Factors affecting profit efficiency among smallholder beef producers in Botswana

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Background

Botswana's livestock sector provides about two thirds of national agricultural value added. Beef production is a vital part of the rural economy as a source of income and employment and has been presented as a key investment and economic diversification opportunity (BIDPA, 2006). Beef is moreover the country's major agricultural source of foreign exchange and generates about 80% of agriculture's contribution to GDP (NDP, 2010), notably due to quota access to European markets. Apparently declining beef productivity during recent decades is seen as the basis of an erosion of competitiveness. Causal factors are likely to include many supply-side constraints, apparent as low off-take rates and high stock losses. Climatic constraints on arable crop production serve both to reinforce livestock's dominance of agricultural statistics and to limit options available for animal feeding. Beyond the farm gate, there is significant overcapacity in processing with consequent low profitability in processing operations (FAO and MoA, 2013, BIDPA, 2006). Throughout the value chain, high costs of Sanitary and Phyto-sanitary (SPS) compliance are apparent, and on the demand side, reductions in EU beef support prices have adversely affected competitiveness. These factors have contributed in turn to the country's inability to utilise fully its preferential access to EU import markets.

Past studies limitations include that they either failed to account for farmers' management-related adjustments to farm budgets in the presence of broader economic change, and/or that they assumed technical efficiency in terms of input use and production technology. Hence, efficiency has not been estimated and examined for its actual and potential influence on competitiveness and the factors affecting it.

The current study employs the profit efficiency approach (Delgado et al., 2008) to address these shortcomings using farm-level cross sectional survey data collected under the auspices of a development research project. The survey was implemented in three districts (Southeast, Chobe and Central) of Botswana. It collected detailed information on costs of and returns to livestock production, along with selected technical, physical and demographic variables for farm household operations across a range of farm sizes. The goal of this study is to measure competitiveness and identify the factors affecting it, so as to advocate change in Botswana's smallholder livestock systems.

Methodology

Farm profit from beef is measured in terms of gross margin (GM) which equals the difference between the total revenue (TR) and total variable cost (TVC) and is given by:

$$GM\ (\pi)=(TR\text{-}TVC)=(PQ\text{-}WXi)$$

$$\frac{\pi}{P}(P,Z)=\frac{\sum(PQ-WX_i)}{P}=Q-\frac{WX_i}{P}=f(X_i,Z)-\sum P_iX_i$$

$$GM(\pi)=\sum(TR-TVC)=\sum(PQ-WX_i) \quad (1)$$

To normalize the profit function, gross margin π is divided throughout by P (the market price of beef output) to obtain:

$$\frac{\pi}{P}(P,Z)=\frac{\sum(PQ-WX_i)}{P}=Q-\frac{WX_i}{P}=f(X_i,Z)-\sum P_iX_i \quad (2)$$

where TR is the total revenue from cattle activity, TVC are total variable costs (feeds, fodder, hired labour, electricity, medicines and vaccines, water, transport etc.), of securing revenue (excluding family labour) per farm i; Q is beef output; X represents the (optimal) quantity of input used; Z represents fixed inputs, P_i = W/P which represents normalized price of input X_i while f (X_i, Z) represents the production function. The Cobb-Douglas profit function was employed, which is expressed as:

$$\pi_i=f(p_i,Z)exp(V_i-U_i)\ \forall i=1,2,\ldots..n \quad (3)$$

where π, P_i, and Z are as defined above. The V_i is assumed to be independent and identically distributed random error, having normal N0,σ2 distribution, independent of the U_i. The U_i is profit inefficiency effect, which is assumed to be non-negative truncation of the half-normal distribution $^{+}N(\mu,\sigma2)$. In estimation we seek to capture, or assign to individual farms, farm-specific effects on inefficiency, following Battesse and Coelli (1995).

The Cobb-Douglas functional form for estimation is specified as:

$$ln\pi=ln\beta0+\beta1lnp1i+\beta1lnp2i+\beta1lnp3i+\beta1lnZ1i+\beta1lnZ2i+\beta1lnxZ3i+(vi\text{-}ui) \quad (4)$$

where π represents the normalized profit, P_1 represents feed prices, P_2 represents veterinary prices, P_3 represents the wage prices, Z_1 represents total fixed capital, Z_2 represents total family labour hours, Z_3 represents crop land sizes and β's are the unknown parameters be estimated.
The technical inefficiency effects (ui) in equation (4), can then be specified as:

$$ui=\delta_0+\sum_{k=0}^{l}M_{ik}\,\delta_k+\nu_i \quad (5)$$

where v_i is the inefficiency error term as defined earlier and the M_{ik} are k socio-economic and farm enterprise explanatory variables.

Results

Table 1: Sample summary characteristics

Variables	HS1 (N=238)	HS2 (N=140)	HS3 (N=178)	Pooled (N=556)	F- statistics
Value of beef Cattle output (Pula per year)	2,076.4	58,60.1	11,215.8	5,955.0	0.000
Average Beef cattle price (Pula)	1,772.3	2,081.4	2,218.7	1,993.0	0.000
Feed cost (Pula per year)	264.6	782.71	922.18	605.6	0.002
Veterinary cost (Pula per year)	296.0	565.92	1,192.2	650.9	0.000
Paid labour cost (Pula per year)	1,450.5	2,765.83	4,797.8	2,853.3	0.000
Cost of other inputs (Pula per year)	3,53.9	725.36	1158.0	704.9	
Value of fixed capital (Pula)	22,170.9	48,869.9	343,544.6	131,779.5	0.006
Total crop land area (Hectares)	4.9	6.88	7.30	6.19	0.198
Family labour (hours per month)	201.5	226.85	209.17	210.3	0.585
Age of household head (Years)	58.9	59.9	60.9	59.8	0.440
Gender (% female farmers)	31.1%	22.1%	10.1%	22.1%	0.000
Education of Household head (years)	4.1	4.24	6.62	4.95	0.000
Household Off farm income (Pula per year)	41,372.6	48,535.9	77,728.8	54,815.6	0.000
Distance to market(Km)	28.9	29.58	61.83	39.7	0.000
Herd size (Beef cattle equivalent)	5.3	14.45	55.99	23.9	0.000
Information access (Yes=1, No=2)	73.5%	79.3%	79.2%	76.8%	0.288
FMD disease zone (Yes=1, No=2)	36.6%	39.3%	53.9%	42.8%	0.001
Crop income (Yes=1, No=2)	43.3%	52.9%	51.7%	48.4%	0.112
Credit access	1.3%	2.9%	3.4%	2.3%	0.333

Table 2: Stochastic profit frontier estimates

Variables	HS1	HS2	HS3	Pooled
Constant	-0.08	1.11	2.01	2.61
Ln (Feed)	-0.24*	-0.30**	-0.23	-0.26***
Ln (Veterinary costs)	-0.23	-0.43**	-0.43**	-0.44***
Ln (Labour)	-0.15***	-0.11	-0.18**	-0.004
Ln (Fixed capital)	0.03**	0.02	0.02	0.01
Ln (Family labour Hours)	0.06*	-0.07	-0.16*	0.003
Ln (Crop land area)	0.05	0.05**	0.08*	0.05***
σ^2	0.21***	0.44***	0.69***	0.44***
Gamma (γ)	0.72***	0.65*	0.68*	0.74***
log likelihood function	-147.6	-138.59	-219.35	-561.98
LR test of the one-sided error	-24.6	17.12186	21.20	70.25

Notes: statistical significance levels: ***1%; **5%; *10%. HS1= Herd size group, HS2=Herd size group1and HS3= Herd size group1

Table 3: Determinants of Profit Inefficiency among beef Farmers

Variables	HS1	HS2	HS3	Pooled
Constant	-0.10	0.30	2.09	2.80
Age of household head	0.15***	0.89**	0.07	0.02
Education of Household head	-0.01	0.02	-0.04**	-0.04*
Annual household non-farm income	-0.02**	0.01	0.04	0.004
Distance market (commonly used)	0.02	-0.14*	-0.12**	-0.03**
Herd size	-0.09	-1.27**	-0.53***	-0.23***
Gender (% female farmers)	-0.13	-0.06	0.07	0.10
Information access (Yes=1, No=0)	0.10*	0.08	0.33	0.11*
FMD disease zone (Yes=1, No=0)	-0.35***	-0.16	0.09	0.04
Crop income (Yes=1, No=0)	-0.03	-0.23	-0.31**	-0.17***
Credit access (Yes=1, No=0)	-0.14	0.26	-0.08	-0.17

Notes: statistical significance levels: ***1%; **5%; *10%. HS1= Herd size group, HS2=Herd size group1and HS3= Herd size group1

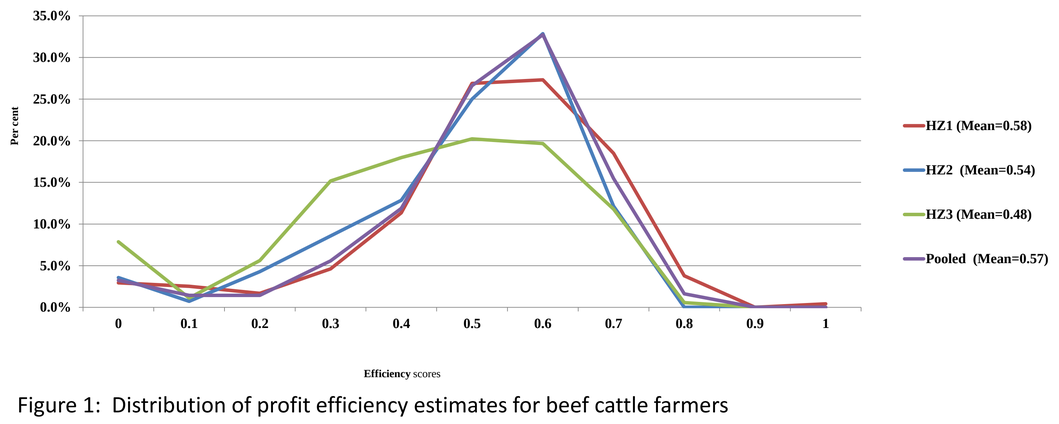

Figure 1: Distribution of profit efficiency estimates for beef cattle farmers

Conclusions

- Profit of smallholder beef producers can be increased through and reduction of input prices.
- Examination of the influence of scale on profitability yielded mixed results which suggest that the relationship differs between herd size groups.
- The presence of inefficiency detected in the study lends support to the proposition that production models that assume absolute efficiency could lead to misleading conclusions.
- The variation in actual profit from maximum profit (profit frontier) between farms, ranged from 65 to 74 per cent, mainly arose from differences in farmers' practices rather than from random variation.
- The study's results identify efficiency drivers, including education level, distance to commonly-used market, herd size, access to information and income from crop production.
- Results show that the average efficiency level is 0.58 for the whole sample and 0.56, 0.62 and 0.68 for the herd size category one, two, and three, respectively, suggesting that there is considerable scope to improve beef profitability in Botswana using the prevailing farm technology.

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