural sector of Iran (%)

	1971-1980	1981-1990	1991-2000	2000-2005	1971-2005
Value-added	5.6	1.9	2.14	3.11	3.5
Labour	1.48	1.62	-0.5	-0.3	0.77
Capital	6.7	0.17	1.24	5.61	3.9
TFP	5.35	3.87	4.05	4.26	4.7

Theoretical framework:

In this study, I apply the endogenous growth concepts to the analysis of value added growth in agriculture and to the evaluation of three important sources of growth in the sector: change in capital accumulation, change in technical progress, and change in the number of workers employed. Endogenous growth theory was developed in 1980s and 1990s as a response to criticism of the neo-classical growth model. In neo-classical growth models, the long-run rate of growth is exogenously determined by either assuming a savings rate (the Harrod-Domar model) or a rate of technical progress (Solow model) without a sound explanation of the manner of these two variables. Endogenous growth theory tries to overcome this problem by building macroeconomic models for explaining the long-run rate of growth endogenously. In this theory, households are assumed to maximize utility subject to budget constraints while firms maximize profits. Crucial importance is usually given to the production of new technologies and human capital. This theory demonstrates that policy measures can have an impact on the long-run growth rate of an economy. For example, subsidies on research and development or education increase the growth rate in some endogenous growth models by increasing the incentive to innovate. Often endogenous growth theory assumes constant marginal product of capital at the aggregate level, or at least that the limit of the marginal product of capital does not tend towards zero. This does not imply that larger firms will be more productive than small ones, because at the firm level the marginal product of capital is still diminishing. It is possible to construct endogenous growth models with perfect competition (Rebelo 1991). However, in many endogenous growth models, the assumption of perfect competition is relaxed, and some degree of monopoly power is thought to exist. Generally monopoly power in these models comes from the holding of patents (Young 1998).

1The average was calculated using the formula for CAGR (Compound Annual Growth Rate):[(FV/IV)$^{1/n}$ -1] 100, where FV is the value at the end of the period, IV is the value at the beginning of the period and n is the number of years.

One of the main critiques on endogenous growth theories is the failure to explain conditional convergence reported in the empirical literature in cross countries per capita growth (Parente 2001). However, endogenous growth theory with proper technical progress measure has proven its usefulness as a powerful method for analysing intra country production growth (Esposti and Pierani 2000).

The model:

To establish a modified endogenous growth model, this study follows Esposti and Pierani (2000) in considering the production process with a technology index as an endogenous variable:

$$Y= f(K, L, T) \quad (1)$$

In which Y is real value added of agriculture, K is the value of capital inputs(machinery and buildings) plus the value of materials (chemical fertilizers, pesticides, and seeds); L is number of agricultural labour employed in the sector, and T is an index of the level of technology, calculated via a latent variable approach. Despite neoclassical and former endogenous technical progress models this approach does not apply total factor productivity (TFP) as a direct index of technical change. Also it doesn't apply non-conventional inputs (such as R&D, extension expenditure, human capital accumulation, and spill-over effects) beside conventional inputs (capital and labour) into the aggregate production function to capture technical change (Kuroda 1997). Instead, this approach calculates a new consistent index for technical progress via structural equation system with latent variable that apply TFP as an indirect measure, and non-conventional inputs as its determinants (Esposti and Pierani 2000). In this study we calculated this new consistent technical level index first, and then applied it as an explicit factor in the aggregate production function.

Expressing equation (1) in growth terms and making some relevant changes, we obtain the following form (Khan and Reinhart, 1990):

$$dY/Y = (\partial Y/\partial K.\ K/Y).dK/K + (\partial Y/\partial L.L/Y).dL/L + (\partial Y/\partial T.T/Y).dT/T \quad (2)$$

For ease in estimation, we can rewrite (2) in natural logarithm terms as:

$$d(\ln Y) = \beta_1.d(\ln K) + \beta_2.\ d(\ln L) + \beta_3 d(\ln T) \quad (3)$$

where $\beta_1 = (\partial Y/\partial K.\ K/Y)$

$\beta_2 = (\partial Y/\partial L.L/Y)$

$\beta_3 = (\partial Y/\partial T.L/Y)$

β_1 represent elasticity of output with respect to capital, β_2 is the elasticity of output with respect to labour , and β_3 is the elasticity of output with respect to technology . For more convenience in denotation let $\overset{o}{Y}$ be equal to d(lnY) and so on:

$$\overset{0}{Y} = \beta_1 . \overset{0}{K} + \beta_2 . \overset{o}{L} + \beta_3 . \overset{0}{T} \qquad (4)$$

This is the growth equation in our model. The equation (4) can be estimated separately, but with respect to nature of I and L, and generation mechanism of T under the effect of R&D expenditures, human capital, and global knowledge spill-over (Esposito and Pierani 2000), it is preferred that the model be estimated in the framework of a structural equation system including value added growth equation, Investment demand equation in a recovered form, labour demand growth equation, and technical progress equation:

$$\overset{o}{Y} = \beta_{11} \overset{o}{Y} + \beta_{12} \overset{o}{K} + \beta_{13} \overset{o}{L} + \beta_{14} \overset{o}{T} + \gamma_{11} \overset{o}{Pk} + \gamma_{12} \overset{o}{Pl} + \gamma_{13} \overset{o}{S} + \gamma_{14} \overset{o}{R} + \gamma_{15} \overset{o}{H}$$

$$\overset{o}{K} = \beta_{21} \overset{o}{Y} + \beta_{22} \overset{o}{K} + \beta_{23} \overset{o}{L} + \beta_{24} \overset{o}{T} + \gamma_{21} \overset{o}{Pk} + \gamma_{22} \overset{o}{Pl} + \gamma_{23} \overset{o}{S} + \gamma_{24} \overset{o}{R} + \gamma_{25} \overset{o}{H}$$

$$\overset{o}{L} \text{L} = \beta_{31} \overset{o}{Y} + \beta_{32} \overset{o}{K} + \beta_{13} \overset{o}{L} + \beta_{34} \overset{o}{T} + \gamma_{31} \overset{o}{Pk} + \gamma_{32} \overset{o}{Pl} + \gamma_{33} \overset{o}{S} + \gamma_{34} \overset{o}{R} + \gamma_{35} \overset{o}{H}$$

$$\overset{o}{T} = \beta_{41} \overset{o}{Y} + \beta_{42} \overset{o}{K} + \beta_{43} \overset{o}{L} + \beta_{44} \overset{o}{T} + \gamma_{41} \overset{o}{Pk} + \gamma_{42} \overset{o}{Pl} + \gamma_{43} \overset{o}{S} + \gamma_{44} \overset{o}{R} + \gamma_{45} \overset{o}{H}$$

(5)

In the above equation system, added to the introduced variables, P_K is the interest rate, P_L is price (wage) of labour, R is R&D expenditures, H is the index of human capital; and S is the relevant index of global spill-over technology to the agricultural sector.

Data:

The data series (1971-2005) for estimating model were collected from Central Bank statistical publications, Jahad-e- Keshawarzi Ministry statistics and United Nations Statistic Division. The education level (tertiary level) in rural areas was assumed as agricultural human capital index (H). The number of annual patent applications, obtained from U.S. patent and trademark office website, considered as the index of global spill-over (following Esposito and Pierani 2000).

Results and Discussion:

The equation system (5) was estimated in a path analysis framework using the LISREL software. In path analysis modelling), there is often no need to estimate all parameters in the model. Instead, the structure of causal relationships between variables is determined primarily on the basis of relevant theory; and represented in a path analysis diagram (Mueller 1996). This reduces the number of parameters, and helps to achieve better estimation results for basic parameters, particularly in the condition of scant available sample cases, as was the case in this study. The path analysis diagram for the model is shown in Figure 1.

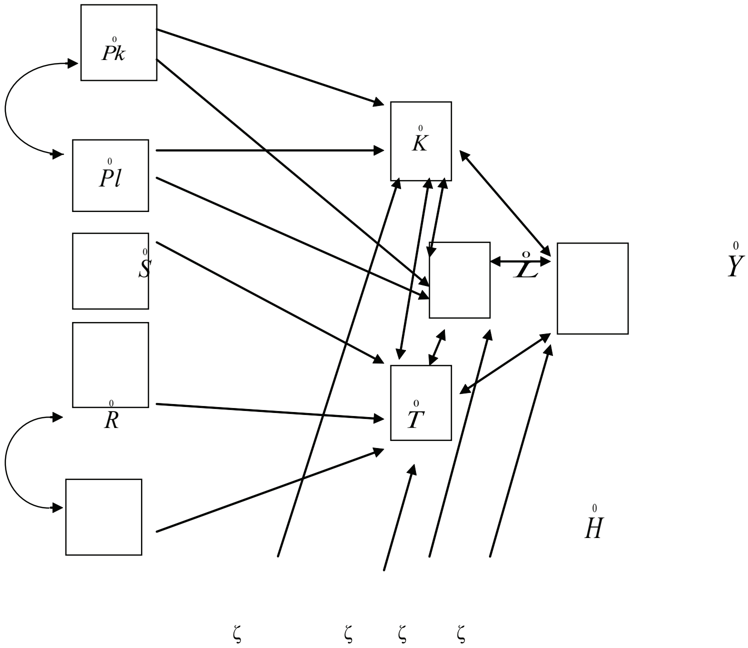

Figure 1. Path Diagram of the model

With respect to the path diagram, restrictions were imposed on the parameters, and the final model was estimated. Results were showed in Table 2.

The results of growth equation indicated that the elasticity of output with respect to capital (value of capital and material inputs) with a coefficient value of 0.2101 is significant at the 1% level. The labour elasticity coefficient is not statistically significant, and the technical progress elasticity (0.0421) is significant at 5% level. According to these findings, capital growth has had the main role in enhancing value added in the agricultural sector of Iran over the study period. In other words, the growth in quantity of inputs such as agricultural machinery and productive buildings, chemical fertilizers, pesticides, and seeds are the main source of the growth in the sector. The second significant source of the value added growth of the agricultural sector of Iran was found to be technical progress. Technical progress can be referred to as change in the amount of output produced from the same inputs. Such a change is not necessarily technological; it might be organizational, or the result of a change in a constraint such as regulations. The result of the model confirmed the significant effect of technical progress on the value added growth. Based on the estimated model, 33% of growth in agricultural value-added in Iran originate from technical progress, and remaining 67% from physical capital and materials growth. This is in agreement with Gharehbaghian and Homayonifar (2001) that estimated agricultural production growth in Iran has been determined 80% by input growth and 20% by technical progress, but shows more important role of technical progress. The effect of growth in employed labour in agriculture could not be confirmed by the result of the model.

Table 2: Model Parameter Estimates for agricultural growth and its determinants in Iran

	Endogenous Variables				*Exogenous Variables*				
	$\overset{0}{Y}$	$\overset{0}{K}$	$\overset{o}{L}$	$\overset{0}{T}$	$\overset{0}{R}$	$\overset{0}{P}$	$\overset{0}{S}$	$\overset{0}{R}$	$\overset{0}{H}$
$\overset{0}{Y}$	-	0.2101 3.84***	0.0118 0.49	0.0421 1.95*		-	-	-	-
$\overset{0}{K}$	2.8253 2.75**	-	-	0.0794 1.47	-0.3148 -2.10**	2.1492 1.92*	-	-	-
$\overset{o}{L}$	2.0584 0.62	-	-	-0.4615 -1.19		-4.8230 -2.05**	-	-	-
$\overset{0}{T}$	-	-	-	-		-	2.0427 2.91***	1.3340 1.62	1.8049 1.90*

, ** and * indicate statistical significance at the 10%, 5%, and 1% levels respectively.*

The coefficients of technical progress in $\overset{0}{K}$ and $\overset{0}{L}$ equations are positive (**0.0794**) and negative (**-0.4615**) respectively, that imply, apparently, a capital-using and labour-saving type of technical change in the agricultural sector of Iran. However, with respect to their statistical insignificance, technical progress path could be remarked as neutral. Anyway, according to these results, the argument that labour-saving technical change is the main reason for workers' migration from agriculture to other sectors, aggravating the national unemployment rate, does not seem convincing. Rural areas in Iran have low living standards, the transportation network is inadequate, and the housing system does not coincide with modern life. Hence, rural population (including agricultural workers), had more complicated reasons for migration than merely technical factors.

In $\overset{0}{K}$ equation, the growth in agricultural value added, and in agricultural wages (as the price of a substitutable input), have positive and significant effect on the growth of capital in agriculture; and interest rate has negative ad significant effect. In $\overset{0}{L}$ equation the only effective variable is wage, restricting the growth of employed labour in Iran agriculture.

Finally, in technical change equation, global spill-over and human capital variables have affected technical progress, significantly. However, the effect of R&D expenditures on the technical progress is not significant. In other words, the agricultural research system in Iran suffers from inefficiency, and needs to be improved. Considering radical changing conditions in Iran trough last decades, Islamic revolution and 8 years war with Iraq that destroyed or delayed research infrastructures and programs, this result is not far from expectation. Another problem in this regard is weak linkage between research system and farmers. Agricultural research system in Iran is a centralized governmental managing system and lack from good linkage with small scattered traditional farm. The extension system is also an old state managed one without enough ability to transfer the result of researches to the scattered small farms in our vast country, while farmers own institutions and organizations have not developed adequately.

According to above results of the model, concluding remarks and policy recommendations can be made as follow:

Technical progress has a major role in agricultural growth in Iran (determining 33% of growth), so more attentions and planning is needed regarding this source of agricultural growth.

Human capital is an important factor affecting technical progress in Iran agriculture, in other word results of this study recommends more public investment in human capital strengthening programs as rural education.

R&D expenditures effect on the technical progress is not significant, indicating serious problem in agricultural research and extension system in Iran, implying urgent need for structural improvement and reorganization.

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