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Changes in the Efficiency of Agricultural Production in Asian Countries

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Abstract. This research presents a framework to describe and analyze data from 14 Asian countries are used to form the cross-sectional units over the period 1961-2004 with emphasis on the agricultural sector in order to examine technical efficiencies by estimated using the stochastic frontier production function approach. A translog production function was used to represent the gross production of agriculture in selected countries. The results show that the estimated elasticity of gross production with respect to labor is 0.61 compared to 0.21 in case of with time trend but labor appears to be the most important factor of gross production. This means that for a 10% increase in the number of labor, gross production will increase by 6.1%. For estimated stochastic frontier model in case of with time trend or technical change, the input elasticity for land slightly decreased to 0.47. However, land elasticity of 0.47 is the highest effective component to increase gross production in Asian countries.

Keywords: Stochastic frontier, Elasticity, Returns to scale

1. Introduction

Much of the past work in estimating production functions focused on the developed world where inefficiency, though present, was not of paramount interest. In developing or underdeveloped continents like Africa and Asia, the focus has been on poverty alleviation and food security, respectively. The underlying outcome of this effort on production functions is the identification, estimation, and examination of elasticity of inputs, technical change, and returns to scale. Production functions have not been as thoroughly measured as well as it has in developed nations. However, when estimating production function in developing countries, accounting for inefficiency is critical (Saleem Shaik, 2008).

Farrell (1957) distinguishes between technical and allocative efficiency (or price efficiency) in production through the use of a "frontier" function. Technical efficiency is the ability to produce a given level of output with a minimum quantity of inputs under a given technology. Allocative efficiency refers to the ability to choose optimal input levels for given factor prices. Numerous studies (e.g. Obwona, 2000; Son *et al*, 1993) have attempted to determine technical efficiencies of farmers in developing countries because determining the efficiency status of farmers is important for policy purposes. Efficiency is also an important factor in productivity growth. In an economy where resources are scarce and opportunities for new technologies are lacking, inefficiency studies will be able to show that it is possible to raise productivity by improving efficiency without increasing the resource base or developing new technology. Estimates of the extent of inefficiency also help in deciding whether to improve efficiency or to develop new technologies to raise agricultural productivity (AA Tijani, 2006).

This research has the purpose to examine the Cobb-Douglas production function, and calculation of returns to scale using the stochastic frontier estimation of production function. Stochastic frontier estimation has become popular tool to estimate the production relationship between input and output. In the research, the Food and Agricultural Organization (FAO) data from 14 Asian countries are used to form the cross-sectional units over the period 1961-2004 with emphasis on the agricultural sector.

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2. Input and Output Agriculture Sector Data for Asian Countries

This analysis considers only four input variables for estimating a production function. These variables include land, labor, capital, and fertilizer (FAO, 2011). The land variable refers to the share of land area that is arable, under permanent crops, and under permanent pastures. Arable land includes land defined by the FAO as land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded. Land under permanent crops is land cultivated with crops that occupy the land for long periods and need not be replanted after each harvest, such as cocoa, coffee, and rubber. This category includes land under flowering shrubs, fruit trees, nut trees, and vines, but excludes land under trees grown for wood or timber. Permanent pasture is land used for five or more years for forage, including natural and cultivated crops.

The capital variable refer to agricultural machinery which covers the number of wheel and crawler tractors (excluding garden tractors) in use in agriculture at the end of the calendar year specified or during the first quarter of the following year.

The labor variable refers to agricultural labor force in thousand people which is the number of economically active persons engaged in agriculture, hunting, forestry or fishing. Economically active persons are defined by the International Labor Organization (ILO) as all persons of either sex who furnish the supply of labor for the production of economic goods and services.

Fertilizer variable refers to fertilizer consumption in metric tons which measures the quantity of plant nutrients used per unit of arable land. Fertilizer products cover nitrogenous, potash, and phosphate.

The output data used in production function is gross production in 1,000 international dollars. The FAO indices of agricultural production show the relative level of the aggregate volume of agricultural production for each year in comparison with the base period 1999-2001. They are based on the sum of price-weighted quantities of different agricultural commodities produced after deductions of quantities used as seed and feed weighted in a similar manner. The resulting aggregate represents, therefore, disposable production for any use except as seed and feed. All the indices at the country, regional and world levels are calculated by the Laspeyres formula. Production quantities of each commodity are weighted by 1999-2001 average international commodity prices and summed for each year. To obtain the index, the aggregate for a given year is divided by the average aggregate for the base period 1999-2001. The average and standard deviations of variables are described in table 1.

Table 1 Average and Standard Deviations of Variables, 1961-2004

Country	Gross production	Land	Machinery	Fertilizer	Labor
			Average		
Bangladesh	7,926,786	94,903	1,981	609,437	31,846
Cambodia	909,987	36,521	1,359	6,621	3,276
China	166,286,186	4,569,899	575,932	18,326,462	420,674
India	90,691,474	1,798,372	784,090	7,978,732	212,808
Indonesia	17,428,681	406,049	2,604	1,481,727	38,391
Myanmar	5,067,396	105,485	85,604	85,604	13,635
Lao PDR	475,960	16,300	157,715	2,455	1,461
Pakistan	15,429,209	255,102	1,365,418	1,365,418	18,925
Philippines	7,200,289	100,305	400,095	400,095	9,859
Korea, Rep.	5,548,082	21,682	49,425	734,017	4,460
Korea, Dem. Rep.	2,388,808	25,409	45,376	450,582	3,690
Sri Lanka	1,564,569	22,937	14,488	162,868	3,028
Thailand	10,654,269	180,366	118,903	696,016	17,345
Vietnam	7,365,863	70,868	50,173	699,220	20,786
			Standard deviation		
Bangladesh	2,129,678	3,919	961	484,320	4,819

Cambodia	327,715	9,077	574	6,564	761
China	9.10e	753,260	342,430	1.39e	78,457
India	3.33e	17,459	778,562	5,930,606	36,257
Indonesia	8,064,933	30,459	2,166	1,101,624	7,789
Myanmar	2,203,979	2,041	64,330	64,330	3,030
Lao PDR	231,500	1,315	133,200	3,264	357
Pakistan	7,234,849	18,515	1,042,810	1,042,810	4,053
Philippines	2,589,735	13,322	239,232	239,232	1,937
Korea, Rep.	2,119,434	1,328	72,562	204,929	1,358
Korea, Dem. Rep.	685,954	1,793	23,351	270,827	159
Sri Lanka	303,873	1,462	3,711	59,762	588
Thailand	4,065,251	32,135	205,809	667,478	2,948
Vietnam	4,131,903	9,669	52,529	707,658	4,812

Source: Own calculation.

Descriptive statistics in Table 1 are the average values and standard deviations used to describe the basic features of the data in this study. Table 1 provides the average values and standard deviations of the gross production variable used in the analysis for the period 1961-2004. China, India, Indonesia, Pakistan, Thailand and Vietnam each have a higher production compared to the average across overall the countries. However, Indonesia, Pakistan, Thailand, Vietnam, China, and Malaysia were the only countries with a relatively higher deviation in the gross production compared to the average of all the countries. This would be reflected in the time-varying of input elasticity and returns to scale estimates.

3. Stochastic Frontier Production Model

A stochastic frontier production model used for testing firm (or country) technical efficiency is the ability of a farmer (or country) to maximize output with given quantities of inputs and a certain technology (output-oriented) or the ability to minimize input uses with a given objective of output (input-oriented). Output-oriented technical efficiency is more commonly used in empirical applications and is defined as stochastic production frontier models were introduced by Aigner, Lovell, and Schmidt (1977) and Meeusen and den Broeck (1977). Let's review the nature of the stochastic frontier problem. Suppose that a country has a production function $f(Z_{it},\beta)$. In a world without error or inefficiency, in time t, the i^{th} country would produce

$$q_{it} = f((z_{it},\beta),t)$$

A fundamental element of stochastic frontier analysis is that potentially produces less than it might due to a degree of inefficiency. Specifically,

$$q_{it} = f((z_{it},\beta),t)\xi_{it}$$

where y denote gross production from vector input z_{it} which are machinery, fertilizer and labor, β is the associated vector of parameter coefficients, and t is the time trend which represents the technical change and ξ_{it} is the error term or the level of efficiency; ξ_{it} must be in the interval (0,1]. If ξ_{it}=1, then the country is achieving the optimal output with the technology embodied in the production function $q_{it} = f(z_{it},\beta)$. When ξ_{it} < 1, the country is not making the most of input z_{it} given the technology embodies in the production function $f(z_{it},\beta)$. Since the output is assumed to be strictly positive (i.e., $q_{it} > 0$), the degree of technical efficiency is assumed to be strictly positive (i.e., $\xi_{it} > 0$). These parameter coefficients are the elasticity of inputs if the vector of inputs and output are in logarithmic form. This research focuses on finding returns to scale of the Asian country and comparing model with time and without time.

3.1 Empirical Results

The estimated stochastic frontier model in case of no time trend, the estimated elasticity of gross production with respect to labor is 0.61 compared to 0.21 in case of with time trend but labor appears to be the most important factor of gross production. This means that for a 10% increase in the number of labor, gross production will increase by 6.1%. For estimated stochastic frontier model in case of with time trend or technical change, the input elasticity for land slightly decreased to 0.47. However, land elasticity of 0.47 is the highest effective component to increase gross production in Asian countries. (see Table 1 from Mundlak, Larson, and Butzer, 1997 and Shaik, 2008).

Table 2 Estimated coefficient of stochastic frontier production function

	No time trend			**With time trend**		
	Coefficient	**Std. Err.**	**P>|z|**	**Coefficient**	**Std. Err.**	**P>|z|**
Land	0.53	0.08	0.00	0.47	0.04	0.00
Machinery	0.16	0.01	0.00	0.05	0.01	0.00
Labor	0.61	0.05	0.00	0.20	0.05	0.00
Fertilizer	0.06	0.01	0.00	0.05	0.01	0.00
Time trend	-	-	-	0.02	0.00	0.00
Constant	2.97	0.65	0.00	7.43	0.35	0.00
Returns to scale	**1.36**			**0.78**		
Returns to scale (trend)				**0.80**		
Mu	1.54	0.28	0.00	0.91	0.24	0.00
Eta	-	-	-	-0.01	0.00	0.00
lnsigma2	-0.43	0.54	0.43	-1.09	0.56	0.00
gamma	3.26	0.57	0.00	3.03	0.60	0.00
sigma2	0.65	0.35		0.34	0.19	
gamma	0.96	0.02		0.95	0.03	
sigma_u2	0.63	0.35		0.32	0.19	
sigma_v2	0.02	0.00		0.02	0.00	
Log likelihood	225.16			364.32		

Source: Own calculation (Land, Machinery, Labor and Fertilizer are presented in logarithmic form).

Interestingly, the elasticity of land, machinery, labor and fertilizer are lower in the model with time trend by 0.06, 0.11, 0.41 and 0.01, respectively compared to the model with no time trend or technical change showing inefficiency use of all variable in the production of output. The estimated returns to scale from both models are 1.36 and 0.78, respectively, for the model of no time trend and with time trend refers to the change in output resulting from a proportional change in all inputs. The lower returns to scale estimates from a stochastic frontier model were dominated by the inefficiency use of land and labor when time is considered.

In conclusion, the results show that the agriculture gross production for Asian countries can be increased with labor and land when time is not concerned which shows increasing returns to scale. When the time is concerned the returns to scale was lower significantly which shows decreasing returns to scale.

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5. References

[1] AA. Tijani. 2006. Analysis of the Technical Efficiency of Rice Farms in Ijesha Land of Osun State, Nigeria. Agrekon, Vol 45, No 2.

[2] Aigner, D. J., C. A. K. Lovell, and P. Schmidt, 1977. “Formulation and Estimation of Stochastic Frontier Production Function Models.” Journal of Econometrics 6(1), 21-37.

[3] FAO, 2011. http://faostat.fao.org/ (Accessed on April 2011)

[4] M. Obwona, et al., 2000. Fiscal Decentralization and Local government Finance in Relation to Infrastructure and Service Provision in Uganda. Consultancy Report: NACAD, EPRC, DANIDA and World Bank,

[5] M.J. Farrell, 1957. ‘The Measurement of Production Efficiency’, Journal of Royal Statistics Society, Series A, 120, pp 253-81,

[6] Meeusen, W. and J. van der Broeck, 1977. ”Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error.” International Economic Review 18(2), 435-444.

[7] S. Saleem., 2008. Accounting for (In) Efficiency in the Estimation of Time-Varying Returns to Scale. Agribusiness and Applied Economics Report No. 635,

[8] TVH. Son, T. Coelli and E., 1993. Fleming Analysis of the Technical Efficiency of State Rubber Farm in Vietnam. Journal of Agricultural Economics 9:183-201,

[9] Y. Mundlak, F.D. Larson, and R. Butzer. , 1997. “The Determinants of Agricultural Production: A Cross-Country Analysis”. Policy Research Working Paper 1827 (Washington, D.C.: The World Bank)