Impact of Agricultural Productivity Changes on Poverty Reduction in Developing Countries

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Abstract

We use multiple measures of agricultural total factor productivity (TFP) change to examine the relationship between agricultural productivity and poverty in developing countries. We employ a stochastic frontier analysis to estimate agricultural TFP changes for 113 countries using output distance function in a multi input multi output framework. We then make alternative groupings of countries to allow for the possibility of different production frontiers for countries with different income level, and we examine the effect of these various measurements of agricultural TFP on poverty reduction. Results from the TFP analysis show that TFP change estimates by income groups differ from those estimated using all countries in a pooled model. This indicates that agricultural technology and production frontiers may differ across countries based on income levels. Preliminary results show that TFP change from the pooled model has significant impact on poverty reduction. However, TFP estimates from different income groups didn't indicate significant impact on poverty. The relationship between TFP change and poverty is therefore sensitive to the method used to estimate agricultural productivity.

Keywords: Total factor productivity, Poverty, Developing countries, Frontier analysis

1. Introduction

In the 21st century, agriculture continues to be a fundamental instrument for sustainable development and poverty reduction (WDR, 2008). The World Development Report (2008) summarizes that the $1 per day poverty rate in developing countries has declined from 28% in 1993 to 22% in 2002. However, there are still 2.1 billion people living on less than $2 a day and 880 million on less than $1 a day, and most of them depend on agriculture for their livelihoods. Promoting agriculture is important for meeting the Millennium Development Goal of halving poverty and hunger by 2015. Agricultural productivity growth is vital for stimulating agricultural growth in developing countries. Agricultural productivity can contribute to development in many ways: by increasing agricultural production, increasing income, increasing food security, and by reducing poverty. Many empirical studies have shown that agricultural productivity can significantly reduce poverty. However, in most of the studies single factor productivity i.e. land productivity and/or labor productivity has been used. It is important to know how agricultural production changes when all the factors of production varies together. In this paper, we use total factor productivity to study its impact on poverty. We use stochastic frontier analysis to estimate TFP change for low income countries, middle income countries, and by pooling 113 countries together. Then, we use these TFP estimates to examine their effect on poverty.

This paper is organized as follows. Section 2 briefly reviews the literature on agricultural productivity and poverty reduction in developing countries. Section 3 discusses the empirical model and data used in the econometric estimation. Section 4 focuses on results and discussion and Section 5 concludes preliminary findings of the paper.

2. Agricultural Productivity and Poverty

Agricultural growth has long been characterized as pro-poor and as a crucial determinant of poverty reduction, but empirical estimates of this relationship are still limited (Janvry & Sadoulet, 2009). The literature identifies several potential linkages between agricultural productivity and poverty through multiple pathways including increases in food production, food price reductions, employment generation, and increases in real income.

Datt and Ravallion (1998) found output per unit of land significantly affects the poverty gap in India. They examined the impact of farm productivity and showed that higher yield significantly reduce poverty via rising average living standards. They found that even small impact of agricultural growth on food prices can have larger effects on reducing poverty. In another study (Datt & Ravallion, 1996), they showed that in India, rural growth reduces poverty both in rural and urban areas, but urban growth does not alleviate rural poverty. Studies by Woden (1999) in Bangladesh and by Thorbecke and Jung (1996) in Indonesia indicated show findings. Agricultural growth is important for rural as well as urban areas in developing countries.

The empirical evidence show that higher rates of agricultural labor productivity relative to the modern sector productivity are associated with lower poverty headcounts in Sub-Saharan Africa and South Asia, but not in Latin America (Hanmer & Nashchold, 2000). Significant positive impact of research-led agricultural productivity growth to poverty reduction in developing countries is illustrated in Thirtle et al. (2003). Their results show that investment in agricultural R&D significantly increases agricultural value added in Africa and Asia, and it has substantial effect on poverty reduction.

Ravallion and Chen (2007) provide evidence of important role of agricultural development in explaining poverty reduction in China. Their study also supports the pro-poor nature of agricultural and rural growth as compared to growth in non-farm activities. In a cross country study, Self and Grabowski (2007) found that agricultural productivity plays crucial role in originating growth and improving well being.

Janvry and Sadoulet (2009) used agricultural land and labor productivity to study their impact on reducing rural poverty. They found that growth in yield and in agricultural labor productivity are highly associated with poverty reduction, but the extent to which they affect poverty sharply varies across regions. Their findings indicate that poverty reducing impact of agricultural growth is higher in poor countries than in rich countries. They also found that agricultural productivity can indirectly affect poverty through strong growth linkage effect on other sectors of the economy.

All of these studies support the role of agricultural development for the poor. There is strong evidence of increasing agricultural productivity and poverty reduction in developing countries. Most of these studies use partial productivities and examine their impact on poverty reduction. It is important to study the impact of agricultural total factor productivity on poverty reduction in order to understand impact of agricultural growth on poverty in a broader view. There is a limited empirical literature on the impact of total factor productivity (TFP) growth on poverty reduction. Fan, et al. (2000) examined the relationship between TFP and poverty reduction in a single country case, where they used a TFP growth index as the ratio of an aggregated output index to an aggregated input index.

The objective of this paper is to investigate the relationship between agricultural total factor productivity and poverty in developing countries. We estimate output distance functions using stochastic frontier analysis (SFA) to calculate TFP change for a panel of 113 countries. We then make alternative groupings of countries to allow for the possibility of different production frontiers for countries with different income level, and we examine the effect of these various measurements of agricultural TFP on poverty reduction. We prefer SFA over other available methods because SFA can be used when price information on inputs and outputs is not available. It is very unlikely to get data on prices for developing countries. Moreover, SFA involves estimation of parametric production function which can separate noise in the data from variations in efficiency (Headey, et al., 2010).

3. Methodology and Data

We estimate a translog output distance function in a multi-output, multi-input framework as

$$\ln D_0 = \alpha_0 + \sum_{m=1}^{M} \alpha_m \ln y_{mit} + \frac{1}{2}\sum_{m=1}^{M}\sum_{n=1}^{M} \alpha_{mn} \ln y_{mit} \ln y_{nit} + \sum_{k=1}^{K} \alpha_k \ln x_{kit} + \frac{1}{2}\sum_{k=1}^{K}\sum_{l=1}^{K} \alpha_{kl} \ln x_{kit} \ln x_{lit} + \frac{1}{2}\sum_{k=1}^{K}\sum_{m=1}^{M} \alpha_{km} \ln x_{kit} \ln y_{mit} + \delta_t t + \sum_{m=1}^{M} \alpha_{ym} \ln y_{mit} t + \sum_{k=1}^{K} \alpha_{xk} \ln X_{kit} t + \frac{1}{2}\delta_{tt} t^2 \qquad (1)$$

where D_0 is the unobservable value of the output distance function. i is index of countries, t represents time period, X is a vector of inputs, and Y is a vector of outputs. To write the above equation in a standard stochastic frontier framework, we impose homogeneity and symmetry restrictions as described in Lovell et al (1994) by normalizing the function by one output. To write the above equation in a standard stochastic frontier framework, impositions of homogeneity and symmetry restrictions are required. The restrictions required for homogeneity of degree 1 in outputs are: $\sum_{m=1}^{M} \alpha_{m} = 1$, $\sum_{n=1}^{M} \alpha_{mn} = 0$, $\sum_{m=1}^{M} \alpha_{km} = 0$. The symmetry restriction requires: $\alpha_{mn} = \alpha_{nm}$, $\alpha_{kl} = \alpha_{lk}$. A convenient method of imposing homogeneity restriction in equation (1) is to normalize the function by one output as described in Lovell et al (1994).

Moving ln D_0 (y, x, t) to the right hand side and replacing it with $-u_{it}$ from (2), and adding an additional random error term v_{it}, the output distance function can be written as:

$$- \ln y_{1i} = \alpha_0 + \sum_{m=1}^{M} \alpha_m \ln y_{mit}/y_{1it} + \frac{1}{2} \sum_{m=1}^{M} \sum_{n=1}^{M} \alpha_{mn} \ln y_{mit}/y_{1it} \ln y_{nit}/y_{1it} + \sum_{k=1}^{K} \alpha_k \ln x_{kit} +$$

$$\frac{1}{2} \sum_{k=1}^{K} \sum_{l=1}^{K} \alpha_{kl} \ln x_{kit} \ln x_{lit} + \frac{1}{2} \sum_{k=1}^{K} \sum_{m=1}^{M} \alpha_{km} \ln x_{kit} \ln y_{mit}/y_{1it} + \delta_t t +$$

$$\sum_{m=1}^{M} \alpha_{ym} \ln y_{mit}/y_{1it}\, t + \sum_{k=1}^{K} \alpha_{xk} \ln X_{kit}\, t + \frac{1}{2} \delta_{tt} t^2 + v_{it} + u_{it} \qquad (2)$$

U_{it} is the technical inefficiency effects and in the above equation it is specified as

$$U_{it} = \varphi_0 + \varphi_1 \ln Z_{it} + \varphi_2 D_i \qquad (3)$$

Z_{it} represents inefficiency effects associated with different production environments and D_i represents regional dummies.

While estimating, we use $\ln y_{1i}$ as our dependent variable and reverse the sign of regressors on the right hand side. All the variables are normalized by their respective sample means prior to maximum likelihood estimation. Once the output distance function is estimated, malmquist index of total factor productivity change (TFPC) between two adjacent periods is calculated following Coelli et al. (2005). Equations 2 and 3 are combined and maximum likelihood estimation of the stochastic frontier model is conducted for all countries in a single pooled dataset as well as for subsets of countries based on income levels, location and other factors to examine the effects of different groupings on productivity estimates.

Productivity-poverty model:

We estimate a cross section regression equation for a set of developing countries to examine the impact of TFP change on poverty. TFP can directly affect GDP per capita, poverty, and inequality in a country. So, first we estimate two equations regressing GDP per capita on TFP change and then regressing Gini on TFP change to get the residuals. These residuals can be termed as TFP free GDP per capita and TFP free Gini respectively and are used in the poverty equation. The poverty equation is:

$$P = \beta_0 + \beta_1 TFPC + GDPC\varepsilon + Gini\varepsilon + \theta X + \mu \quad (4)$$

where, $$GDPC = \gamma 0 + \gamma 1\ TFPC + GDPC\varepsilon \quad (5)$$

and $$Gini = \lambda 0 + \lambda 1\ TFPC + Gini\varepsilon \quad (6)$$

P, the poverty head count ratio at $1 per day is used as the dependent variable. GDPC is GDP per capita, Gini represents Gini index, X includes variables other than agricultural TFP included in previous poverty change models and μ is white noise. Equation 4, 5, and 6 are estimated twice, once taking TFPC from small groups (different income groups) estimation and once taking TFPC from pooled sample estimation. We estimate an OLS regression equation robust to heteroscedasticity.

Data

We use country-level annual data on two outputs (crop and livestock output) and five inputs (land, labor, live animals, tractors, fertilizers) from FAOSTAT (2010) from 1961-2002.The outputs are value of net agricultural production in 2004-2006 international dollars. Land represents total agricultural area. Labor represents the economically active population in the agricultural sector. The number of tractors is used as a proxy for machinery. Fertilizer is the total amounts of Nitrogen, Potassium, and Phosphate consumed. The livestock input variable represents sheep-equivalent of five categories of animals. The conversion factors are 8.0 for buffalo and cattle, 1.0 for sheep, goat, and pigs (Hayami & Ruttan, 1970). Rainfall is used to account for inefficiency and is used in the inefficiency equation. Rainfall variable, collected from Mitchell et al. (2003) represents annual precipitation in a country. Recent data on annual precipitation has been obtained directly from the author upon request.

For the poverty equation, all the variables are collected from World Development Indicators (2007). Poverty headcount ratio at $1 per day is used as the dependent variable. GDP per capita is used as a proxy for level of development of countries. Gini index is used to account for level of inequality in a country. We expect that TFP is positively related to GDP per capita. We also expect that increase in TFP leads to lower poverty rate and greater equality. Other variables used in the poverty equation are population growth, Gross domestic fixed investment (% of GDP), and trade (exports plus imports as a % of GDP). All the data are extracted from WDI, 2007 CD-ROM. All the variables in the poverty equation are transformed into geometric annual growth rates in logarithm form due to missing years of observation.

4. Results and Discussion

4.1. TFP results

We estimated annual TFP change and cumulative TFP index for all the countries by grouping them based on their income level and also by pooling them altogether. We found that for some countries, the TFP growth rates obtained from the two different samples look similar. However, TFP growth rates calculated from small sample are different from the TFP growth rates obtained from the pooled sample estimation for most of the countries. To the extent they differ from each other varies across countries. Therefore, we expect that the impact of TFP change estimated from small samples and pooled sample on poverty will be different.

4.2. Poverty regression: Preliminary results

Preliminary results from the poverty equation are presented in Table 1. The results indicate a positive and significant relationship between TFP change (pooled sample) and GDP per capita. TFP change obtained from both small samples and pooled sample has a negative and significant impact on Gini, which indicates that increase in TFP decreases inequality. We see a negative and significant coefficient between TFP change (pooled sample) and poverty. It supports the poverty reducing implication of agricultural TFP growth. TFP change variable taken from small sample doesn't show any significant impact on poverty reduction. However, we got very low R^2 in both models, which means there are other relevant variables that can affect poverty in a country. We will take care of this problem in our future analysis.

Table 1: Regression results –Poverty equation

	TFP (Small sample)	TFP (Pooled sample)
Explanatory Variables	Coefficients	Coefficients
GDP Percapita		
TFP	0.017	0.127*
	(0.149)	(0.073)
Constant	0.013***	0.012***
	(0.003)	(0.003)
Gini Index		
TFP	-0.662***	-0.247***
	(0.191)	(0.096)
Constant	0.009***	0.009***
	(0.004)	(0.003)
Poverty		
TFP	0.261	-0.626*
	(0.518)	(0.344)
GDP per capita	-1.037*	-1.120*
	(0.622)	(0.662)
Gini index	1.652***	1.404***
	(0.547)	(0.578)
Fixed investment	0.013	0.066
	(0.160)	(0.164)
Trade	-0.120	-0.118
	(0.128)	(0.117)
Population growth	1.52	1.157
	(1.13)	(1.13)
Constant	-0.056**	-0.036
	(0.026)	(0.029)
R-squared	0.13	0.12

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5. Conclusion

Agricultural growth is essential for poverty reduction in developing countries. And agricultural total factor productivity is important factor determining agricultural growth. However, a country's performance differs when a regional frontier moves than when the global frontier shifts. We employ a stochastic frontier analysis to estimate TFP change for countries with different income levels and then pooling all the countries together. We found that the two TFP measures differ significantly for some countries, where as for other countries the trend in cumulative TFP growth from both samples looks very similar. Based on these results we examined the impact of TFP growth on poverty reduction. We found that increase in TFP (pooled sample) leads to increase in GDP per capita, decrease in inequality as well as poverty reduction. TFP growth also helps decreasing inequality in developing countries. This paper is an early version of our intended study. In future, we aim to explain the differences in the two TFP measures and how that might affect the productivity-poverty relationship.

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