Assessment of cost optimization in smallholder baby vegetable production in Eswatini

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ABSTRACT

Baby vegetable production is an emerging export-oriented industry in Eswatini. The smallholder farmers mainly drive it through extensive support from the buyer, NAMBoard; hence, it is a government program. Though initiated in 2003, the sector has not flourished to meet the observed market demand. The growth through farmer numbers has remained low. This study investigates enterprise allocative efficiency levels and its effects on farm outcomes. Using a stochastic frontier cost function permitted distinguishing between inefficiency effects from within and external to the farm. The results presented an average allocative efficiency level of 0.53, ranging from 0.9 and 0.84. An average efficiency farmer can still reduce production costs by 37% to attain the maximum (0.84) efficiency recorded in this group. All input coefficients were less than 1 implying over-expenditure on farm inputs. Elasticity for seed and fertilizer costs were significant and positive, indicating that a cost-saving could be made upon optimizing expenditure on these inputs. Agrochemicals were negative but insignificant, indicating that expenditure on these is contributing to lower output levels. The return to scale was 0.788 and less than one, showing that an increase in the spending on inputs resulting in a less proportionate output level will be realized. Farm capital was more productive (0.679) than labour (0.109). It is therefore recommended that smallholder farmers be assisted to adopt optimal use levels of inputs and cost-effective solutions. Furthermore, there is a need for empowerment on labour management during harvest season.

Key words: Allocative efficiency, farm enterprise, smallholder, cost efficiency, optimization.

INTRODUCTION

The ratio on the total actual unit cost of producing an output to the total cost of optimal factor combinations of producing the same output is called allocative efficiency of production (Chukwuji et al., 2006). It can be computed using the cost efficiency of production, revenue efficiency of production, or the combination of the two, which is called the profit efficiency of production (Wu, 1996). The ration of the possible least-cost mix for the enterprise to the actual observed farm costs of production is called the cost efficiency, while the ratio of the potential maximum enterprise revenue a farmer can be observed to the actual recorded in the farm is call revenue efficiency. Profit efficiency, therefore, refers to the combination of the two. The choice of which method to used depends on the prevailing market conditions, especially the input and output prices observed (Merwe, 2012). For an industry where farmers face the same produce prices but different input prices use cost efficiency while for the same input prices, yet different output prices use the revenue efficiency. Profit efficiency will therefore be used when both input and produce prices are different.

Allocative efficiency establishes if respondents are
producing using the best possible cost combination. Farmers are to optimally allocate the direct, operational and overhead costs of production to be efficient (Purdy and Langemeier, 2019). While the composition of the overhead of production will vary the system and scale of production, the composition of the direct cost for a unit produce does not vary. Therefore, a comparison using the direct cost of production gives a better indication of farm allocative efficiency and the use of stochastic frontier analysis (SFA) for estimation enables the understanding of the production in farming. In Eswatini, the SFA was adopted to direct policy intervention into the smallholder growth of numerous sectors in agriculture, such as in smallholder beekeeping, mushroom production, organic vegetables, dairy, maize, credit use and sugarcane production (Kongolo, 2014; Masuku, 2013; Masuku et al., 2014; Sihlononyane et al., 2014; Malinga et al., 2015; Dlamini et al., 2010; Dlamini et al., 2018). Results have brought forth policy implications of current policies and farm management practices to help the smallholder farmers. Using inefficiency effects evaluation, the factors inhibiting growth in these sectors were identified. Recommendations targeted the relative benefit to be accrued the present level of input used that was to be optimized. The effect of socioeconomic characteristics farm was used to explain the inequality of production. However, there is less regard to the magnitude of disparities of observed inefficiencies in the producing group and for the emerging baby, vegetable sector limited information is available (Langwenya, 2014).

Baby vegetables are smaller immature breeds, tender, and delicate versions of the conventional varieties. They originated from England in the 1800s and promoted massively in French cuisine and preferred by consumers for their minimal waste. They are more flavorful, tender, and have shorter plant to harvest period than the mature type. Their baby stage is too short, making harvesting time a critical phase for maximized gain. They are harvested immaturely and are highly perishable, therefore have a concise shelf life. Post-harvest handling, therefore, targets quality preservation through rapid cooling, proper refrigeration, and wiping to remove dirt.

In Eswatini, these are grown through government extension support and sell their products to the National Marketing Board. These are farmers growing solely for the export market. Baby vegetable production is promoted in two main regions in Eswatini, which is Manzini and Hhohho administrative region. Farmers mainly grew baby green beans, baby marrows, yellow petty pens, baby gem squash, snap peas and green petty pens. Producers are linked to NAMBoard through producer contracts and they receive extension and market support from the same. NAMBoard is a government organization tasked with horticultural development and regulation of all imports and exports in Eswatini. The agribusiness unit at Encabeni is responsible for crop development through extension, transport, input supply, warehousing, and sales. Storage is through the established and certified pack-house for the horticulture products. Since 2003, the smallholder baby vegetable production has not grown significantly to meet the observed demand. As an export-oriented sector, the understanding of sector inefficiencies effects will enable an understanding of the priority areas of intervention to help this emerging industry grow.

METHODS AND MATERIALS

The study used an exploratory, descriptive research design to any cost related inefficiencies in smallholder farm enterprises. A census of the producing farmers in the Manzini and Hhohho regions of Eswatini was conducted for all producing farmers in the 2018/2019 season. The study area included four rural development areas (RDAs) and seven villages. RDAs included Motjane, Luve, Ludzeludze, and Ntfonjeni. As a short-season crop, it was essential that the study eliminates opportunistic growers to capture the heart of the baby vegetable production. A total of fifty-seven farmers were interviewed face-to-face through a structured questionnaire, and the interview guide was with key informants of the sector. Data were analyzed using the stochastic frontier model to determine the allocative inefficiency effects in the production.

Stochastic frontier analysis of any firm is grounded in two steps, namely; (1) the estimation of the frontier model and (2) the use of the two-limit regression model to establish the factors contributing to the observed inefficiency. These estimates then form the basis of comparing among individual firms. While the Data Enveloping Analysis (DEA) also permits the analysis of production and cost, it is limited in capacity to provide different firm estimates and therefore limits comparison within a group. Thus, the stochastic frontier analysis was adopted to analyze study data. The stochastic frontier analysis assumes the specification of maximizing firm production and permits the effects of outside random shocks into the production process. Thereby, it allows estimating and distinguishing between the inefficiency effects caused by measurement error and exogenous effects (Coelli, 1995). Random effects are of paramount importance to the agricultural industry, which bears numerous external factors that cripple its performance; these include the variability of weather conditions, pests and diseases, and poor record-keeping among farmers. As an emerging smallholder driven industry, the production analysis of the baby vegetable sector in Swaziland will adopt the SFA. Efficiency analysis under present technologies and systems enable policy development into formulation into advancing pricing, extension services, credit, input distribution, and output marketing policies (Hassaapour, 2012).

Developed by Aigner et al. (1977), the SFA formulation is presented as follows:

\[ Y = \beta'x + v - u \]

\[ (1) \]
U = |v| and v ~ N [0, δv²]  .......... (2)

Where;
Y is the observed output, \( \beta'x \) + v is the best frontier goal as 

pursue by individual firms. As a two-part formula, the 

stochastic frontier is made of; \( \beta'x \) is the determinstic aspect 
of the frontier while the v - u, v ~ N [0, \( \sigma_v^² \)] is the stochastic part. 

The error contained in v - u has two components, the 
symmetric disturbance (v) from exogenous shocks and 
measurement error, then the non-negative inefficiency 
component (u).

This inefficiency is the change (v - u) in a stochastic cost 
frontier representing the minimal cost frontier; hence it is 

the normal-half normal model. Using stochastic frontier 
production function, the model assumes the presence of 
technical inefficiency of production, therefore, separating 
the effects of noise from the effects of inefficiency. 

According to Battese and Coelli (1995), the specification of 
the general stochastic production function frontier model 
analysis is given in Equation (3):

\[ Y^*_i = F(X_i; \beta + \exp(v_i), i = 1,2,3,n) \]  .......... (3)

Allocative efficiency (AE) involves harnessing the cost and 
demand consideration into the production process. 

Equality of these renders a firm competitive (Heather, 
2000). Therefore, the allocative efficiency of a firm is its 
ability to produce goods and services using the minimum 
cost ratios possible for the market. Kopp and Deiwart 
(1982) noted that a rational firm will adopt a behavioral 
goal of optimum costs possible through saving of inputs for 
every level of output produced. While Bravo-Ureta and 
Pinheiro (1997) noted that allocative efficiency was more 
significant as a source of gain in economic efficiency than 
technical efficiency. Allocative efficiency is the ratio of the 

marginal value product of and input over the marginal 
factor costs (Heather, 2000; Muhammed et al., 2017). Refer 
to Equation 4:

\[ r = \frac{\text{MVP}_{xi}}{\text{MFC}_x} = \frac{\text{MPP}_x \times P_y}{\text{MFC} = P_x} \]  .......... (4)

Where:
P_x is the price of the input under consideration;

r is the resource use efficiency, where \( r = 1 \) is efficient, \( r > 1 \) 
is overutilization of a resource, and \( r < 1 \) is underutilization.

The stochastic production frontier is presented as a Cob 
Douglas model in equation 5 below (Muhammed et al., 
2017; Ali et al., 2019; Aktar et al., 2018), which represented 
the model specification for the study.

\[ \ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \epsilon \]  .......... (5)

Where - \( \ln \) = natural logarithm

\( Y_i \) = total output (kg/ha) for each farm, where \( i=n \)

\( X_1 \) = Total Seed cost (E/ha)

\( X_2 \) = Total fertilizer cost (E/ha)

\( X_3 \) = Total tractor costs (E/ha)

\( X_4 \) = Total cost of agrochemicals (E/ha)

\( X_5 \) = Total labour Costs (E/ha)

\( X_6 \) = Land size used in hectares (ha)

\( \beta_0 \) = constant

\( \beta_i \) = coefficient for the \( i \)th input, called the production 
elasticities.

The summation of the estimated coefficients presents the 
return to scale of the industry (Hong and Yabe, 2015; 
Muhammad et al., 2017). The sum greater than one implies 
increasing returns to scale. That is, increasing the scale of 
production will be productive and profitable.

The direct costs are typical to every producer's faces and 
could enable them to trace inefficiencies in the production. 
Data simulation employed R-studio.

RESULTS

Fifty-eight percent (58%) farmers were from the Hhohho 
region, while forty-two percent (42%) came from the 
Manzini region. Females constituted 77%, while 33% were 
males. Grower distribution in the RDA was 45% for 
Ntfonjeni RDA, 37% for Ludzeludze RDA, 11% for the 
Motjane RDA, and 7% for Luve RDA. The youngest was age 
26 and female while the average was 48.4 years.

The average land used for baby vegetable production is 
1.4 ha and yields 3, 220 kg of output. Total seed and labour 
costs are the most significant shares at 36 and 35% of total 
variable cost each, making a total of 71% Labour costs 
when split consists of 23% family and 12% hired labour. 
Total fertilizer cost is 19% composed of lime basal and top-
dressing costs at 7, 6, and 6%, respectively. Agrochemicals 
are 4% and tractor at 5% of the overall cost.

The average allocative efficiency for the sample is about 
53%, with a minimum efficiency value of about 9% and a 
maximum efficiency value of 84%. The results imply that, 
based on the cost frontier model, on average, the 
smallholder baby vegetable farmers can obtain 53% of 
potential income from a given mix of production inputs 
costs (seeds, fertilizer, agrochemicals, labour, tractor). 
Therefore, a potential exists for these farmers to improve 
farm returns by 47% through improving production 
efficiencies to maximum (100%). Similarly, the results 
obtained by Shresta et al. (2015) showed that the mean 
allocative efficiency of small scale vegetable farmers in 
Nepal was 0.5, while Mokgalabone (2015) recorded 0.39 
allocative efficiency on smallholders in Tzaneen, South 
Africa.

The gamma \( \gamma = 0.769 \) (p<0.001), showing that it is 
significantly different from zero; therefore, the cost-
oriented efficiency is essential in explaining the variability
of the recorded outputs. That is, the inefficiency effects are significant in determining the level of variability recorded in the baby vegetable producing farms in the Kingdom of Eswatini. Therefore, the null hypothesis \( \delta = 0 \) is rejected, which says there are no inefficiency effects in the production of baby vegetables in Eswatini. Similar to the production of red onions in Sri Lanka, Atapattu and Rupasena (2016) observed that farmers inefficiently used resources in their production.

Table 3 shows the distribution of the farmers according to the efficiency of their farming operations. The results showed that 64.9% of farmers have efficiency values above the mean efficiency value, while the remaining 35.1% have an efficiency level below the overall mean efficiency level. The mean efficiency level was 0.532, while the range was from 0.091 to 0.845. Only 1.8% of farmers had efficiency below 10%, and none were above 85% efficiency.

According to Bravo-Ureta and Pinheiro (1997) and Hong and Yabe (2015), the average efficient farmer could reduce production cost by 37% (equation.6) for them to attain the maximum (0.845) observed efficiency in these farmers. While the most inefficient farmers could realize 89.2% (eq... 7) cost-saving if they can achieve the maximum (0.845) observed efficiency in the group. The difference in the value of harvest and post-market returns indicates the true value accumulated by the farmer for the farm capital investment made. Therefore, savings here could be actual input cost and improvement in the volume of harvest sold. In line with Gautam et al. (2017) who reported that the postharvest losses in tomatoes amounted to a quarter of the total harvest weight of the product and it is lost along the value chain before reaching the consumers while about a fifth of it was bought at lower than market prices due to poor quality in Nepal.

\[
1 - \frac{\text{mean efficiency}}{\text{maximum efficiency}} = 1 - \frac{0.532}{0.845} = 0.370414 \\
\text{.... (6)}
\]

\[
1 - \frac{\text{minimum efficiency}}{\text{maximum efficiency}} = 1 - \frac{0.091}{0.845} = 0.892308 \\
\text{.... (7)}
\]

However, only two elasticities for seeds and fertilizer were significant (p<0.01; p=0.5, respectively). Seed cost coefficient at 0.237 (p<0.001) is a positive indication that an optimized seed allocation will enable the smallholder baby vegetable farmers to attain the same level of output. Overuse of fertilizer was recorded in the rice production in Nigeria and needed to be reduced by 98.2% (Ajoma et al., 2016). While seed rate significantly affected yield levels in red onions and wheat in Vietnam and Afghanistan, respectively (Atapattu and Rupasena, 2016; Tavva et al., 2017). There exists a potential for the farmers to reduce their cost by 76.3%, while an optimized fertilizer allocation will reduce their cost of production by 50% (0.469, p<0.001) for the same level of output.

Noted is the negative relationship with agrochemicals, though statistically insignificant, the present use of this input is negatively affecting the output levels released by farmers. Agrochemicals have an adverse effect on tea in Vietnam (Hong and Yabe, 2017). Farmers should adopt a more optimal use of agrochemicals to cut off production costs. The elasticity for tractor and labour costs are positive but not statistically significant. All input elasticities were less than one indicating overutilization of input in the production, which increase the cost of production relative to the scale.

The scale efficiency of baby vegetable production is given by the summation of the elasticities of the production inputs (Hong and Yabe, 2015; Tavva et al., 2017; Tahir et al., 2019). The 0.788 scale efficiency is less than 1, reflecting decreasing returns to scale. Indicating that, with respect to the farm capital and labour, the benefit in output realized will be less proportionate to an increase in the amount of the additional inputs. This is in line with the results recorded for tea production in Vietnam (Hong and Yabe, 2015). Returns to scale was 0.229, implying far less change in output given an increase in the scale of smallholder tea production.

Farm capital was presented as the sum of the cost of all the inputs; seeds, fertilizer, agrochemicals, and tractor (Tahir et al., 2019). The 0.679 scale efficiency recorded for farm capital reflects that farm capital is more productive than labour (0.109) on these producers. Farmers can benefit more from improvement in labour management to optimize their use in their production. Farmers mainly had excessive use of family labour and hired harvesting labour in the production. As stated in one interview on the 16th May 2019, Horticulture expert 1 responded:

"Baby vegetables grow massively at an hourly rate. Therefore, farmers use more labour in this period to harvest them at the required sizes. Farmers never replace gaps of seedlings lost to cutworm, dumping off as well as losses to harvest to post-harvest handling. The implication is that the harvest falls short of the actual seed rate applied on the scale, yet fertilizer quantity is applied to the land scale. Consequently, the value of harvest relative to scale and expenditure is low. Yet the value of harvested is further reduced at quality grading at the pack house."

Product loss to postharvest handling and grading are in strawberries where the grading index was the color, freshness, texture, and taste (Mahat and Chaudhari, 2018). Kankainen et al. (2016) established that produce quality traits such as product texture and skin color significantly affect profitability. This is similar to the postharvest losses recorded in tomatoes (Gautam et al., 2017). Therefore, postharvest handling of products needs to be regarded as a critical element of efficiency when optimal gains are to realize.
Conclusion

The study reveals that farmer’s losses are caused by allocative inefficiency effects in the production expenditure on seeds and fertilizer. The overutilization of agrochemicals is negatively affecting output levels. Cost-effective production methods should be employed to enable cost-saving towards optimizing production returns. Farm capital is productive than labour in the group and enterprise experiences, decreasing returns to scale. Aligning the actual volume of harvest sold to the seed rate enabled the realization of the magnitude of losses. It reflected the need for optimizing the post-harvest handling as an efficiency area in this industry. It is recommended that policy intervenes to help these farmers improve their cost-efficiencies through maximizing returns to expenditure. Policy strategies should include farmer training on resource cost optimization for competitiveness as well as post-harvest handling and quality control to optimize production returns. Furthermore, research on factors of efficiency should consider the proportion of rejected product as a variable to establish its contribution to the cost inefficiencies observed. This will eliminate attributing inefficiency to only farm and farmer characteristics and include the postharvest handling and transportation efficiency requirements of the sector.

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REFERENCES