Cost efficiency, Morishima, Allen-Uzawa and Cross-Price elasticities among Irish potato farmers in Dedza district, Malawi

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Abstract

Malawi has experienced a forward shift in its demand for Irish potato (Solanum tuberosum) consumption. Given limited resources at farmers' disposal, meeting the growing demand will require farmers to follow the efficient path of the farm production resources. This paper, therefore, is an attempt to measure the cost efficiency of smallholder Irish potato farmers in Dedza district of Malawi using a translog cost function, inefficiency effect model and input elasticities derived from a system of cost share equations estimated by Iterated Seeming Unrelated Regression method. A multi-stage random sampling technique was used to select 200 Irish potato farmers in Dedza in 2011 from whom input-output data and their prices were obtained. Results indicate that the mean cost efficiency of Irish potato production in Dedza District is 0.67 with scores ranging between 0.15 and 0.94. The cost efficiency differences are significantly explained by non-farm employment, education, credit access, farm experience, degree of specialization, household size and frequency of weeding. The highest input substitution existed between labour and fertilizer, followed by seed-fertilizer. One policy issue is raised; credit should be extended to Irish potato farmers to enable them purchase farm inputs.

Keywords: Cost efficiency, elasticity, Irish potato

JEL Classification: D12, D24, O33

1. Introduction

The agricultural sector has always been an important component of the Republic of Malawi's economy. During the 2000s, agriculture accounted for as much as 35-40% of the Gross Domestic Product (GDP), 92% of overall employment, over 90% of the country's foreign exchange earnings, provided 64% of total income for rural people and contributed

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33.6% to the economic growth. Agriculture supports the manufacturing industry by supplying 65% of the raw materials needed. A significant feature of the Malawi's agriculture is its duality in structure. This dual structure consists of large scale farming, which includes estates sector, and small scale production (GoM, 2007; Damaliphetsa et al., 2007).

Research has shown that cultivation of horticultural crops is a potential alternative source of income to tobacco which is a major income source for most farmers and an important export earner for the country. A horticultural commodity such as Irish potato (*Solanum tuberosum*) has the potential to contribute to household nutrition, food security and income (Kachule and Franzel, 2009). There is, therefore, increasing demand for the Irish potato both in the domestic and export market. The growing population in Malawi, particularly in urban areas, has been a key factor causing increasing consumption of Irish potatoes. There is also evidence that eating habits in urban areas are changing, for example potatoes are substituting *nsima* as main meal (Kauta et al., 2008). As a result, annual consumption of Irish potatoes in Malawi has more than tripled over the past 15 years to a high of 88 kilograms per capita (FAO, 2009).

In an effort to enhance performance of the sector and meet growing demand, the government emphasizes strategies aimed at increasing productivity, developing marketing and agribusiness management skills. It is envisaged that such efforts have the potential to contribute to development of horticultural production, marketing and food processing in Malawi (Kachule and Franzel, 2009; Ray, 2012). However, such efforts would be undermined by inefficiency in resource use.

Efficiency studies have become more relevant in today's world especially in Malawi's agriculture sector which is characterised by resource constraints (Theodoridis and Psychoudakis, 2008). The subject of efficiency in Malawi has received considerable attention in the literature (Chirwa, 2002; Edriss and Simtowe, 2002; Tchale and Sauer, 2007; Maganga, 2012). However, none of such studies has estimated cost efficiency and input elasticities in Irish potato production. Thus, this study aimed at identifying the socio-economic characteristics of the smallholder farmers, estimating the cost efficiency in Irish potato production among smallholder farmers and establishing derived conditional factor demand elasticities, Allen and also Morishima technical substitution elasticities of inputs for cost items such as labour, seedling, fertilizers and land, which play a key role in the production of Irish potato.

The remainder of the paper is organised as follows: The next section presents the specification of the models that we employ and their econometric estimation strategy; the third discusses the data and the results and the last section concludes.

2. Methodology

2.1 Data

The data used in this study were collected from Dedza district in Malawi in 2011, 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 city, 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).

A Multi-stage sampling technique was undertaken where 200 smallholder Irish potato farmers were selected. 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, prices, socio-economic and institutional variables.

2.2 Theoretical and Econometric Construct

The stochastic frontier cost function model for estimating plot level overall cost efficiency is specified as:

$$C_i = g\,(Y_i, W_i; \alpha) + \varepsilon_i \qquad i = 1, 2, \ldots n. \tag{1}$$

where C_i represents minimum cost associated with Irish potato production, Y_i represents output produced, W_i represents vector of input prices, α, represents the parameters of the cost function and ε_i represents the composite error term. Using Sheppard's Lemma we obtain

$$\frac{\partial C}{\partial P_i} = X^*(W, Y, \alpha) \tag{2}$$

This corresponds to minimum cost input demand equations (Bravo-Ureta and Evenson, 1994; Bravo-Ureta and Pinheiro, 1997). In the presence of input price information, it would be possible to measure the cost efficiency of the firm under consideration. Substituting farm's input prices and quantity of output in equation (2) yields the cost minimizing input vector. Let X and X^* represent the input vector associated with the technically efficient and the cost-minimising input vectors, respectively. Then, cost efficiency (CE) of the farm is defined as the ratio of input costs associated with input vectors, X and X^* (Coelli et al*.,* 1998), Thus,

$$CE = \frac{W'X}{W'X^*} \tag{3}$$

Cost efficiency was measured using stochastic translog cost frontier function for Irish potato production. The function is specified as follows:

$$\ln c_i = \beta_0 + \sum_{k=1}^{4} \beta_k \ln w_{ki} + \theta_1 \ln y_i + \frac{1}{2}\sum_{k=1}^{4}\sum_{l=1}^{4} \beta_{kl} \ln w_{ki} \ln x_{li} + \frac{1}{2}\theta_2 y^2 + \sum_{k=1}^{4} \beta_{ky} \ln w_k \ln y + v_i + u_i \tag{4}$$

where c_i represents total input cost of the i[th] farm, w_1 is the average price for a kg of fertilizer, w_2 is the average wage rate per man days of labour per day per hectare, w_3 is the price per kg of tuber, w_4 is the average rental price and y_i Irish potato output. The βs, θs and β_0 are parameters to be estimated. The cost frontier function is estimated using maximum likelihood estimation technique. For a cost function to be well behaved, it must be homogeneous of degree 1 and concave in prices. Imposing linear homogeneity and symmetry restrictions leads to the following relationships between the parameters:

$$\sum \beta_k = 1, \ \sum \beta_{kl} = \sum \beta_{lk} = \sum \beta_{ky} = 0 \tag{5}$$

Concavity is satisfied if the Hessian matrix of second-order derivatives is negative semi-definite. The Hessian matrix is negative semi-definite if (i) the sign of the first leading principal minor is non-positive; (ii) the signs of the further leading principal minors alternate (Chiang, 1984) as;

$$H = \begin{pmatrix} \frac{\partial^2 c}{\partial w_1 \partial w_1} & \frac{\partial^2 c}{\partial w_1 \partial w_2} & \frac{\partial^2 c}{\partial w_1 \partial w_3} & \frac{\partial^2 c}{\partial w_1 \partial w_4} \\ \frac{\partial^2 c}{\partial w_2 \partial w_1} & \frac{\partial^2 c}{\partial w_2 \partial w_2} & \frac{\partial^2 c}{\partial w_2 \partial w_3} & \frac{\partial^2 c}{\partial w_2 \partial w_4} \\ \frac{\partial^2 c}{\partial w_3 \partial w_1} & \frac{\partial^2 c}{\partial w_3 \partial w_2} & \frac{\partial^2 c}{\partial w_3 \partial w_3} & \frac{\partial^2 c}{\partial w_3 \partial w_4} \\ \frac{\partial^2 c}{\partial w_4 \partial w_1} & \frac{\partial^2 c}{\partial w_4 \partial w_2} & \frac{\partial^2 c}{\partial w_4 \partial w_3} & \frac{\partial^2 c}{\partial w_4 \partial w_4} \end{pmatrix} \text{ with } |H_1| < 0, \ |H_2| > 0, \ |H_3| < 0 \text{ and } |H_4| > 0$$

Secondly, curvature restrictions are checked by calculating the Eigen values for the Hessian matrix of input prices. Eigen values need to be negative for the matrix of prices to satisfy concavity (Mulik et al., 2003).

Discovering whether farms are cost efficient might not be important exercise unless an additional effort is made to identify the sources of the inefficiencies. Taking cognisance of this, the study investigated the sources of plot-level cost inefficiencies for the surveyed farmers. Empirically, the inefficiency model u_i is specified as (;

$$u_i = \varphi_0 + \sum_{r=1}^{9} \varphi_r z_{ri} \tag{6}$$

where, z_i is a vector of farm specific determinants of cost inefficiency, φ are the inefficiency parameter vector to be estimated.

The cost share equation for factor i is derived by differentiating the cost function with respect to $\ln w_i$ following Chiang (1984):

$$\frac{d \ln c}{d \ln w_i} = \alpha + \sum \beta_{kj} \ln w_j + \beta_{ky} \ln y \tag{7}$$

But, using Shephard's Lemma for the penultimate equality:

$$\frac{\partial \ln c}{\partial \ln w_i} = \frac{w_i \partial c}{c \partial w_i} = \frac{w_i x_i}{c} = s_i \tag{8}$$

Therefore:

$$s_i = \alpha + \sum \beta_{kj} \ln w_j + \beta_{ky} y \tag{9}$$

To derive the elasticity of factor demand, which is the change in the quantity of factor i in response to a change in the price of factor j, observe that:

$$x_i = \frac{c}{w_i} s_i \tag{10}$$

$$\lambda_{kj} = \frac{\partial \log x_i}{\partial \log w_j} = \frac{w_j}{x_i} \frac{\partial}{\partial w_j} (\frac{c}{w_i} s_i) \tag{11}$$

$$= \frac{w_j}{x_i} \left(\frac{c \beta_{kj}}{w_k w_j} + \frac{x_j s_i}{w_k} \right) \text{(using Shephard's Lemma)}$$

$$= \frac{\beta_{kj}}{s_i} + s_i \left(\frac{w_j x_j}{c} \right) \left(\frac{c}{w_i x_i} \right)$$

Therefore:

$$\lambda_{kj} = \frac{\partial \log x_i}{\partial \log w_j} = \frac{\beta_{kj}}{s_i} + s_j \tag{12}$$

Allen Elasticity of Substitution (AES) is given as:

$$\sigma_{ij} = \frac{\beta_{ii}}{s_i s_j} + 1 \tag{13}$$

$\beta_{ij} = 0$, yields an AES of unity. The expression for the own elasticity of factor demand is (Binswanger, 1974):

$$\lambda_{kk} = \frac{\beta_{ii}}{s_i s_i} + s_i - 1 \tag{14}$$

While the corresponding AES is:

$$\sigma_{ii} = \frac{\beta_{ii}}{s_i s_i} + 1 - s_i \tag{15}$$

Humphrey and Wolkowitz (1976) suggest that own AES can be interpreted as a change in a factor's demand responsiveness to a change in its own price. While, the Morishima elasticities of substitution (MES) were estimated from the factor demand elasticities as $\lambda_{kj} - \lambda_{kk}$. AES do not indicate the curvature or ease of substitution. They are single input - price elasticities and do not relate optimal input ratios to those of input prices. Thus, they cannot provide information on the relative input responsiveness to changes in input prices. In contrast, the MES preserve the salient features of the Hicksian concept in the multifactor context and measure the ease of substitution. The MES are, therefore, sufficient statistics for assessing the effects of changes in the price on relative factor shares (Blackorby and Rusell, 1989).

3. Results and discussion

3.1 Descriptive Statistics

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 was 45 years old, with 4 years of education, 19 years of farming experience and an average household size of 4.9 persons. The average Irish potato farmer cultivated 0.6 ha, made an average of 1.4 extension 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/ha of Irish potato per annum. Irish potato production in the district is a male dominated with about 62% of the farmers being males.

3.2 Estimation of Farm Level Cost Efficiency

The stochastic frontier model is specified for the analysis of cost efficiency of farmers in the production of Irish potato in Dedza district. The stochastic cost frontier in Equation 4 is used to estimate the model. The Maximum-Likelihood estimates of the parameters of the Translog frontier cost function are presented in Table 2.

Table 1: Definition of variables and descriptive statistics

Variable	Units	Average	Minimum	Maximum
Age	Years	44.5	28	60
Education	Years	3.5	0	7
Farming Experience	Years	19.7	3	36
Potato plot	Hectares	0.60	0.09	1.38
Land size	Hectares	1.25	0.45	2.13
Land rent	Imputed cost of land	3329	2952	3538
Extension visit	No. of visits	1.4	0	3
Fertilizer	Kg/ha	254	7.6	561
Price of fertilizer	Malawi kwacha/kg	23	16	31
Labour	Person-days/ha/year	176	97	300
Wage rate	Price of labour/month	2700	1145	4284
Irish potato Yield	Kg/ha	12371	8084	19468
Irish potato price	Malawi kwacha/kg	60	45	75
Household size	No of persons	4.25	2	9
Seed price	Malawi Kwacha/kg	215	67	325
Seed quantity	Kg	1852	1134	2652
Gender of household head	1 = Male; 0 = female	-	0	1
Hoes	Number of hoes	3	1	6
Cost of hoes	Total cost of hoes	684	100	2860
Experience	Years in farming	19	3	36
Credit status	1 = access 0 = otherwise	0.34	0	1
Degree of specialization	Potato plot/Total crop acreage	0.31	0.12	0.78
Weeding frequency	Number of times/year	1	0	2
Non-farm employment	1 = yes; 0 = Otherwise	-	0	1
Farmer organization membership	1 = yes; 0 = Otherwise	-	0	1

1 USD = 167 Malawi Kwacha (MK).

The cost function estimates showed that all the linear terms were significant at different conventional levels. Though some quadratic and interactive elements were not significant, most of them were significant hence validating suitability of translog model.

For the cost function, the sigma ($\sigma^2 = 0.65$) and the gamma (γ=0.97) are quite high and highly significant at 1.0% level. The high and significant value of the sigma square (σ^2) indicates the goodness of fit and correctness of the specified assumption of the composite error terms distribution (Idiong, 2005). In addition, the Wald chi-square statistic for joint test of the model indicates that the model is significant ($p < 0.01$), overly. There was tolerable level of multicollinearity justified by a mean VIF of 3.32 <10 (Edriss, 2003). The homoskedasticity hypothesis was also satisfied as indicated by Breusch Pagan chi-square estimate of 0.042 ($p > 0.1$). Checking for theoretical restrictions on the cost function revealed that the estimated cost function was well behaved for both symmetry and homogeneity. Concavity was also verified firstly by eigenvalues which were all found to be negative.

Secondly, the alternating signs for leading principle minors proved presence of concavity in factor prices beginning with a negative first leading principle minor ($|H_1|<0$, $|H_2|>0$, $|H_3|<0$, $|H_4|>0$).

The gamma ($\gamma = 0.97$) shows that 97% of the variability in the output of Irish potato farmers that are unexplained by the function is due to cost inefficiency. The predicted cost efficiencies (CE) differ substantially among the farmers, ranging between 0.15 and 0.94 with a mean CE of 0.67. This means that if the average farmer in the sample area were to reach the CE level of its most efficient counterpart, then the average farmer could experience a cost saving of 29% [i.e. (1-(0.67/0.94))x100]. The same computation for the most cost inefficient farmer suggests a gain in cost efficiency of 87% [i.e. (1- (0.12/0.94)) x100].

Table 2: Estimated Translog Stochastic Frontier Cost Function for Irish Potato in Dedza District, Malawi

Variable	Parameter	Coefficient	Std. Err.	t-value	p > |t|
Constant	β_0	849.23***	15	57	0.000
Ln (Price of fertilizer)	β_1	0.167**	0.05	2.8	0.012
Ln(Wage rate)	β_2	0.358***	0.11	3.25	0.000
Ln(Price of Seed)	β_3	0.226***	0.05	4.12	0.000
Ln(Land rent)	β_4	0.249**	0.13	2.00	0.039
Ln(output)	θ_1	0.23*	0.15	1.52	0.088
0.5Ln(Price of fertilizer)^2	β_{11}	-0.67*	0.39	-1.72	0.060
0.5Ln(Wage rate)^2	β_{22}	-0.85	0.93	-0.91	0.321
0.5Ln(Price of Seed)^2	β_{33}	-0.44**	0.17	-2.55	0.022
0.5Ln(Land rent)^2	β_{44}	-0.7*	0.40	-1.20	0.082
0.5Ln(output)^2	θ_2	-1.1	1.183	-0.93	0.455
Ln(Price of fertilizer)×Ln(Wage rate)	β_{12}	0.31	1.55	0.20	0.764
Ln(Price of fertilizer)×Ln(Price of Seed)	β_{13}	0.13*	0.08	1.70	0.062
Ln(Price of fertilizer)×Ln(Land rent)	β_{14}	0.23***	0.07	3.28	0.001
Ln(Wage rate)×Ln(Price of seed)	β_{23}	0.19**	0.09	2.04	0.049
Ln(Wage rate)×Ln(Land rent)	β_{24}	0.35***	0.09	3.75	0.000
Ln(Price of seed)×Ln(Land rent)	β_{34}	0.12***	0.03	4.13	0.000
Ln(Price of fertilizer)×Ln(Output)	θ_3	0.17***	0.05	3.20	0.000
Ln(Wage rate)×Ln(Output)	θ_4	0.32***	0.08	4.00	0.000
Ln(Price of seed)×Ln(Output)	θ_5	0.19***	0.02	7.41	0.000
Ln(Land rent)×Ln(Output)	θ_6	-0.68	0.98	-1.55	0.506
Log-likelihood function		79.12			
Total Variance	σ^2	0.65***	0.07	9.47	0.000
Variance ratio	γ	0.97***	0.051	19.01	0.000
Wald chi2(20)		1203			0.000
Mean VIF		3.32			
Breusch Pagan		0.042			0.729

***, **, *, mean, 1, 5, and 10% significance level, respectively.

And to give a better indication of the distribution of the cost efficiencies, a frequency distribution table of the predicted cost efficiency scores is presented in Table 3. The frequencies of occurrence of the predicted cost efficiency scores indicate that the highest number of farmers have cost efficiencies between 0.76 – 0.80, representing about 14% of the respondents while about 58% of the respondents have CE of 0.61 and above which is an indication that farmers are fairly efficient. That is, the farmers are fairly efficient in producing a pre – determined quantity of Irish potato at a minimum cost for a given level of technology.

Table 3: Distribution of Cost Efficiency for Dedza Irish Potato Production

Cost Efficiency range	Frequency	Percent
< 0.20	6	3.00
0.21 –0.25	6	3.00
0.26 –0.30	9	4.50
0.31 –0.35	8	4.00
0.36 –0.40	10	5.00
0.41 –0.45	11	5.50
0.46 –0.50	11	5.50
0.51 –0.55	12	6.00
0.56 –0.60	12	6.00
0.61 –0.65	18	9.00
0.66 –0.70	14	7.00
0.71 –0.75	20	10.00
0.76 –0.80	28	14.00
0.81 –0.85	22	11.00
0.86 –0.90	8	4.00
0.91 –0.95	5	2.50
Total	**200**	**100.00**

With respect to the sources of efficiency in Table 4, the coefficients of extension visits, education and farm experience were statistically significant at least at 5% significance level. These findings are similar with those of Wadud (2000) and Nwachukwu (2006). With education, farmers have high aptitude to learn and understand new information about farming technologies and calculate gross margins.

While with experience, farmers improve on previous flows they had. In contrast with priori, extension visits decreased cost efficiency. This could be attributed to low extension – farmer ratio in Malawi, in which case, the effectiveness of extension advice is undermined. Non-farm employment significantly reduced cost efficiency among Irish potato farmers. Most probably, it competes with family labour supply to the Irish potato farms. Possible alternative to non-farm employment could be improving access to credit.

Credit access increased cost efficiency ($p<0.01$). Degree of specialization and household size significantly increased cost efficiency ($p<0.01$). Degree of specialization enables the farmer to enjoy economies of scale, spread the costs over a large output. Household size is mostly a source of cheap labour that helps to cut on production costs. Weeding was very crucial in the study area as it increased cost efficiency ($p<0.01$). Programs that encourage farmers to increase their frequency of weeding would be enhancing cost efficiency among Irish potato smallholder farmers.

Table 4: Determinants of Cost Inefficiency of Irish Potato Production

Variable	Coefficient	Std. Err.	t-value	p-value
Intercept term	0.759	0.816	0.93	0.3742
Non-farm employment	0.423***	0.124	3.42	0.0065
Education	-0.876**	0.389	-2.25	0.0482
Extension visits	0.1143***	0.036	3.21	0.0093
Credit status	-0.968***	0.205	-4.72	0.0008
Farm Experience	-0.4493**	0.144	-3.11	0.0110
Degree of specialization	-0.6232***	0.115	-5.437	0.0002
Age	0.2431	12.155	0.02	0.9844
Household size	-0.8654***	0.200	-4.337	0.0014
Frequency of weeding	-0.1123	0.079	-1.43	0.1832

*,** and *** means significant at 10%, 5% and 1% levels.

3.3 Factor Demand Elasticities

The parameters of the system of cost share equations for labour, fertilizer, seed and land were estimated using Iterated Seemingly Unrelated Regression (ISUR) technique. The parameters could be estimated using the ordinary least squares (OLS). However, OLS estimation would yield inefficient results because of the restrictions imposed and the correlation of the error terms across the systems of equations (Zellner, 1962). Breusch Pagan test gave a value of 19.13 ($p<0.05$) suggesting that the residuals of the estimated cost share equations were correlated, thus using the seemingly unrelated regression technique was appropriate. As the sum of the shares is equal to one and therefore the system is not linearly independent, one of the cost share equations was dropped. The estimated results are presented in Table 5. The coefficients for the price variables in the cost share equations are represented by the diagonal coefficients in Table 5.

Table 5: Cost share parameter estimates – Iterated Seemingly Unrelated Regression

	Inputs			
	Share of fertilizer	**Share of labour**	**Share of seed**	**Share of land**
Regressors	**Coefficients (SE)**	**Coefficients (SE)**	**Coefficients (SE)**	**Coefficients (SE)**
Fertilizer	-0.67(0.356)*	0.31(1.033)	0.13(0.070)*	0.23(0.070)***
Labour		-0.85(0.857)	0.19(0.097)**	0.35(0.089)***
Seed			-0.44(0.192)**	0.12(0.031)*
Land				-0.7(0.402)*
Output	0.17(0.047)***	0.32(0.088)***	0.19(0.057)***	-0.68(1.022)
Intercept	0.167(0.066)**	0.358(0.096)***	0.226(0.064)***	0.249(0.121)**

In parenthesis are standard errors. ***, ** and * denote 1, 5 and 10% significant levels, respectively.

Elasticities of conditional factor demand in Irish potato, calculated from the cost share system of equations, are given in Table 6. Own price elasticities of fertilizer, seedling, labour and land for Irish potato were estimated by Irish potato input demand model as -1.2711, -0.5322, -0.8292 and -1.2218, respectively. Own elasticities of fertilizer and land were elastic and of seedling and labour were inelastic. Ten percent (10%) increase in fertilizer, labour, seedling and land prices will decrease the demands of these inputs by 12.71, 5.32, 8.3 and 12.21%, respectively.

Table 6: Derived Elasticities of Conditional Factor Demand

Price	Fertilizer	Labour	Seed	Land
Fertilizer	**-1.2711**	0.0758	3.5253	-0.6754
Labour	4. 5354	**-0.5322**	-1.0693	0. 6227
Seed	5.4227	-0.8650	**-0. 8292**	0.5617
Land	-3.1117	3.0076	1.0151	**-1.2218**

Source: original calculations.

According to these values, in case of price increase in inputs, the farmer will give up the input of fertilizer the easiest, and this will be followed by land, seedling and labour, respectively. Labour prices had the hardest elasticity among the inputs used for Irish potato production.

A positive sign between two inputs shows substitution relationship between them, while negative sign between them shows complementary relationship. The cross-price effects between seed and labour and between fertilizer and land were negative, suggesting that these pairs of purchased inputs were complements. The rest of the derived cross-price elasticities of conditional factor demand were positive. Cross price elasticity of fertilizer and labour, fertilizer and land, seed and labour, and between seed and land were inelastic. The highest substitution was between seed and fertilizer, followed by labour-fertilizer.

A 10% increase in fertilizer price increases labour demand by 44.5%, while 10% increase in labour price increases fertilizer demand by 0.8%. A 10% increase in fertilizer price increases seed demand by 54%, while 10% increase in seed price increases fertilizer demand by 36.3%. A 10% increase in fertilizer price decreases land demand by 36%, while 10% increase in land rent decreases fertilizer demand by 7%. This shows strong complementary relationship between fertilizer and land. A 10% increase in labour wage decreases seed demand by 8.7% and 10% price increase in seed decreases labour demand by 13%. A 10% increase in land rent will increase labour and seed demands by 6.2% and 5.6%, respectively. A 10% increase in the wage and price of seed increases demand for land by 30% and 10percent, respectively.

Morishima Technical Substitution Elasticities (MES) are shown in Table 7. As can be seen in the table, the substitution elasticities are higher than zero. Accordingly, it is understood that there is an incomplete substitution between all input pairs in Irish potato production. Here, technical substitution elasticity between seed and fertilizer was found to be 6.25. If fertilizer prices increase when seed prices are stable, fertilizer use will decrease, and more labour (the production factor with lower cost) will be used instead. The decrease in the use of seed will be 6.25% of seed-fertilizer use ratio. Similarly, the decrease in fertilizer use will be 5.07% of labour-fertilizer use ratio, while it will increase land-fertilizer use ratio by 4.9%. A similar situation is also valid for the other inputs, and it appears that these inputs are substitutable inputs, one for the other, for Irish potato, except for land-fertilizer and seed-labour.

Table 7: Allen-Uzawa and Morishima Elasticities of Factor Substitution

	Fertilizer		Labour		Seed		Land	
Price	**AES**	**MES**	**AES**	**MES**	**AES**	**MES**	**AES**	**MES**
Fertilizer	-1.332	-	1.1358	1.3469	0.3763	4.7964	0.0976	0.5957
Labour	1.1358	5.0676	-0.4234	-	0.7943	-0.5371	2.5634	1.1549
Seed	0.3763	6.2519	0.7943	-0.0358	-1.0987	-	0.0321	1.3909
Land	0.0976	-1.8899	2.5634	4.1906	0.0321	2.2369	-3.401	-

Source: original calculations.

The Allen Elasticities of Substitution are also presented in Table 6. The Allen partial elasticities of substitution (AES) were calculated at the sample mean of the cost shares for Irish potato production. Positive signs indicate substitution relationships between any pair of inputs. A strong substitution relationship was found between land and labour.

4. Conclusion

The study analyzed cost efficiency and input elasticities among Irish potato farmers in Dedza district, Malawi, using the stochastic translog cost frontier and system of cost share equations which were estimated by Iterated Seemingly Unrelated Regression (ISUR) technique. The findings of the study showed that Irish potato farmers in Dedza district are not operating at full cost efficiency level such that opportunities exist for improvement in cost efficiency by Irish potato farmers. Education, credit access, farm experience, degree of specialization, household size and frequency of weeding increased cost efficiency. One policy issue is raised: Credit should be extended to Irish potato farmers to enable them to purchase farm inputs. Non-farm employment led to misallocation of the resources employed by Irish potato farmers. Therefore, there is need for households to be linked to microfinance institutions for credit access which can take the place of non-farm employment.

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