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IMPACT OF INFORMATION AND COMMUNICATIONS TECHNOLOGY ON GROWTH OF AGRICULTURE SECTOR

Seyed Abdolmajid Jalaee[1], Sina Zeynali[2]

[1]Department of Economics, Shahid Bahonar Univresity,
[2]Department of Management, Shahid Bahonar Univresity, Kerman,
IRAN.

dr_jalaee@yahoo.com

ABSTRACT

Information technology is the extract of human's 2000-year knowledge and experience. Information technology has been seriously taken under consideration in a new form during the recent years. In this juncture of time, many countries have reached to the conclusion that development of information technology is regarded as an important factor in their economic growth and development. Information and communications technology have manifested the ability to act effectively for empowering and strengthening the agriculture sector. Hence, application and determination of the specific roles which this technology can encompass with respect to progress and effectiveness in agriculture sector deserve essential attention. Agriculture sector requires utilization and deployment of information technology for improvement of efficiency in production and marketing of the agricultural crops as information technology have provided opportunities for development of agriculture sector through empowerment and unification of access to the available knowledge and information. The present paper analyzes impact of information and communications technology on growth of agriculture sector during 1972-2008 by depicting a suitable model for Iran's agriculture sector. The model benefits from Auto-Regressive Distributed Lag (ARDL) Method. Estimation results indicate that information and communication technology have positive and significant effect on the growth of agriculture sector.

Keywords: Information and Communications Technology, Economic Growth, Agriculture Sector

INTRODUCTION

THEORETICAL FRAMEWORK

According to OECD's definition (2002), Information and Communications Technology (ICT) signifies set of production and service industries used for electronic storage, transfer, and displaying of data and information. This definition assumes ICT as a set of Hardware, software, and network-ware which enables studying and application and processing of data in the scopes of storage, manipulation, transfer, management, displacement, exchange, control, switching, and automatic data testing. The production industries in the definition refer to industries which are intended to complete the information and communication process including their transfer and representation and take use of electronic process for detection, measurement and/or preservation of physical phenomena or control of physical processes. Service industries include the services which aim at empowering the performance of information and communication process via electronic means (Mahmudzadeh & Asadi, 2007). ICT is among the most novel scientific achievements of mankind which have apparently presented numerous capabilities to the human society, and, it is expected that they can be effective and useful in alleviation of the current problems of human society.

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Growth of agriculture sector as a context is considered a vital matter for achieving development targets in developing countries. Among the respective objectives, economic improvement and growth and poverty alleviation, improvement of nutrition security and preservation of natural resources are highly significant. In low-income countries, agriculture sector serves as the engine and primary impetus of economic growth due to its extensiveness and strong linkages to other economic sectors.

Agriculture in these countries accounts for the largest portion of labor force and holds a special position in national economy with 68% of employment and 24% of gross domestic production. Majority of poor population is directly dependent on this sector and live on agriculture. Enhancement of productivity level in agriculture sector leads to cheaper prices of foods and makes a remarkable contribution to the economics of poor families. Also, modern agriculture is accompanied with higher employment in technological units and is followed by further supply of services and products in the market. This trend will indirectly lead to job creation in farms. In this way, agriculture sector helps the economic growth and consequently causes creation of new openings directly through more production and exports and indirectly through increasing the demand for industrial services and products (Moeinadini, 2005). The intent of the current paper is to find an answer to the question that whether information and communications technology have any effect on the growth of Iran's agriculture sector or not.

Application of information and communications technology is expected to be effective in growth of agriculture sector. The paper is organized as follows: following the literature review, the third section of the paper deals with model specification. Model estimation is included in the fourth section, and finally, the conclusions are presented in the last section.

Overall, the research works in the scope of ICT can be divided into three groups: the first group includes the researches which analyze the correlation between ICT and economic growth and productivity. The second group studies the factors affecting expansion of ICT, and the third group investigates impact of ICT spillovers. In this regard, a study was conducted by Kim (2003) in South Korea concerning information technology (IT) and its impact on economic growth and productivity during 1971-2000. In the respective study, growth shares of factors including standard input, capital input of information technology, and trade cycle effect on official account framework of growth were evaluated. The results of the respective study revealed the fact that share of information technology capital is 16.3% of the product growth and has strong and positive impact on productivity growth of the labor force in the long term.

Edward & Ford (2001) carried out a study on information technology and economic growth; the results indicate that investment in information technology will have small effect on economic growth. Similarly, Kanamori & Motohashi (2005) also conducted a study on information technology and economic growth, in which economic growths of Japan and South Korea were compared during 1958 to 2004. In both countries, information technology was an essential resource of economics and productivity growth form output aspect. Furthermore, investment in IT activities contributed to stimulation of services of IT capital share in economic growth from input aspect.

Shu (2003) conducted a study on investment in information technology, economic growth and employment. In the respective study, economic models and macroeconomic theories were applied to solve the productivity problem. The research hypothesis was impact of IT in structural changes on productivity. It was confirmed that structural changes could solve the productivity problem and make prediction of future economic growth.

Selim (2001) also carried out a research concerning economic growth and information technology where three major impacts were discovered: 1-Effective impact 2- Scale impact 3-Capital consumption impact. The first two impacts are increasing and the third impact has a positive effect on total productivity of products. It was also proved that IT is greatly effective provided that the economy is able to replace it with constant capital resources at an extended rate.

Another study was carried out by Mahmudzadeh & Asadi (2007) about impacts of information and communications technology on productivity growth of labor force in Iran's economics. The estimations used time series data for 1971-2004 by means of ordinary least squares method. Their results demonstrated that total productivity and non-ICT capital have the largest impact on productivity of labor force in Iran's economics. Impacts of human capital and information technology capital on labor force productivity are positive and significant.

In another research by Moshiri & Nikpour (2007) about impact of information and communications technology and their spillovers on economic growths of the world countries during 1993-2003, the results indicate that ICT have significant and positive effect on productivity growth of labor force both directly and indirectly. This impact is larger in developed countries than in less developed countries on contrary to the initial hypotheses. Also, Moshiri & Jahangard (2004) performed a study on information and communications technology and Iran's economic growth during 1969-2002. The estimation results are suggestive of positive and significant impact of ICT on Iran's economic growth. Following a period of reduction in late 1980s and early 1990s, the impact has improved with increase in investment indices since late 1990s.

MODEL SPECIFICATION

Economic growth is among the fundamental issues in modern economics. Adam Smith and Karl Marx argued considerable discussions concerning economic growth. Afterwards, the economic growth issue was considered in the framework of growth models as static, dynamic, long-term, and short-term. In particular, after the First World War, long-term economic growth attracted attentions of economists such that they recognized economic growth as a function of domestic resources, population growth rate, saving rate, organization manner, economic management, and technology which influence capital accumulation and production enhancement.

Numerous studies have been also conducted for modeling the relationship between economic growth and its determining factors. The first simple method is attributed to Harrod and Domar in which the most essential determining factors of economic growth were assumed to be investment and labor force growth. The relationship between product growth and capital stock and labor force is derived from a total production function with constant coefficients. In other words, the substitution positions of factors are not considered in the respective model. Solow alleviated flexibility of the aforementioned model by applying a total production function with the possibility of factor substitution (Cobb-Douglas). The main features of Solow's model were: inclusion of a total production functions with possibility for substitution of capital and labor force (Cobb-Douglas), fixed rate of returns to scale, and diminishing final output.

Solow applies a surjective and continuous function in his growth model which correlates production to use of capital and labor force and these two variables can interchangeably replace each other. He also showed that with variability of technical coefficient, capital to labor ratio adapts itself to the economic conditions of the capital such that the economy

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Vol. 2. No. 2. April 2013

reaches a balanced growth. If economic growth of capital to labor is initially higher, capital and production will grow less than the labor force and vice versa. In Solow's analysis, with any initial capital to labor ratio, the economy would move along a uniform equilibrium line. In economy, only one commodity is produced and total production equals commodity production in economy. Annual production rate of this commodity is y (t) which represents the actual income of the society, part of which is consumed and the rest is saved. The saved portion of the income is fixed (s) and saving amount in the same year equals s*y (t) and capital reserves are also equal to k (t). Therefore, net investment equals amount of increase in capital stock i.e. $\frac{\partial k}{\partial t}$ or $\dot{k}$. Accordingly, the main relationship of the model will be:

$$k= s.y \qquad (1)$$

Since labor and capital are production factors and facilities of technical improvement are hidden in production function, thus:

$$Y = F(\dot{K}, L) \qquad (2)$$

This equation is representative of fixed output for the production factors consumed in production. Combining equations (1) and (2), then:

$$\begin{aligned} y &= \frac{s}{k} \\ \frac{s}{k} &= F(KL) \\ K^{\cdot} &= sl(k^{\cdot}, l) \end{aligned} \qquad (3)$$

In Equation (3), L represents the total employment. Since population growth is an exogenous factor, labor force grows at a relative rate (n). Therefore, Equation (4) is expressed as below:

$$L(t) = \log e^{nt} \qquad (4)$$

In Solow's opinion, n in fact denotes Harrod's natural growth rate in absence of technical progresses, L (t) is supply level of labor force at time t. Equation (4) can be known as labor force supply.

Neoclassical growth model is based on a production function with the features of fixed returns to scale, possibility for substitution of labor and capital, and diminishing marginal productivity of data.

This production function:

$$Q = F(K, L) \qquad (5)$$

is homogenous of first degree, or in other words, have the feature of fixed returns to scale.

An instance of production function with fixed returns to scale and diminishing marginal productivity is the famous Cobb-Douglas function.

$$Q = bK^{\alpha} L^{1-\alpha} \qquad (6)$$

Here, for dimensional equality of all exponents of K and L, first degree homogeneity and fixed returns to scale are insured. This type of production function can be also expressed in terms of capita variables:

$$q = \frac{Q}{L} = (b.K^{\alpha}.L^{1-\alpha})/L = b.k^{\alpha}/L^{\alpha} = b.\left[\frac{K}{L}\right]^{\alpha} = b.K^{\alpha} \quad (7)$$

Marginal productivity "K" can be evaluated using the following equation:

$$MPK = \frac{\partial q}{\partial k} = b.\alpha.K^{\alpha-1} \quad (8)$$

The values of function are always positive and its second derivative:

$$\frac{\partial(MPK)}{\partial K} = \frac{\partial^2 q}{\partial k^2} = b.\alpha.(\alpha-1)k^{\alpha-2} \quad (9)$$

is negative because α<1. This indicates that mpk is descending with increasing k i.e. production function is concave downward.

Neoclassical production function with possibility for substitution of labor and capital data provides a method for changing capital to product ratio during the growth process. Each point of the production function represents a ratio of q to k.

$$\frac{q}{k} = (Q/L)(K/L) = Q/K \quad (10)$$

It is in fact reciprocal of capital to product ratio "V".

The major bottleneck of Harrod-Domar's model is the fact that this model is too definite and cannot be solved.

q_1, V, and S are all determined exogenously such that the equilibrium condition: $g_1=s/v$ can be determined randomly and arbitrarily. Having introduced neoclassical production function allow "v" to vary as "k" value increases. Thus, flexibility of Harrod -Domar's model is nullified. The base model is established as follows:

$$Y(t) = F(K(t), L(t)) \quad (11)$$

This formulation of N-K model is assumed first degree homogenous for F.

$$Y(t)/N(t) = f(K(t), N(t)) \quad (12)$$

Stock reserve represents a ratio of gross domestic production (GDP) but is corrected by degradation at a fixed rate δ . This is the simplest formulation performed by Solow in 1956.

$$dK(t)/dt = \delta.Y(t) - \delta K(t) \quad (13)$$

It is assumed that population grows along the time at the fixed rate "n".

$$dL(t)/dt = n.L(t) \quad (14)$$

Solow's model is used in the present study. Thus, the model can be expressed as below:

$$Y = Af(K, L) \quad (15)$$

Where; Y is total production level, K is amount of physical capital, L is labor force, and A measures the total returns of the factors. Equation (17) can be expressed in terms of

growth rate as follows:

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$$dY\ /Y = \left[\frac{\frac{A.\partial Y}{\partial K.K}}{Y}\right]\frac{dK}{K} + \left[\frac{\frac{A\partial Y}{\partial L.L}}{Y}\right]\frac{dL}{L} + \frac{dA}{A} \quad (16)$$

Equation (16) can be written via estimation as:

$$\frac{dY}{Y} = \alpha_0 + \alpha_1.\frac{1}{Y} + \alpha_2.\frac{dL}{L} \quad (17)$$

Where: $\alpha_0 = \frac{dA}{A}, \alpha_1 = A_0\frac{\partial Y}{\partial K}$

In these equations, returns growth, product to capital elasticity, product to labor force elasticity and elasticity of product to other factors are represented from left to right respectively.

Therefore, production function at each time "t" is defined as:

$$Q_t = A.K_t^{BK}.L_t^{bl}.Q_t^{BO} \quad (18)$$

Q_t refers to the production resulting from production inputs such as labor force, physical capital, and other inputs. Using Solow's growth model and taking logarithms and first-order difference, Equation (18) is transformed into the following linear equation:

$$\Delta q_t = \Delta\alpha_0 + \beta^k.\Delta k_t + \beta_l.\Delta l_t + \beta^o\Delta o_t \quad (19)$$

The lowercase letters denote logarithms of the aforementioned variables and delta represents the first-order difference. Total productivity growth i.e. the term $\Delta\alpha(0)$ is normally known as Solow residual in experimental literature measured as difference between production growth and weighted average of growth rates of inputs:

$$SR_t = \Delta q_t - S_t^k.\Delta k_t - S_t^l.\Delta L_t - (1 - S_t^k - S_t^L).\Delta o_t \quad (20)$$

Where, S_t^L, S_t^K respectively represent shares of physical capital and labor force.

Production function (18) can be used for analyzing impact of information technology on growth of agriculture sector. Y is the added value in agriculture sector and L and k respectively signify the labor force and capital stock in the respective sector. Now, applying these changes, production function will have the form below:

Y=F(K,L)

Y: added value in agriculture sector (billion Rials)

K: capital stock in agriculture sector (billion Rials)

L: number of labor force in agriculture sector (thousand persons)

In this step, to assess impact of information technology on growth of agriculture sector, research budget index of agriculture sector is incorporated in the model based on researcher's studies (this index includes all costs spent by the government for instructing the farmers and agricultural researches; researches in agriculture sector are among the growth resources of agriculture and thus have significant impact on growth in this sector). The resulting production function will be:

Y=F(K,L,R)

R: research budget index of agriculture sector

Ultimately, Cobb-Douglas production function can be written as:

$$Y=AL^{\alpha}K^{\beta}R^{\gamma}$$

Taking natural logarithm from both sides of the former equation:

$$LY = LnA + \alpha LnL + \beta LnK + \gamma LnR$$

In the present study, the data of added value in agriculture sector were acquired from Iran's Central Bank; capital stock and research budget of agriculture sector were collected from Iran's Statistics Center, and, the data of labor force in agriculture sector were obtained from FAO website.

RESULTS AND DISCUSSION

It is greatly significant to determine stationary degree of variables in the studies related to time series. Time series is stationary when the mean value and covariance remain constant along the time. If the time series data are non-stationary, the assumption of standard regression model cannot be executed in general. Results of unit root test are included in Table (1).

Table 1. Results of unit root test

Name of variable	*Dickey-Fuller's statistics*	*Stationary degree*
LY	-1.75	1(1)
LK	-4.93	1(1)
LL	-13.49	1(0)
LR	-3.84	1(1)

Results of Table (1) indicate that the variables of added value of agriculture sector, capital stock, and research budget of agriculture sector are zero-degree homogeneous and the variable of labor force is first-degree homogenous. ARDL technique is used since the model variables are homogenous of zero and first degrees.

To analyze the long-term relationship, the optimal number of lags is initially specified for each of the explanatory variables with the aid of Schwarz-Bayesian Criterion (SBC) and model coefficients are estimated as represented in Table (2).

Table 2. Results of Auto-Regressive Distributed Lag (ARDL) model of growth in agriculture sector using Schwarz-Bayesian Criteria ARDL (1, 0, 1, 0)

Name of variable	*Coefficient*	*Standard Error*
LY(-1)	0.53	0.145
LK(-1)	0.16	0.071
LL	-0.35	0.23
LR	0.067	0.024
C	0.84	3.92
F=783	R^2=0.99	D.W=2.2

*: significance at p-value=1%, and, **: significance at p-value=5%

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Results of Table (2) demonstrate that there exists a positive and significant correlation between added value of agriculture sector and capital but the impact of labor force sector on added value in the respective is negative and at insignificance level. Also, a positive and significant relationship is observed between researches in agriculture sector and added value of the same sector. Determination coefficient equals 0.99 which indicates an acceptable fit. In this step, the following formula is used for testing presence or absence of a long-term relationship. The sum of coefficients with the dependent variable lag must be subtracted from each other and then divided by its standard deviation

$$t = \frac{\sum_{i=1}^{p} \alpha\hat{}_i - 1}{\sum_{i=1}^{p} s\alpha_i\hat{} - 1} = \frac{0.53 - 1}{0.145} = -3.35$$

The computed statistic equals -3.35 and is greater than the critical value of BENERJI, DOLADO, and MASTER's table (-2.92). Consequently, null hypothesis stating absence of long-term relationship is rejected and therefore existence of long-term relationship is confirmed. For the same reason, the long-term coefficients of the model are estimated. The results are shown in Table (3).

Table 3. Estimation of long-term coefficients of growth model using ARDL method

Name of variable	*Coefficient*	*Standard Error*
LK	0.34*	0.02
LL	-0.96**	0.35
LR	0.14*	1(0)
C	1.8	5.9

*: significance at p-value=1%, and, **: significance at p-value=5%

Results of table (3) indicate that in the long term coefficients of capital and labor force variables and researches in agriculture sector are significant. With one unit of increase in capital, the added value of agriculture sector increases 0.34 of magnitude. Also, one unit of increase in labor force is followed by -0.96 of unit reduction in added value of agriculture sector. An increase of one unit in researches of agriculture sector leads to 0.14 of unit increment in added value of the respective sector. After observation of results, it is possible to propose the related error correction model as well. The results of error correction model are presented in Table (4)

Table 4. Error Correction Model of growth function for agriculture sector

Name of variable	Coefficient	Standard Error
dLK	0.16**	0.07
dLL	0.092	0.26
dLR	0.067**	0.024
Dc	0.86**	0.39
Ecm(-1)	-0.46*	0.14
F=2.7	R^2=0.73	D.W=2.12

*: significance at p-value=1%, and, **: significance at p-value=5%

Results of table (4) suggest that capital of agriculture sector and researches of agriculture sector as well as error correction term are all significant. Determination coefficient equals 0.73 which reflects relatively good explanatory power for the model. Coefficient of error correction term is estimated to be -0.46 which indicates 0.46 of the imbalance in GDP of agriculture sector in each year is adjusted in the next year period. In this state, adjustment proceeds slowly toward equilibrium (balance).

CONCLUSIONS

Global studies demonstrated the fact that information and communications technology (ICT) positively affect economic growth and productivity of production inputs. The present study also showed that altogether information and communications technology has positive and significant impact on growth of Iran's agriculture sector. The study results also indicated that ICT has turned into one of the inseparable elements of the world and can make remarkable contribution to the agriculture sector.

This issue is particularly significant in Iran since agriculture system is not currently mechanized on agricultural centers and farms. Scientific usage of ICT in agricultural poles could help the growth of this sector, and consequently, the economic growth. This matter is of specific importance due to position of production inputs in agriculture sector and its traditional production system. Accordingly, increase in the budget of agricultural researches, strategic planning of academic researches and paying attention to scientific innovations coupled with timely transfer of novel production techniques based on information and communications technology could profoundly transform Iran's agriculture within the upcoming years.

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