Agricultural Productivity and Economic Growth: Empirical Analysis on the Contemporary Developing Countries
Introduction

It seems there is a general consensus that agriculture is less productive than the non-agriculture sectors in terms of value creation. In other words, most countries that have larger non-agriculture sector in relative terms are richer than those whose economies dominated by agriculture. However, the role of agriculture in achieving sustainable economic growth is still debatable. Does investing in the agriculture sector have higher degree of relevance in accelerating the overall growth of such economies beyond increasing agricultural productivity? Or does it affect the prospect of other sectors negatively and, hence, the overall long-term growth of the economy? Such questions have not been answered contention.

On the one hand, there is an argument that takes growth in agriculture as a precondition for industrialization. Among the earlier development economists the works of R. Nurkse (1953) and that of W.W. Rostow (1960) are worth mentioning. Nurkse made agriculture as a prerequisite for industrialization by saying that “everyone knows that the spectacular industrial revolution would not have been possible without the agricultural revolution that preceded it,” and similarly Rostow argued that “revolutionary changes in agricultural productivity are an essential condition for successful take-off.” The idea behind this view is that as agricultural productivity increases countries are able to produce more food with less labor input which allows them to feed their growing population while releasing labor for manufacturing sector. Moreover, the increase in income and the surplus created in the agriculture sector would create demand for the manufacturing products and serve as a means to finance the manufacturing sector, respectively.

On the other hand, by mentioning the fact that some countries and regions with lesser agricultural productivity have managed to industrialize earlier than those with higher agricultural productivity, there are people who argue that there is a negative link between agricultural productivity and industrialization. Here again, the works of Mokyr(1976) which is the comparative study of industrialization in Belgium and the Netherlands, and that of Field (1978) and Wright (1979) which are comparative studies on industrialization in New England (i.e. the north eastern part of the US) and the South of the US. According to this view, the manufacturing sector has to compete with the agriculture sector for labor. Low productivity in agriculture implies the abundant supply of “cheap labor” which the manufacturing sector can rely on. Matsuyama has made an attempt to theoretically explain why these apparently conflicting views and facts towards the role of agricultural productivity in the long-run economic growth of
countries exist. He argues that that “the key to understanding these two conflicting views can be found in the difference in their assumptions concerning the openness of economies”. He argues if we assume a closed economy, “an exogenous increase in agricultural productivity shifts labor to manufacturing and thereby accelerates economic growth”. Thus, his closed economy model provides a formalization of the conventional wisdom. If we assume an open economy, he argues, “high productivity and output in the agricultural sector may, without offsetting changes in relative prices, squeeze out the manufacturing sector and the economy will de-industrialize over time, and, in some cases, achieve a lower welfare level.”

In this short paper, I attempt to test empirically the impact of agricultural productivity on the long-run economic growth of the contemporary developing countries. Particularly, I identified those developing economies which had reasonably large relative size of agriculture sector in the early 1980’s, and checked the relationship between the productivity of their agriculture sector and the growth of their economy in the past two and half decades using the data from World Bank (WDI, 2008) and employing Ordinary Least Squares (OLS) and panel data regression techniques. Such relationship is examined whether it is dependent up on the openness of the economies as Matsuyama argues. In order to see clearly the impact of openness of the economies, of the identified countries only those which are considered to be highly closed and highly open economies are peaked. Some countries are also further dropped due to lack of data in one or more important variables.

The empirical model is specified by augmenting the MRW’s (1992) version of Solow growth model in order to take into account the role of agricultural productivity in growth. An interactive dummy variable also introduced in the model in order to check and measure the impact of openness in this relationship.

The findings of this empirical paper suggest Matsuyama’s prediction regarding the relationship between productivity in the agriculture sector and growth is only partially consistent with the evidences from the contemporary developing countries. As the theory predicts the openness of economies negatively affects the gains in the economic growth from improvement in the agricultural productivity, however, this effect is not strong enough to cause either a long-run negative relationship between economic growth and agricultural productivity in the contemporary developing countries which are assumed to be open (which Matsuyama called

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1. N. Gregory Mankiw; David Romer; David N. Weil (1992)
welfare loss) or to bring large differences in the gains from agricultural productivity between the open and closed economies.

Theoretical Foundation

In his seminal theoretical paper, Matsuyama (1996) has made an attempt to reconcile the apparently conflicting views towards the role of agricultural productivity in the long-run economic growth of countries by arguing that “the key to understanding these two conflicting views can be found in the difference in their assumptions concerning the openness of economies. Note that the logic behind the conventional wisdom crucially rests on the implicit assumption that the economy is an effectively closed system. This assumption, which may be appropriate for Britain during the half-century of the Seven Year War, the War of American Independence, the French Revolution, and the Napoleonic Wars, should not be taken for granted for many developing countries.”

In an attempt to highlight the point made above, the paper presents an endogenous growth model. The model is essentially a two-sector model with one mobile factor (called labor) combined with diminishing returns technologies. There are two additional features. First, preferences are non-homothetic and the income elasticity of demand for the agricultural good is less than unitary. Second, manufacturing productivity rises over time because of learning-by-doing.

For the closed economy case, the paper argues, an exogenous increase in agricultural productivity shifts labor to manufacturing and thereby accelerates economic growth. The model therefore provides a formalization of the conventional wisdom, which asserts, at least, countries having a comparative advantage in agricultural in their early stage of development could speed up their growth and structural transformation by investing in agriculture.

For the open economy case, however, there exists a negative link between agricultural productivity and economic growth. The paper argues that, in an open trading system, where prices are mainly determined by the conditions in the world markets, a rich endowment of arable land (and natural resources) could be a mixed blessing. High productivity and output in the agricultural sector may, without offsetting changes in relative prices, squeeze out the manufacturing sector and the economy will de-industrialize over time, and, in some cases, achieve a lower welfare level. The paper argues “ Economies which lack arable land and thus
have the initial comparative (but not necessarily absolute) advantage in manufacturing, on the other hand, may successfully industrialize by relying heavily on foreign trade through importing agricultural products and raw materials and exporting manufacturing products, as recent experiences in the newly industrialized economies in East Asia suggest. An economy with less productive agriculture allocates more labor to manufacturing and will grow faster. For a sufficiently small discount rate, it will achieve a higher welfare level than the rest of the world." Thus, if the prediction of the model is true, we will have different policy prescription to developing countries having reasonable size of agriculture sector depending on the openness and the size of their economy.

Some Descriptive Discussions

Here, the paper tries to look at the evolution of some closed and open economies that had a relative comparative advantage in agriculture in the early 1980’s graphically.

The first group of countries comprises China, India, Indonesia and Bangladesh. Based on Matsuyama’s definition, this paper identified these economies as highly closed economies: they have very large population (i.e. big domestic market) and they had limited relative external trade for long (i.e. it was relatively difficult to freely access the domestic market for long).
It is seen from the graphs that productivity of labor in agriculture has been increasing steadily in all of the four economies while their overall economy has been growing at a relatively faster rate than the agriculture sector for long. At the same time, in all the four countries we see evolution in the structure of their economy: the share of agriculture has been steadily declining while the shares of the other sectors, particularly service and manufacturing, have been increasing. This is consistent with Matsuyama’s argument about the closed economies which has a comparative advantage in agriculture: the improvement in the productivity of agriculture does not seem to hinder, rather helps, the growth and structural evolution of the economies.

The second group of countries comprises Malaysia, Belarus, Bosnia, Estonia, Guyana, Lesotho, Mauritius, Moldova and Tajikistan. Here, the paper chooses a larger group of countries in order to the existing variation among the countries. Based on Matsuyama’s definition, the paper identified these economies as highly open economies: they have relatively small population and, above all, the domestic market is open that could be easily accessed by the external world.
In the seven of the nine economies, average income from agriculture has been growing steadily and is higher than the GDP per capita of the economies for decades. Of the seven economies, five of them (i.e. Belarus, Bosnia, Moldova, Guyana and Tajikistan) were stagnant for decades. In contrast, the two economies (i.e. Estonia and Lesotho) which didn’t experience improvement in their agricultural productivity experienced a steady economic growth. These seem again consistent with Matsuyama’s prediction. However, the fact that the other two highly open economies (i.e. Malaysia and Mauritius) have been experiencing a parallel growth of agricultural productivity and economic growth is something that can’t be explained by Matsuyama’s model.

Model Specification

Basically this paper attempts to test the relevance of Matsuyama’s prediction for the contemporary developing country. It tries to answer the question whether or not agricultural productivity played a role in accelerating the growth of the contemporary developing countries in the last two and three decades? If so, was that dependent up on the size and openness of the economies as Matsuyama’s model predicts?

In order to answer these research questions, the paper uses MRW’s version of the Solow growth model as a starting point. In this model, a Cobb-Douglas production function of the following type is assumed where production at time t is given by:

$$Y_t = K_t^a A_t L_t^{1-a} \quad (1)$$

Where Y is output, K is physical capital stock, L is labor and A is technology.
For this specific study purpose, however, the above model is augmented by $G$, which is a
variable introduced to take into account the role of agricultural productivity in growth and to
partially explain the role of $A$ in the growth regression which is not normally estimated in the
Solow mode.

$$Y_t = K_t^{\alpha} G_t^{\beta} A_t^{1-\alpha-\beta}$$  \hspace{1cm} (2)

$A$ and $L$ are assumed to grow exogenously at rates $n$ and $a$, respectively:

$$A_t = A(o) e^{at}$$  \hspace{1cm} (3)

$$L_t = A(o) e^{nt}$$  \hspace{1cm} (4)

The number of effective units of labor, $A_t L_t$, is growing at rate $(a+n)$. The model assumes that
constant fractions of output, $S_k$ and $S_g$, are invested in the physical capital stock and on
agricultural technology, respectively. Defining $y_t = Y_t/AL$, $k_t = K_t/AL$, $g_t = G_t/AL$ as quantities per
units of effective labor, the evolution of $k$ and $g$ is governed by:

$$\frac{dk_t}{dt} = s_k y_t + (n + a + \delta) k_t$$  \hspace{1cm} (5)

$$\frac{dg_t}{dt} = s_g y_t + (n + a + \delta) g_t$$  \hspace{1cm} (6)

Where $\delta$ is the rate of depreciation. Here, it is assumed that the same production function implied
for physical capital, agricultural technology and consumption. In other words, one unit of
consumption is transformed costlessly into either one unit of physical capital or one unit of
agricultural technology. In addition, it is assumed that agricultural technology depreciates at the
same rate as physical capital. Here, it is believed that, at least for initial examination, it is natural
to assume that the two types of production functions are similar. The above two equations imply
that the economy converges to its steady state defined by:

$$k^* = \frac{(S_k^{1-\beta} S_g^\beta)^{1/(1-\alpha-\beta)}}{(n + a + \delta)}$$  \hspace{1cm} (7)

$$g^* = \frac{(S_k^{1-\alpha} S_g^\alpha)^{1/(1-\alpha-\beta)}}{(n + a + \delta)}$$  \hspace{1cm} (8)

Substituting into the production function and taking logs, would give:

$$\ln(Y_t/L_t) = \ln A(o) + a_t - [(\alpha + \beta) / (1-\alpha-\beta)] \ln(n + a + \delta) + [\alpha / (1-\alpha-\beta)] \ln S_k + [\beta / (1-\alpha-\beta)] \ln S_g$$  \hspace{1cm} (9)
This equation shows how income per capita depends on population growth, accumulation of capital and agricultural technology. In this model, it is assumed that ‘a’ and δ are constant across countries. In contrast, A(0) term reflect not only the non agricultural technology but resource endowments, climates, institutions and so on; it may therefore differs across countries.

MRW assumed that

\[ \ln A(0) = C + \varepsilon, \]  

(10)

where C is a constant and \varepsilon is country-specific shock. By assuming that the rate of population growth (n) and savings (Sk and Sg) as independent from country specific-shock, MRW identified their empirical specification in the following manner:

\[ \ln \left( \frac{Y_t}{L_t} \right) = C + \frac{\alpha}{(1-\alpha-\beta)} \ln S_k - \frac{(\alpha + \beta)}{(1-\alpha-\beta)} \ln (n + a + \delta) + \frac{\beta}{(1-\alpha-\beta)} \ln S_g + \varepsilon \]  

(11)

Their assumption implies that the above equation can be estimated with ordinary least squares (OLS).

This paper also tries to test its major research question by using this empirical specification. In order to take into account the impact of openness of an economy on the relationship between per capita income and agricultural productivity, I introduced a dummy variable, D, that interacts with lnSg. The interactive dummy variable takes 1 for those economies that are assumed to be open and 0 for those economies that are assumed to be closed. If openness affects the impact of agricultural productivity on per capita income negatively as the theory predicts, then we will have a negative and statistically significant value as an estimate of the parameter coefficient, γ, of the interactive variable, D*lnSg.

\[ \ln \left( \frac{Y_t}{L_t} \right) = C + \frac{\beta}{(1-\alpha-\beta)} \ln S_g + \gamma D*\ln S_g + \frac{\alpha}{(1-\alpha-\beta)} \ln S_k - \frac{(\alpha + \beta)}{(1-\alpha-\beta)} \ln (n + a + \delta) + \varepsilon \]  

(12)

Assuming openness have a negative impact on the relationship between income and agricultural productivity, the overall impact of agricultural productivity on income would be positive, negative or zero depending on the estimated value of the coefficient, γ, and the estimated value of the coefficient \[ \frac{\beta}{(1-\alpha-\beta)} \]. In this model, impact of agricultural productivity on per capita income is mathematically given by:
In addition, by taking the advantage of the available time series data and the developments in econometrics in a panel data analysis technique, this paper goes beyond this specification. The paper tries to control the effect of time invariant or slow moving country specific variables by introducing $\eta$ and year in the above regression. For this purpose, the empirical specification for the panel regression is given by:

$$
\ln(Y_t/L_t) = C + \left[\frac{\beta}{1-\alpha-\beta}\right] \ln S_{g} + \gamma D \ln S_{g} + \left[\frac{\alpha}{1-\alpha-\beta}\right] \ln S_{k} - \left[\frac{\alpha+\beta}{1-\alpha-\beta}\right] \ln(n+a+\delta) + \eta + \text{year} + \varepsilon \quad (14)
$$

Data and Samples

The data are from the World Bank’s world development indicators (WDI, 2007). The data set includes real per capita income (2000 US $), real average agricultural productivity (2000 US $), working age population, real gross capital formation as a percentage of GDP, real value of exports and imports as percentage of GDP for 46 developing countries that are considered to have reasonable relatives size of agricultural sector by the year 1981. The data are annual and cover the period between 1981 and 2005.

For the OLS regression, the dependent variable, per capita GDP, is taken as real per capita GDP in 2005. I measure $n$ as the average annual growth rate of the working age population and $s$ as the average real gross capital formation as percentage of GDP for the period between 1981 and 2005. Real agricultural productivity is directly taken as explanatory variable. To take into account the degree of openness of economies a dummy variable $D$ is introduced as an interactive variable with agricultural productivity in the model. Countries whose average values of exports plus imports as a percent of GDP is greater than 100 percent for the period between 1981 and 2005 are considered to be open and take the value $D=1$ while countries whose average values of $2$

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2 Of the total countries having agricultural value added 15 percent and above of their GDP countries are dropped either to have a clear distinction between open and close economy or due to lack of data on the other variables.
exports plus imports is less than 50 percent of their GDP for the same period are considered to be closed and take the value D=0.

For the panel data regression, the each five years starting from 1981 are considered as one period; this implies each country normally have five periods data that include 1981-85, 1986-90, 1990-95, 1995-2000 and 2000-05.

Result

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>OLS</th>
<th>Panel Data Regression</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fixed-effects (within)</td>
<td>Random-effects GLS regression</td>
</tr>
<tr>
<td>lnnavapw</td>
<td>0.8363*** (0.0557)</td>
<td>0.5584** (0.1943)</td>
</tr>
<tr>
<td>D*lnnavapw</td>
<td>-0.05162** (0.02212)</td>
<td>0.1944 (0.1797)</td>
</tr>
<tr>
<td>lngcfpgdp</td>
<td>0.6241** (0.2558)</td>
<td>0.1321** (0.0537)</td>
</tr>
<tr>
<td>lnlfg</td>
<td>-0.01340 (0.4161)</td>
<td>0.0877 (0.0735)</td>
</tr>
<tr>
<td>year</td>
<td>0.0059 (.0042)</td>
<td>0.0023 (0.0018)</td>
</tr>
<tr>
<td>Constant</td>
<td>2.1297 (1.2424)</td>
<td>-8.8216 (7.675)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.8838</td>
<td>within= 0.5338</td>
</tr>
<tr>
<td></td>
<td></td>
<td>between= 0.5182</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of obs</td>
<td>46</td>
<td>213</td>
</tr>
<tr>
<td>Number of groups</td>
<td>46</td>
<td>46</td>
</tr>
<tr>
<td>Av obs per group</td>
<td>4.6</td>
<td>4.6</td>
</tr>
</tbody>
</table>

Hausman Test

Test: H0: difference in coefficients not systematic

\[
\chi^2(5) = (b-B)'[(V_B-V_B)^{-1}](b-B)
\]

\[
= 1.24
\]

Prob>\chi^2 = 0.9407

As it is seen from the OLS regression, the coefficient of the explanatory interactive variable, D*lnnavapw, is statistically significant value with the expected negative sign. As a result, the
positive impact of agricultural productivity on per capita GDP of “open” economies is slightly less than that of closed economies. One percent increases in the agricultural productivity is associated with 0.84 percent increase in per the capita GDP of the closed economies while it is associated with 0.78 percent increase in the open economies.

When we look at the panel regression, the overall findings are more or less the same as the findings of the OLS regression. However, we need some econometric discussion in order to see the different results that are obtained from using different models of panel data regression.

The fixed-effect regression, which controls for time-invariant country-specific unmeasured variables (η_i), suggests openness has no statistically significant role on the relationship between agricultural productivity and growth. The fixed effect regression assumes that there are country-specific unmeasured variables (η_i) which are correlated with one or more of the regressors - agricultural productivity (lnavgp), the rate of gross capital formation (lngcfpgdp) and growth rate of the labor force (lnglf). However, the hausman test suggests that it is very difficult to reject the hypothesis that says – the unmeasured country-specific time-invariant variables are uncorrelated with the regressors. In such circumstances, it is better to assume that η_i are uncorrelated with the regressors. This implies the random effect regression gives us better results than the fixed effect regression.

The random effect regression suggests almost the same as what the OLS suggested. The positive impact of agricultural productivity on per capita GDP of “open” economies is again slightly less than that of closed economies. One percent increases in the agricultural productivity is associated with 0.83 percent increase in per the capita GDP of the closed economies while it is associated with 0.79 percent increase in the open economies. The random effect regression assumes that both η_i and the error term (ε_it) are homoskedastic and normally distributed, and uses the Maximum Likelihood Estimator which is the most efficient estimator in large samples. The validity of the standard errors for the random-effect estimator, however, depends on the assumption of homoskedasticity which we can’t guarantee. In connection to this, econometricians suggest that even if the error terms are not homoskedastic the pooled OLS regression with clustered standard errors produce valid result.

The results of the pooled-OLS regression again suggest the same as the OLS and the random-effect except the fact that the impact of agricultural productivity on per capita GDP is higher for
both types of economies as compared to the respective impacts seen in the other panel data regression models.

Conclusion

The findings of this empirical paper suggest Matsuyama’s prediction regarding the relationship between productivity in the agriculture sector and growth is only partially consistent with the evidences from the contemporary developing countries. As the theory predicts the openness of economies negatively affects the gains in the economic growth from improvement in the agricultural productivity, however, this effect is not strong enough to cause either a long-run negative relationship between economic growth and agricultural productivity in the contemporary developing countries which are assumed to be open (which Matsuyama called welfare loss) or to bring large differences in the gains from agricultural productivity between the open and closed economies.

Reference