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Full Length Research Paper

Technical efficiency and its determinants in Irish potato production: Evidence from Dedza District, Central Malawi

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The study examined empirically the technical efficiency of Irish potato producer of Dedza district using cross section data from 200 farmers. Translog stochastic production frontier model was used to predict farm level technical efficiency using Maximum Likelihood Method. The study found that individual farm level technical efficiency was about 83%. The result show that non-farm employment, education, farm experience, degree of specialization and weeding to are positively related to technical efficiency and significant at 1%. Age and household size were negatively related to technical efficiency and significant at 5 and 10%, respectively. There was no significant relationship between technical efficiency and extension visits and credit access.

Key words: Irish potato production, technical efficiency and Translog production frontier function.

INTRODUCTION

Despite the fixed and limited land resource committed to potato production, the government's policy goal is to improve yield in order to improve farmers' income in the Irish potato sector, in turn, reducing food insecurity and poverty (MoA, 2005). Although investments have been made in research and development in an effort to improve Irish potato productivity of smallholder farmers, these efforts have focused on development and adoption of high yielding varieties (MoA, 2005). Yet low productivity remains a major challenge – the average national farm level yields given fixed land factor. One way of mitigating the problem is increasing the use of improved technologies and improving the efficiency of farmers in using inputs.

Malawi is Sub-Saharan Africa's biggest potato producer (FEWSNET, 2008). In the major potato growing Districts of Dedza and Ntcheu, 64% of farmers own total land area per farmer varying between 0.44 and 1.20 ha (CIP, 2008). Most farmers use less than 20% of their total land area to grow potato each season (CIP, 2008). Despite the fixed and limited land resource committed to potato production the government's policy goal is to improve yield in order to improve farmers' income in the Irish potato sector, in turn, reducing food insecurity and poverty (MoA, 2005). Although investments have been made in research and development in an effort to improve Irish potato productivity of smallholder farmers, these efforts have focused on development and adoption of high yielding varieties (MoA, 2005). However, how much farmers are technically efficient in the region is not known. Thus, there is no evidence in the study area as to the level of technical efficiency.

The present study will help fill this knowledge gap in central Malawi where no such study exists that explores efficiency in Irish potato production. The main objective of the present study is to estimate technical inefficiency in potato production in Malawi's Dedza district, by employing the stochastic production frontier approach and to determine the sources of inefficiency in order to develop policy parameters to improve the existing situation.

MATERIALS AND METHODS

Study area

The data used in this study were collected from Dedza district in Malawi, which is one of high Irish potato producing districts. Dedza is a district in the Central Region of Malawi. It covers an area of 3,624 km² to the south of the Malawi capital, Lilongwe, between

Mozambique and Lake Malawi with 145,878 households (NSO, 2008). The landscape is a mixture of grassland with granite outcrops, natural woodland and commercial pine plantations on the mountains and some bamboo forest nearer the Lake (DDA, 2001). The wet season is November to April with almost no rainfall at other times. The higher altitudes have moderate temperatures and can be cold in June and July (DDA, 2001).

The data

A survey of the production practices and household characteristics of smallholder Irish potato producers was conducted in June 2011. Data were obtained from 200 smallholder Irish potato farmers. A Multi-stage sampling technique was used. The district was clustered into Extension Planning Areas (EPAs) from which one EPA was randomly selected from the District. Secondly, a simple random sampling technique was used to sample two sections from the sampled EPA as secondary sampling units. Thirdly, sections were clustered into villages whereby villages were randomly sampled from each sampled section. Fourthly, from each sampled village, simple random sampling technique was used to select Irish potato farmers proportionately to size (Edriss, 2003). Data were collected using a structured questionnaire and focus group discussions. The questionnaire was designed and pre-tested in the field for its validity and content and to make overall improvement of the same and in line with the objectives of the study. Data were collected on output, input use, socio-economic and institutional variables.

Empirical model

Following Issahaku et al. (2011), by applying a Translog production function, the stochastic production function is described by:

$$\ln y_i = \alpha + \sum_{k=1}^{4}\beta_k \ln x_{ki} + \frac{1}{2}\sum_{k=1}^{4}\sum_{l=1}^{4}\psi_{kl}\ln x_{ki}\ln x_{li} + \sum_{z=1}^{3}\sum_{j=2}^{4}\theta_{zj}\ln x_{zi}\ln x_{ji} + v_i - u_i \quad (1)$$

Where, Y = Production (kg/ha); x_1 = (kg/ha); x_2 = Labour (persondays/month); x_3 = Seed (kg/ha); x_4 = Land (ha). And, *k, l, z, j* = input 1, …, 4; v_i denotes the traditional error component and *u* the non-negative inefficiency component. v_i is assumed to be independently and identically distributed (iid), symmetric and distributed independently of u_i. Thus the error term $\varepsilon_i = v_i - u_i$ is asymmetric, since $u_i = 0$, *β*'s represent parameters of linear terms, ψ's represent parameters of quadratic terms and *θ*'s represent parameters of interactions. Symmetry is imposed by constraining (1) according to: $\psi_{kl} = \psi_{lk}$ and $\theta_{zj} = \theta_{jz}$.

Two kinds of information are needed in estimating the efficiency of firms. First, varying degrees of success of firms at maximizing output from given levels of inputs. This is the technical efficiency dimension. Following Jondrow et al. (1982) and Battese et al. (1995) report, technical efficiency estimation is given by the mean of the conditional distribution of inefficiency term μ_i given ε; and thus defined by:

$$E(u_i|\varepsilon_i) = \frac{\sigma_v - \sigma_u}{\sigma}.\left[\frac{f(\varepsilon_j\lambda|\sigma)}{1-F(\varepsilon_i\lambda|\sigma} - \frac{\varepsilon_i\lambda}{\sigma}\right] \quad (2)$$

Here, λ = $\sigma_v / \sigma_u, \sigma^2 = \sigma_v^2 + \sigma_u^2$ while *f* and F represents the standard normal density and cumulative distribution function respectively evaluated at $\varepsilon_i\lambda/\sigma$. The term σ^2 is the variance parameter that denotes the total deviation from the frontier, σ_u^2 is the variance parameter that denotes deviation from the frontier due to inefficiency and σ_v^2 is the variance parameter that denotes deviation from the frontier due to noise. The farm–specific technical efficiency is defined in terms of observed output (y_i) to the corresponding frontier output (y_i*) using the available technology derived from the result of the Equation (2) as (Aigner et al., 1977; Meeusen et al., 1977):

$$TE = \frac{y_i}{y_i*} = \frac{E(y_i|u_i, x_i)}{E(y_i|u_i = 0, x_i)} = E[\exp(-ui)/\varepsilon_i] \quad (3)$$

TE takes values within the interval (0,1), where 1 indicates a fully efficient farm, y_i is the observed output and y_i* is the frontier output and *x*'s are production inputs.

The literature indicates that a range of socio-economic and demographic factors determine the efficiency of farms (Seyoum et al., 1998; Coelli and Battese, 1996; Wilson et al., 1998). Following the report of Coelli (1996), the farm specific inefficiency (1-TE_i) is considered as a function of six different variables and the inefficiency effects model is estimated as:

$$u_i = \gamma_0 + \gamma_r \sum_{r=1}^{9} z_{ri} \quad (4)$$

Where, u_i is farm specific inefficiency, γ_0 is the intercept term and γ_r is the parameter for the *r*-th explanatory variable and z_1 = Experience (Number of years in Irish potato farming); z_2 = Age of the farmer (years of age); z_3 = Education (Years of Schooling); z_4 = Size of the household (n); z_5 = Access to credit (1 = yes, 0 = otherwise); z_6 = Frequency of weeding (times/fallow period); z_7 = Non farm employment (1= Yes = 0 other wise); z_8 = Extension service visits (Number extension visits); z_9 = Degree of specialization in Irish potato (acreage in potato/total crop acreage).

The coefficients of unknown parameters are to be estimated by the method of maximum likelihood using the computer program STATA version 10.

RESULTS AND DISCUSSION

The average statistics of the sampled Irish potato farmers are presented in Table 1. On the average, a typical Irish potato farmer in the district is 44 years old, with 4 years of education, 20 years of farming experience and an average household size of 5 persons. The average Irish potato farmer cultivated 0.6 ha, made an average of 2extension contacts in the year, used about 254 kg of fertilizer and 1852 kg of Irish potato, employed 176 man-days of labour and produced an output of 12371 kg of Irish potato per annum. Irish potato production in the district is a male dominated occupation as about 62% of

Table 1. Average statistics of irish potato farmers in Dedza District, Malawi, 2011.

Variable	Unit	Average	Minimum	Maximum
Age	Years	44.5	28	60
Education level	Years	3.5	0	7
Farming experience	Years	19.7	3	36
Potato plot	Hectares	0.60	.09	1.38
Land size	Hectares	1.25	.45	2.13
Extension visit	Number of visits	1.4	0	3
Fertilizer	Kg/ha	254.08	7.6	561.3506
Labour	Man-days/ha/year	176.35	97	300
Irish potato Yield	Kg/ha	12371	8084	19468
Household size	Number of persons	4.25	2	9
Seed	Kg/ha	1852.51	1134	2652
Gender	**Frequency**			
Male	124			
Female	76			

Table 2. Estimated Translog stochastic frontier production Function for Irish potato in Dedza District, Malawi.

Variable	Parameter	Coefficient estimate	Std error	T-value
Constant	α	1.752**	0.818	2.14
LnFertilizer	β_1	0.282**	0.132	2.13
LnLabour	β_2	-2.072	1.36	-1.525
LnSeed	β_3	-5.287***	1.589	-3.33
LnLand	β_4	0.143***	0.031	4.61
½(LnFertilizer)^2	ψ_{11}	0.163***	0.05	3.41
½(LnLabour)^2	ψ_{22}	0.305***	0.062	4.91
½(LnSeed)^2	ψ_{33}	0.769*	0.39	1.95
½(LnLand)^2	ψ_{44}	0.311***	0.04	7.76
LnFertilizer×LnLabour	θ_{12}	0.324*	0.17	1.94
LnFertilizer×LnSeed	θ_{13}	-0.158**	0.048	-3.29
LnFertilizer×LnLand	θ_{14}	-0.943***	0.36	-2.61
LnLabour×LnSeed	θ_{23}	0.512**	0.24	2.14
LnLabour×LnLand	θ_{24}	0.542***	0.15	3.60
LnSeed×LnLand	θ_{34}	0.536**	0.26	2.06
Sigma-squared $(\sigma_v^2 + \sigma_u^2)$	σ^2	0.339***	0.106	3.19
Gamma $(\sigma_u^2 /(\sigma_u^2 + \sigma_v^2))$	γ	0.826***	0.29	2.85
Log likelihood		26.19		

***, **, *, mean significance at 1%, 5%, and 10% level, respectively. Source: Field survey, 2011.

the farmers were males. It is observed that the Maximum Likelihood (ML) estimate of γ is 0.826 with estimated standard error of 0.29 (Table 2). This is consistent with the theory that the true γ-value should be greater than zero and less than one (Backman et al., 2011). The value of the γ-estimate is significantly different from one,

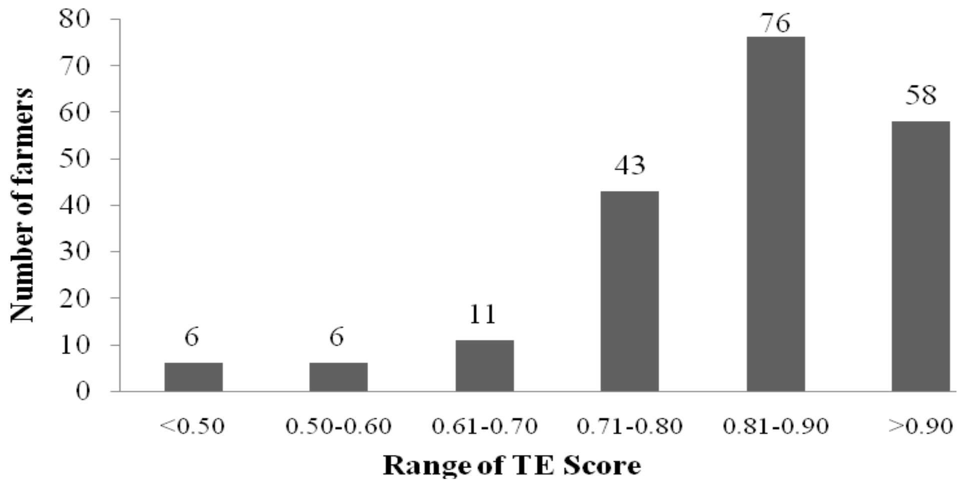

Figure 1. Frequency distribution of the range of individual technical efficiency level.

indicating that random shocks are playing a significant role in explaining the variation in potato production, which is expected especially in the case of agriculture where uncertainty is assumed to be the main source of variation (Abedullah et al., 2007). This implies that the stochastic production frontier is significantly different from the deterministic frontier, which does not include a random error. However, it should be noted that 83% of the variation in yield is due to technical inefficiency and only 18% is due to the stochastic random error.

The mean level of technical efficiency of Irish potato growing farmers was about 83%, with the minimum and maximum efficiency levels of about 45 and 98%, respectively (Table 2). This shows that there is a wide disparity among Irish potato producer farmers in their level of technical efficiency, which may in turn indicate that there exists a room for improving the existing level of Irish potato production through enhancing the level of farmers' technical efficiency. The mean level of technical efficiency further tells us that the level of Irish potato output of the sample respondents can be increased on an average by about 17% if appropriate measures are taken to improve the level of efficiency of Irish potato growing farmers. In other words, there is a possibility to increase yield of Irish potato by about 17% using the resources at their disposal in an efficient manner without introducing any other improved (external) inputs and practices.

It is observed that about 33% of the sample farmers are operating below the overall mean level of technical efficiency, while about 29% of the farmers are operating at the technical efficiency level of more than 90%. However, as illustrated in Figures 1, majority (about 67%) of the Irish potato growing farmers were able to attain above the overall mean level of technical efficiency. This might imply that in the long run improving the existing level of technical efficiency of farmers alone may not lead to significant increment in the level of Irish potato yield. So, in the long run, it needs attention at policy level to introduce other best alternative farming practices and improved technologies in order to alleviate the overall Irish potato shortage.

Table 3 shows the results of the factors influencing allocative efficiency of Irish potato farmers in Dedza district. The coefficient of the non farm employment variable entered into the technical inefficiency effect model indicated that the variable affects the level of technical efficiency in Irish potato production negatively. The result obtained is consistent with similar studies by Parikh et al. (1996) and Ali (1996). This can further be explained in such a way that either farmers devote less time for their actual farm operations if they have other alternative work from which they can get immediate cash income, while their own farm operations are delayed.

The coefficient for education and farm experience were negative and statistically significant at 1% level of probability. The negative sign on the education variable indicates that an increase in the number of school years decreases technical inefficiency. This finding is consistent with Awudu and Eberlin (2001) in their study on technical efficiency in Nicaragua in which education increased production efficiency. Abdulai and Eberlin (2001) in their study established similar results. The result for farm experience obtained in this study is not in line with the results obtained by Ngagaka et al. (2010). However, our study result is in line with that found by Amara et al. (1999) in Canada.

The result unexpectedly found household size to determine efficiency negatively. The coefficient for technical efficiency is significant at 10% level. Ajibefun (2002), Mohammad et al. (1999) and Parikh and Shan (1996) among others have found positive but insignificant result of inefficiency that family size determines efficiency negatively. This may be due to the fact that household with large number of family members may not be able to

Table 3. Maximum likelihood estimates of the determinants of technical efficiency of the Irish potato farmers, Dedza district, Malawi, 2011.

Variable	Coefficient	Std error
Intercept term	1.483*	0.884
Non farm employment	0.812***	0.271
Education	-0.14***	0.004
Extension visits	-0.012	0.077
Credit status	-0.015	0.031
Farm experience	-0.028***	0.004
Degree of specialization	-0.066***	0.024
Age	0.008**	0.004
Household size	0.017*	0.013
Frequency of weeding	-0.955***	0.227

Dependent variable = Technical inefficiency. Values in parenthesis are standard errors. *,** and *** means significant at 10%, 5% and 1%, respectively. Source: Computed from Survey data, 2011.

use appropriate input combinations due to shortage of cash.

In this study, a negative and statistically significant relationship between the degree of specialization in the Irish potato production and technical inefficiency was observed at 1% level of significance. Abdulai and Huffman (2000) registered similar results for rice producers in Northern Ghana.

Frequency of weeding registered negative and significant coefficients for technical inefficiency measure, which is at significant at 1%. Tamado (2001) reported that there was sorghum grain yields loss with increased density infestation of weed in sorghum field. There is also additional evidence by Ejeta et al. (1993) that there was an estimated yield reduction of 65-70% in major sorghum growing areas where in heavy infestation losses often reach 100%.

CONCLUSION AND POLICY IMPLICATIONS

A Translog stochastic frontier production function is used for the analysis of cross-sectional data. The study has indicated that Irish potato farmers in Dedza district are predominantly men. Individual levels of technical efficiency range between 45 and 98% with a mean of 83.5%, which reveal substantial technical inefficiencies. Hence, the study indicates considerable potential for improving productivity of the crop with given level of inputs use and technology. In addition, improving efficiency will mean farmers gaining considerably in terms of profits. Inefficiencies could be attributed to non farm employment, education level farm experience, degree of specialization, age of household head, household size and frequency of weeding.

Setting minimum education level in primary schools for the long run result and increasing number of extension workers are other policy options sine qua non to reduced inefficiencies in Irish potato production. Farmers need education on Irish potato production. Irish potato farmers need also to specialise in the production of this crop other than overspreading.

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