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AN ANALYSIS OF TECHNICAL EFFICIENCY OF VEGETABLE'S HOUSEHOLDS IN MONGOLIA

Amar Uuld[1], Robert Magda[1,2]
[1, 2] Szent Istvan University, [2]North West University, South Africa

Abstract
Efficiency is one of the most important concept in production. Specifically, technical efficiency is expressed as the side of production and defined as the level of production that ratio between the observed output(s) to the potential output(s). The aim of this study is to analyse the technical efficiency of vegetable's households in Khovd province of West region in Mongolia. The Western region is one of main producer in vegetable production and produces approximately 20 percent of total vegetables production in Mongolia (National Statistics office of Mongolia, 2017). We defined the technical efficiency using SFA (Stochastic Frontier Analysis) model. Primary data was collected from 100 vegetable's households in Norjinkhairkhan bag of Buyant soum of Khovd province of Mongolia. Our resukts showed the mean technical efficiency was 34.7% which means that household's vegetable's production could have been increased further by 65.3% at same levels of inputs if households had been technically efficient.
KEY WORDS: Vegetable's production; technical efficiency; stochastic frontier analysis.

Introduction

For Mongolia, vegetable production is one of the most important agricultural products in crop production after wheat and potatoes. In our country, we are planting a variety of vegetables due to the climatic extreme condition such as cabbage, carrots, turnips, onions, garlic, cucumber, tomatoes, watermelon, and a small number of peppers and beet. In 2017, vegetables sown area was 8.4 thousand hectares which have increased by 8.4 times compared to the first year (1960) of vegetables sown area. Total sown area divided into a region, including Central region (60%), Western region (20%), Khangai region (15%), Eastern region (4%) and Ulaanbaatar area (1%). Vegetables main growing area is located in Selenge, Darkhan -Uul, Tuv (Central region) and Khovd (Western region) provinces. Currently, there are 15985 households and 1447 companies are in crop production (Agricultural statistics, 2017). Most of the households in crop sector (approximately 80%) are producing vegetables.

In the recent years, the studies of efficiency have been taken the attention policy makers. But, to date, there is no efficiency analysis for vegetable production in Mongolia. The aim of this study is to measure the technical efficiency of vegetable's household's production in Norjinkhaikhan bag, Buyant soum, Khovd province. Buyant soum is about 25 km far from Khovd city, which divided into 5 bags (Bag is minimum level of our country's) namely, Norjinkhairkhan, Narankhairkhan, Tsagaan Burgas, Tsagaan ereg and Tsagaan burgas. In total 800 households and 3000 peoples live in this soum. Norjinkhairkhan bag is main vegetable's planting area in Buyant soum.

According to statistics, the total sown area was 600 ha, total harvest was 5200 ton for potato and 3800 ton for vegetables, which are producing 60% of total harvest of Khovd province.

Materials and methods

a) Stochastic frontier analysis

Since the seminal work of Farrell (1957), there are two widely used methods of measuring the efficiency of a decision making unit: The Data Envelopment Analysis (DEA) - non-parametric approach and the Stochastic Frontier Analysis (SFA)- parametric approach. (Dennis J.Aigner, 1976) proposed the stochastic frontier production function to account for the presence of measurement error in production in the specification and estimation of frontier production functions. Other dual frontiers, such as a cost, revenue frontier and profit frontier, are defined in similar manner. Cost frontier represents the minimum expenditure on inputs required to produce output (Lovell, 1995).

Stochastic frontier production functions have two error terms, one to account for the existence of technical inefficiency of production and the other to account for factors such as, measurement error in the output variable, luck, weather, etc. and the combined effects of unobserved inputs on production (Battese, 1995). According to Aigner et al. (1977), the general form of SFA model:

$$ln y_{it} = \ln f(Z_{it},\beta) + v_{it} - u_{it}$$
$$\varepsilon_{it} = v_{it} - u_{it}$$

Where *ln* indicates the natural logarithm function form, y_{it} represents the vector of the output of i^{th} firm, Z_{it} denotes a set of inputs and β is the associated vector that describes technology parameters to be estimated. ε_{it} refers to the composed error term consisting of v_{it}, is two-side random noise distributed to be normal distribution as $N(0; If_v^2)$, and u_{it}, the technical inefficiency part, is one-side error term that assumed to be independent to u_{it} with half-normal distribution of $N^+(0;\ If_u^2)$. The error component u_i needs to satisfy the assumption $u_{it} \geq 0$. u_{it} and v_{it} are independent. i = 1,2, …, N; N is number of total observations, and t is time variable measured as year, t = 1,2, …, T.

The majority of the applications which try to explain the distinctions in technical efficiencies of farmers use a two-stage approach. The first stage includes the estimation of a stochastic frontier production function and the prediction of farm level technical inefficiency effects (or technical efficiencies). In the second stage, these predicted technical inefficiency effects (or technical efficiencies) are related to farmer-specific factors using ordinary least square regression. This approach seems to have been first used by (Kalirajan, 1981). This method has been criticized since the identical distribution assumption on the inefficiencies in the first step contradicts with the regression of the second step by subverting the variation due to inefficiency (Holtkamp, 2016).

Furthermore, correlations between the firm characteristics and the inputs may exist, leading to biased estimates (Wang, Schmidt, 2002). The Cobb-Douglas and translog models mostly dominate the applications literature in stochastic frontier and econometric inefficiency estimation and literature in DEA—by construction—is dominated by linear formulations (Greene, 2007). For our estimations, we choose the general empirical model in the form of the Cobb-Douglas production function. Cobb-Douglas production function of SFA model can be written as:

$$lny_{it} = \beta_0 + \sum_{j=1}^{8} \beta_i\, lnz_{jit} + v_{it} - u_{it}$$

Where, y_{it}- is total vegetable production of household, by ton. z_{ji}- is vegetable production inputs j^{th} of i^{th} household at t year, j is number of inputs variables, j= 1, 2, 3 …. 8, namely, total land (ha), sown area (ha), seed cost (MNT), manure cost (MNT), labor cost (MNT), pesticide (MNT), cultivation cost (MNT) and capital (MNT). β_0, β_i are to be estimated coefficients. $v_{it} - u_{it} = \varepsilon_{it}$ is error term. $N(0; If_v^2)$~u_{it}, $N^+(0;\ If_u^2)$~ v_{it} , ln-natural logarithm, we will take logarithm the all variables. The parameters estimation SFA model can be achieved by applying Maximum-Likelihood (ML) estimation method which estimates the likelihood function in terms of two variance parameters (Coelli et al. 1995).

$$\gamma = \frac{\sigma_u^2}{\sigma_s^2}\ ;\ If_s^2 = If_v^2 + If_u^2$$

where γ takes value between 0 to 1, reflects validity of random disturbances $(v_{it}; u_{it})$ proportion. If $\gamma \sim 0$, it shows that gap between actual output and maximum possible output mainly comes from uncontrolled pure random factors, makes use of SFA model meaningless. In contrast, if $\gamma \sim 1$, it represents gap comes mainly from technical inefficiency due to effects of one or more exogenous variables, indicates using SFA model is more appropriate (Coelli and Battese 1996, Coelli et al. 2005).

Technical efficiency of i^{th} household can be estimated by the ratio of observed output for i^{th} household relative to the potential output defined by SFA model, as follow:

$$TE_{it} = \frac{y_{it}}{f(x_{it}, t)} = \exp(-u_{it}) \leq 1$$

b) Data collection and variables sign

We use primary data of 100 randomly selected vegetable's households in Norjinkhairkhan bag, Buyant soum, Khovd province using SFA model, Stata software. The data was collected in the field from end of August to first of September, 2019. The SFA model was constructed by one output (total quantity of vegetable's production of households, by ton) and 8 inputs including total land (ha), sown area (ha), seed cost (MNT), manure cost (MNT), labor cost (MNT), pesticide (MNT), cultivation cost (MNT) and capital (MNT). We try to define some variables sign based on previous literature (Table 1).

Table 1. Some variables expected sign

Inputs	To be estimated sign	Meaning	Some related references
Land	+	Increasing quantity used of total irrigated area and non-irrigated area could cause the increasing of farms' production.	(Battese Coelli, 1996), (Kea, Li, & Pich, 2016)
Fertilizer, pesticide and so on	+	Increasing quantity used of fertilizer, pesticide could cause the increasing of farms' production.	(Kea et al., 2016)
Labor	+	The total quantity of labor for family members and hired labor	(Battese Coelli, 1996)
Age	+	The older farmers who are likely to be more experienced in farming utilize resources more efficiently in production. If	((Anang, Tetteh et al., 2016)), (Mwajombe & Mlozi, 2015)

		the household head is older, there is the likelihood that the family labor may increase as the children become older.	
Gender (sex)	+/-	Many researchers have recognized the important role of women as agricultural producers. However, gender inequality in access to production technology in many developing countries means that women farmers are often disadvantaged which can adversely affect their level of efficiency. Women also face other challenges that have negative impact on their technical efficiency. Male farmers more efficient.	(Msuya, 2008)
Farm size	-/+	Smaller farms are more efficient; this may be due to the better use and higher care for the use of inputs by smaller farms because they are also poorer. Some empirical studies result show larger families appear to be more efficient than smaller families.	((Osmani & Andoni, 2017)), ((Bravo-Ureta & Pinheiro, 1993)), (Anang, Tetteh et al., 2016), (Abdulai & Eberlin, 2001)

Results

a) Descriptive data of variables

Table 2 shows that summary statistics of variables. Most of the households are harvesting potato, carrot, cabbage, watermelon and onion. Average age of household's head is 48.62 years, family size 5.1 members, 80% of household's head are male, 20% of household's head are female.

Table 2. Summary statistics of variables for vegetable's households, 2019

Variables	*Mean*	*Standard error*
Age	48.62	1.33
Family size	5.1	0.15
Output quantity, tn	20.27	1.14
Total land, ha	3.76	0.16
Sown area, ha	2.1	0.11
Seed cost, MNT	1546400	93115.3
Manure cost, MNT	471600	24985.3
Labor, MNT	506875	28510.7
Pesticide, MNT	209600	11105
Capital, MNT	6988000	427705.4
Cultivation cost, MNT	314400	16657

Source: Calculated by MS. Office excel

Average vegetable's household's production was 20.27 tn. Land input divided into 2 section, one is total land of households, second is sown area. Sown area is covered by harvesting area in hectare (ha). Most of households responded some of households does not enough labor force, some of household has a financial problem, some of households responded need to change harvesting field that question: why are not harvest total land?

The average cost of seed was 15646400 MNT this year. Some of households keep seed in warehouse for next year's sowing while some of households directly sale to market due to not warehouse. For manure cost, most of the households using organic fertilizer namely, manure. It cost is depended on sown area.

The labor cost is only cultivation and harvesting period who is working in field. Pesticide cost is including cost only cabbage, onion field. These vegetables are easy to infected. So, households buy using only for these vegetables. All of households spent money for cultivation period and harvesting period. Because households are not tractor for cultivation and harvest. So, every households rent a tractor and pay 150000-200000 MNT for 1 hectare. Capital is indicated every household's equipment's cost. Every households have a truck for sale to market.

b) Estimation result of SFA model

We estimated using SFA model in Stata software. Firstly, we checked there is technical efficiency exist or not exist efficiency using γ parameter. Our γ parameter is closed to 0 which means that gap between actual output and maximum possible output mainly comes from uncontrolled pure random factors (Table 3).

Some of variables for example, manure cost, pesticide, cultivation cost does not estimate due to multicollinearity. Only sown area input had positive coefficient and significant at 5%. Capital and labor variables had negative coefficient and significant at 5% and 1%. So, we need improve our questionnaire and check respondent's response's truly situation.

Table 3. Results of Cobb-Douglas stochastic frontier production function based on normal/half normal distribution.

Dependent variable: Lntotal output			
Independent variables	Coefficient	Standard error	P value
Constant	445.3	26.2	0.09
lnsown_area	19.6	8.48	0.02
lnmanure_cost		does not defined	

lnlabor_cost	-25.07	7.99	0.002
lnpesticide_cost		does not defined	
lncapital	-5.14	7.95	0.03
lncultivation_cost		does not defined	
lnsig2v	6.6	0.57	0
lnsig2u	1.29	0.101	0.09
sigma_v	27.12	7.83	
sigma_u	1.91	29.6	
sigma2	739.5		
lambda	0.07		
γ	0.004		
LR test of sigma_u=0: chibar2(01) = 7.0e-06		*Prob >= chibar2 = 0.499*	

Source: Author's calculation

But we try to estimate technical efficiency for vegetable's household production in Buyant soum Khovd province. The computed mean of technical efficiency was 34.7% which means that household's vegetable's production could have been increased further by 65.3% at same levels of inputs if households had been technically efficient. Also, we defined technical efficiency for clarified household's land size (Table 4). There is no difference efficiency depending on land size. The literature points, it indicates that large farms are more efficient than small or medium farms.

Table 4. Mean efficiency level, by household's land size

	Technical efficiency, by farm
Small (0-2 ha)	0.341
Medium (2-4 ha)	0.349
Large (more than 4 ha)	0.345

Source: Author's calculation

For example, small land size household (0-2 ha)'s technical efficiency was 34.1%, medium size (2-4 ha) household's efficiency was 34.9 % and large size (more than 4 ha)'s efficiency was 34.5%.

Conclusions

The main goal of this paper was to determine technical efficiency of vegetable's households in Khovd province of Western region in Mongolia. The Western region is one of main producer in vegetable production and produces approximately 20 percent of total vegetables production in Mongolia. So, we tried to define the technical efficiency of 100 vegetable's production households in Norjinkhairkhan bag in Buyant soum. Our technical efficiency study is first study in Mongolia. There is no efficiency analysis for vegetable production. Unfortunately, our result is not expected result. In the future, we need to improve our questionnaire.

References

Abdulai, A., & Eberlin, R. (2001). Technical efficiency during economic reform in Nicaragua : evidence from farm household survey data, *25*, 113–125.

Anang, Tetteh, B., Bäckman, S., & Sipiläinen, T. (2016). Agricultural microcredit and technical e ffi ciency : The case of smallholder rice farmers in Northern Ghana, *117*(2), 189–202.

Battese Coelli, T. B. (1996). Identification of factors which influence the technical inefficiency of Indian farmers. *Australian Journal of Agricultural Economics*, *40*(2), 103–128.

Battese, G. E. (1995). A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data, 325–332.

Bravo-Ureta, B. E., & Pinheiro, A. E. (1993). Efficiency Analysis of Developing Country Agriculture: A Review of the Frontier Function Literature. *Agricultural and Resource Economics Review*, *22*(01), 88–101. https://doi.org/10.1017/s1068280500000320

Dennis J.Aigner, C. K. L. and P. S. (1976). Formulation and estimation of Stochastic frontier production function models.

Greene, W. H. (2007). The Econometric Approach to Efficiency Analysis, 92–250.

Holtkamp, A. M. (2016). *Technical and environmental efficiency of smallholder palm oil and rubber production presented by*.

Kalirajan, K. (1981). An Econometric Analysis of Yield Variability in Paddy Production. *Canadian Journal of Agricultural Economics*, *29*.

Kea, S., Li, H., & Pich, L. (2016). Technical Efficiency Analysis of Cambodian Household's Rice Production, *16*(3).

Lovell, C. A. K. (1995). Stochastic Frontier Analysis : An Econometric Approach. *European Journal of Opertational Research*, *80*, 452–461.

Msuya, E. (2008). An Analysis of Productivity and Technical Efficiency of Smallholder Maize Farmers in Tanzania, *81*(0).

Mwajombe, K. K., & Mlozi, M. R. S. (2015). Measuring Farm-level Technical Efficiency of Urban Agriculture in Tanzanian Towns : The Policy Implications, *2*(1). https://doi.org/10.5430/wjss.v2n1p62

National Statistics office of Mongolia. (2017). *Mongolian Statistical yearbook*.

Osmani, M., & Andoni, M. (2017). Efficiency of Vegetable Production in Albania : a Stochastic Frontier Approach. *International Journal of Economics, Commerce and Management*, *V*(10), 1–18.

Wang, Schmidt, H.-J. P. (2002). One-Step and Two-Step Estimation of the Effects of Exogenous Variables on Technical Efficiency Levels, 129–144.

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Amar Uuld, PhD Candidate in Doctoral School of Management and Business Administration in Szent István University (Hungary). Also, she is lecturer in Agricultural and applied economics department, School of Economics and Business, Mongolian University of Life Sciences (Mongolia). Now she is study focusing on agricultural production efficiency and agricultural foreign trade and agricultural policy. E-mail: amar.u@muls.edu.mn, uuld.amar@phd.uni-szie.hu

Robert Magda, PhD (in economics), Professor in Szent István University (Hungary), Faculty of Economic and Social Sciences, Institute of Economics, Law and Methodology. Extraordinary Professor in North-West University, South Africa. He is an author and co-author of more than 200 refereed papers in scientific journals, books, and conference proceedings. Current research interests: efficiency of natural resource utilization, economy of rural areas. E-mail: magda.robert@gtk.szie.hu