*International Journal of Agricultural Management & Development (IJAMAD)*
*Available online on: www.ijamad.com*
*ISSN:2159-5860 (Online)*
*ISSN: 2159-5852 (Print)*

# Investigating Agricultural Productivity Growth and Convergence in Iran and Eastern African Countries

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*Received: 15 October 2011,*
*Accepted: 10 August 2011*

**Abstract**

The issue of convergence or divergence of productivity has important policy for regional poverty reduction and increasing standards of living. If productivity converges to a common level without intervention, there is little need for explicit policies in lagging regions to promote catch up. On the other hand, productivity has divergence trend, then explicit policies would be needed to prevent further lagging of TFP and standard of living. Therefore, with regard to importance subject, this paper in finding out whether Iran and Eastern African countries in agriculture have managed to narrow their productivity gap? The results show that the range changes of average TFP growth lies between -4.9 percent in Rwanda countries and 1.1 percent in Iran and Somalia. The results of convergence test indicate that, from among 9 countries under consideration only five countries, be converging to the mean. Therefore, these countries managed to make better use of new available technologies, thus reaching far greater productivity levels than others. On the opposite, convergence can not be accepted for the rest countries.

***Keywords:***
***Productivity, Convergence, Agriculture, Iran, Eastern Africa.***



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## INTRODUCTION

Among the various economic sectors of a developing country, agricultural sector is the bedrock of development and core of the export market and plays an essential role in the nutrition. Also it is accountable for one-fourth to one-half of (GDP) gross domestic product in developing countries (Karbasioun, *et al.,* 2008). Regarding the increasing population in the world and limitation production factors, factor productivity should be improved progressively. Thus, addressing the productivity of the production factors in agricultural sector is especially crucial. In addition to, productivity growth indicates significant differences between countries that grow faster and whose lags behind others. The differences in the rates of productivity growth in the various countries may be the result of regional inequalities. Therefore, it is important to understand the long-run movement in the district level productivity differences and take effective measures (such as higher investment in infrastructure, research and development, etc). Concerning the importance of TFP studies many research had been done on mentioned topic. Jayasuriya (2003) showed that decrease in production costs is due to technological improvement of tea production in Seri Lanka, so that despite the considerable reduction in the amount of inputs usages, the production amount remained unchanged. Colli and Prasada Roa (2003) concluded that China's annual incraes of TFP is 6 percentages which acquired the highest amount among the countries involved in their research. Bayarsaihan and Coelli (2003) showed that the rate of changes in cereals and apple production technology from 1976 to 1990 lies at a low level so that the annual average of the TFP changes was 1.7 and 0.8 percentages, respectively. Also, during the last seven years involved in the study, government's policies caused TFP increase. In their research, Ha and *et al.,* (2006), showed that during 1970-2003 in South Korea, improvement of labor productivity and production development altogether bear positive impression and also, TFP increase in productive industries was more than those of service sectors. Suphannachart and Warr (2010) studied TFP of Thai agriculture sector and the factors influencing it. Results showed that agricultural research plays an important role in determining TFP in both the crop and livestock sectors. With regard to the importance of this topic, this study is finding out whether or not there has been a tendency towards convergence in agricultural productivity Iran and Eastern African countries in the last four decades?

The rest of the paper is constructed as follows: In section 2, we discuss the brief outline of Malmquist index and time series approach for convergence test. Next section introduces the data. Then section 4 reports the TFP results, including the usual decomposition into technical change and efficiency change, also reports the results of convergence test. Finally, conclusion part summaries the key findings.

## MATERIALS AND METHODS

### Productivity Measurement (Malmquist index)

This study applies the generalized Malmquist index, developed by Fare *et al.,* (1992 a) that allows for the presence of technical inefficiencies and is nonparametric. This approach does not require the use of prices of inputs or outputs in its construction. The Malmquist index avoids specification but is deterministic while the production function is stochastic.

The Malmquist productivity proposed by Cave *et al.,* (1982) based on distance functions developed by Malmquist (1953). Fare *et al.,* (1994) decomposed it into two mutually exclusive components: technical change and efficiency change over time. They calculated the productivity change as the geometric mean of two MIF using output distance functions.

Let region j=1,2,…,J use inputs to produce outputs during t=1,2,…T, where denotes a real positive vector. The production technology set can be defined as:

$$S^t = \{(x^t, y^t) : x^t \text{ can produce } y^t\} \quad (1)$$

Alternatively, the production technology may also be represented by an input requirement set

$$L^t(y^t) = \{x^t : (x^t, y^t)\} \in S^t \quad (2)$$

The within-period input distance functions are defined as

$$D_i^t(y, x) = \max\{\lambda : (x^t/\lambda) \in L^t(y^t)\} \quad (3)$$

And

$$D_i^{t+1}(y^{t+1}, x^{t+1}) = \max\{\lambda : (x^{t+1}/\lambda) \in L^{t+1}(y^{t+1})\} \quad (4)$$

The value of these distance functions is equal to or greater than one, but conventionally it is the reciprocals that are reported. Only if the value is equal to one are the regions efficient and therefore on the frontier. The adjacent-period input distance functions may also be defined as

$$D_i^{t}(y^{t+1}, x^{t+1}) = \max\{\lambda : (x^{t+1}/\lambda) \in L^{t}(y^{t+1})\} \quad (5)$$

and

$$D_i^{t}(y^{t+1}, x^{t+1}) = \max\{\lambda : (x^{t+1}/\lambda) \in L^{t}(y^{t+1})\} \quad (6)$$

These four input distance functions are used to construct the Malmquist productivity index. Following Fare *et al.,* (1994) the Malmquist productivity index using input orientation for region i between period t and t+1 is defined as

$$M_i^{t,t+1} = \left(\frac{D_i^t(y^t, x^t)}{D_i^{t+1}(y^{t+1}, x^{t+1})}\right)\left(\frac{D_i^{t+1}(y^{t+1}, x^{t+1})}{D_i^{t}(y^{t+1}, x^{t+1})}\frac{D_i^{t+1}(y^{t}, x^{t})}{D_i^{t}(y^{t}, x^{t})}\right)^{1/2} \quad (7)$$

The ratio in the first bracket captures technical efficiency change and the ratio in the second bracket provides a measure of technological change. Efficiency change is greater than, equal to, or less than unity as technical efficiency improves, remains unchanged, or declines between period's t and t+1. Change is greater than or equal to unity, and shows whether the frontier is improving or stagnant. Technological regression is precluded by the accumulation of all past data. Since the Malmquist productivity index is the product of technical efficiency change and technological change, it is also greater than, equal to, or less than unity.

## Test of Convergence

Convergence between e.g. country i and a group average of all countries is defined as:

$$\lim_{k \to \infty} E(Y_{i,t+k} - \overline{Y}_{t+k} | I_t) = 0 \quad (8)$$

where $Y_{i,t}$ is the log of TFP for country *i* in year *t* and $I_t$ is the information set available at time *t*, and convergence requires equality of long-term forecasts. In an empirical testing strategy it is essential to assess whether the deviations from the group average contain either a non-zero mean or a unit root because this implies that there cannot be convergence, and the series will diverge over time. Bernard and Durlauf (1995) note that certain non-stationary $Y_{i,t} - \bar{Y}$ processes can meet their definition of convergence so that a test for stationary of the process may fail to reject the null hypothesis of unit root and wrongly conclude that there is no convergence. A similar argument applies to the method developed by Evans and Karras (1996), according to whom a necessary and sufficient condition for convergence, as defined by equation (8), is that every $Y_{i,t}$ is non-stationary while every $Y_{i,t} - \bar{Y}$, is stationary. However, also in this case Nahar and Inder (2002) show that a non-stationary $Y_{i,t} - \bar{Y}$, process can meet the definition given in equation (8), thus implying that stationary is not a necessary condition for convergence. With regard to advantage, this paper employs the time series approach proposed by Nahar and Inder (2002).

If $Z_{it} = (Y_{i,t} - \bar{Y})$ and $W_{it} = (Z_{it})^2$, then convergence requires that $W_{it}$ should always be getting closer to zero. That is, we require that $(dw_{it}/d_t) < 0$. To construct a test of convergence, Nahar and Inder represent $W_{it}$ as a simple (stochastic) polynomial in time:

$$w_{it} = \theta + \theta_1 t + \theta_2 t^2 + \ldots + \theta_{k-1} t^{k-1} + \theta_k t^k + u_{it} \quad (9)$$

Where the $\Theta_i$' s are unknown parameters, and $u_{it}$ is a well-behaved random error term. The slope function is derived as the first derivative of (1). Convergence now corresponds to a negative value of the average of the slope functions, as not every slope can be expected to be negative:

$$\frac{1}{T}\sum_{t=1}^{T}\frac{\delta w_{it}}{\delta t} = \theta_1 + \theta_2 r_2 + \ldots + \theta_k r_k < 0 \quad \text{where } r_k = \frac{K}{T}\sum_{t=1}^{T} t^{k-1} \quad (10)$$

We can test the null hypothesis of no convergence, $H_0 : \acute{r}\,\Theta \geq 0$, against the alternative hypothesis $H_1 : \acute{r}\,\Theta \leq 0$, using OLS estimation of (9) and a simple t-test. A rejection of the null hypothesis implies convergence to the group mean.

Data for the 9 countries are used in this analysis, which covers the period from 1961 to 2009. TFP growth is measured by using one output and five inputs. The inputs are land, labor, fertilizer, livestock and machinery. Data are from FAO Agrostat database.

International Journal of Agricultural Management & Development, 1(4): 241-245, December, 2011.

## RESULTS AND DISCUSSION

Average Malmquist indices and components are reported in Table 1. Notice from Table 1 that, the highest TFPCH growth rate, among countries, has been observed in Iran and Somalia (1.1percent), followed by Tunisia (1 percent). While Uganda, Kenya, Sudan and Mozambique have experienced growth less than 1 percent. Burundi and Rwanda have shown a declining trend during the period under study.

The decomposition of TFPCH into its components suggests that in the period 1961 to 2009, in neither of countries, impressive productivity growth is not due to 3 components of productivity. Also the source of the productivity growth mainly was progress in technology rather than an efficiency increase. However, Kenya, Burundi and Rwanda has shown decline in the technical change. This result indicates that these countries have potential to increase their productivity through improving technology level. In addition to, among the three components of TFPCH, the change in PECH except for Tunisia and Kenya, and SECH except for Kenya and Sudan, had remained unchanged for all other countries under study. This was also evidenced by Arnad (1998), who argued that in many developing countries, the increased technical change associated with decline inefficiency may arise from the unfamiliarity with the new technology.

Table 2 presents our results relating to testing for convergence to the mean for productivity growth, using the approach of Nahar and Inder (2002). Based on the average slope estimates of the squared demeaned TFP levels, five countries, Burundi, Kenya, Somalia, Tunisia and Uganda appear to be converging to the mean. Among these countries, Burundi and Uganda have the highest mean at a rate of 0.02%, and 0.01% per annum respectively and the rest show a much more modest convergence pattern. On the opposite, four countries –Iran, Mozambique, Rwanda and Sudan- have positive average slopes with significant values, suggesting a divergence from the mean. In other words, the productivity gaps are not narrowing or these regions are not catching up to average region. With regards to the results of productivity in Table 1, Burundi and Rwanda experienced productivity losses, but only Burundi country is converging to the mean

Table 1: Summary of decomposition of Malmquist indices for the period1961 to 2009

| country | TECCH | PECH | SECH | TFPCH |
|---|---|---|---|---|
| Tunisia | 1.003 | 1.006 | 1.000 | 1.01 |
| Somalia | 1.011 | 1.000 | 1.000 | 1.011 |
| Uganda | 1.008 | 1.000 | 1.000 | 1.008 |
| Kenya | 0.999 | 1.003 | 1.002 | 1.005 |
| Iran | 1.011 | 1.000 | 1.000 | 1.011 |
| Burundi | 0.951 | 1.000 | 1.000 | 0.951 |
| Rwanda | 0.969 | 1.000 | 1.000 | 0.969 |
| Sudan | 1.002 | 1.000 | 1.001 | 1.003 |
| Mozambique | 1.005 | 1.000 | 1.000 | 1.005 |

Table 2: Time series estimates of convergence

| country | Polynomial order | Average slope | t-statistic |
|---|---|---|---|
| Burundi | 2 | -0.000182 | -11.10* |
| Iran | 3 | 0.000035 | 14.78** |
| Kenya | 5 | -0.000029 | -5.81* |
| Mozambique | 2 | 0.000010 | 5.31** |
| Rwanda | 3 | 0.000481 | 27.82** |
| Somalia | 2 | -0.000038 | -6.93* |
| Sudan | 2 | 0.000009 | 4.91** |
| Tunisia | 6 | -0.000041 | -7.44* |
| Uganda | 3 | -0.000105 | -3.52* |

*Convergence, significant at the 5% level
**Divergence, significant at the 5% level

TFP. These findings are sustained by the fact that Burundi with low productivity levels manage to grow faster than others with a higher productivity level.

## CONCLUSIONS

This paper analyses productivity growth and its convergence in Iran and Eastern African countries from 1961 to 2009. We used Malmquist index for calculating TFP growth and time series tests to determine if there is narrowing down of productivity dispersion or catch up in regional productivity to a certain level. Results show that generally productivity is low in sample under study. So that improvement technology made the largest contribution to the TFPCH. This result shows how R&D can be an important element of agricultural policy in these countries. There is evidence of time series convergence in agriculture among 5 countries of Africa (Burundi, Kenya, Somalia, Tunisia and Uganda) towards average TFP estimate. This is a positive finding, from a policy perspective, as it implies possible reduction in agricultural productivity in long-run. In other words, these countries managed to make better use of new available technologies, thus reaching far greater productivity levels than others. On the opposite, there is not tendency towards convergence among the rest of African countries and Iran. As the highest rate of divergence is nearly 0.05% in Rwanda country.

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