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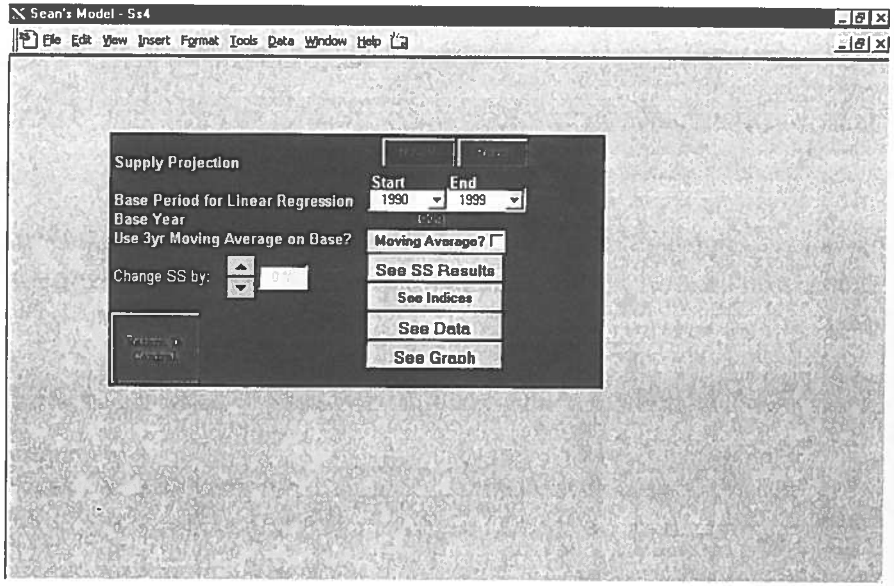

Appendix Figure 3: Supply model front end

MINIMUM ECONOMIC FARM SIZE: A CASE STUDY OF THE SMALLHOLDER TEA SUB-SECTOR IN KENYA

M.M. Kavoi[1], P.O. Owuor[2] and D.K. Siele[2]

The average area under tea in the smallholder sub-sector is approximately 0.27 ha. The population pressure in the tea growing districts is quite high compared to the neighbouring districts without the enterprise. The robust population growth in tea growing zones translates into continued sub-division of tea farms to school leavers who cannot get alternative employment in other sectors of the economy. This scenario is a potential threat to the future of the smallholder tea production in Kenya. The problem of continued sub-division of tea farms has degenerated into what has been termed as "uneconomic tea farm sizes". The objective of this study was to determine the optimal economic number of bushes a tea farm should have below which it would be referred to as "uneconomic tea farm size." A profit function model was fitted on 259 smallholder farms. It is concluded that all tea farms in these subsets are more successful in responding to the set of prices they face (Price efficiency) and /or because they have higher quantities of fixed factors of production, including entrepreneurship (technical efficiency).

1. INTRODUCTION

The average area under tea in the smallholder tea sub-sector in Kenya is approximately 0.27 ha (Kenya Tea Development Agency, 1964-2000) and it is still declining. The population pressure in the tea growing districts is quite high compared to the neighbouring districts without the enterprise (Kenya, GoK, 1999). For example, the population density in Kirinyaga, Nyambene, Nandi and Nyamira Districts with tea are 309, 153, 200 and 556 persons per sq.km. respectively as compared to 145, 25, 60 and 257 persons per sq.km for the respective neighbouring Nyandarua, Kitui, Transmara and Migori Districts without tea. The high population growth in tea growing zones enhanced by escalating unemployment in the country translates into continued sub-division of tea farms to school leavers who cannot get alternative employment in other sub-sectors of the economy. This scenario is so severe that sub-division of tea to farms of 500 bushes or below is not uncommon. This problem is a great cause of concern to all stakeholders in the tea industry. In the past few years, incessant sub-division of tea farms has degenerated into what has been refereed to as "uneconomic tea farm sizes". Farmers use various spacings to plant tea (Kenya, GoK, 1986). The most common one is the 5 * 2.5 ft which translates to a population of 8 611 plants per hectare. Others range from 4

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* 4 ft to 4 * 2 ft with population densities of 6 730 to 13 448 plants per hectare respectively. Thus, different spacing result in different bush numbers on the same area of land. As a result, farmers frequently sub-divide tea to their children in terms of the number of bushes because they are easy to count. The main thrust of this study therefore was to determine the minimum economic number of bushes a smallholder tea farm should have below which it would be termed as an "uneconomic tea farm size". This phenomenon was conveniently termed as "minimum economic number of bushes hypothesis".

2. METHODOLOGY

Primary data used in this study were gathered from smallholder tea farms in Kirinyaga and Nyambene Districts in East Rift Valley and Nandi and Nyamira in West Rift Valley. Multistage random sampling selection was adopted. First a random selection of the number of buying centres determined in each factory was undertaken after which a proportionate number of farms were randomly selected. The sample total in the four districts was 259. The data collected was on agronomic practices, input use, output, prices and extension in tea enterprise.

The analytical procedure used was the profit function model. According to production economic theory, efficiency relates basically to the common observation that farm-firms that produce homogeneous outputs such as green leaf have different factor productivities (Yotopoulos & Nugent, 1976). This phenomenon could be explained by the fact that different farms face different prices, or, different farms have different endowments of fixed factors of production or different farm-firms use different systematic behavioural rules. The use of profit function specifically allows for differences in the prices of the variable factors of production and in the quantities of the fixed inputs in its attempt to compare economic efficiency between farms with different endowments of the land resource to grow green leaf. Moreover, the profit function is used in such a way as to allow inter-farm differences in the ability to equate the value of the marginal products of the variable factors to their prices, that is maximise profits. It is an appropriate tool for measuring economic efficiency and both of its components, technical efficiency and price efficiency. However, not much is known about how disturbance terms in general should be introduced into the economic relationships (Lau & Yotopoulos, 1971). It is assumed that the error in the profit is due to climatic variations, divergence of the expected output price from the realised output price, imperfect knowledge of the technical efficiency parameter of the farm and differences in technical efficiency among farms.

Lau and Yotopoulos (1971) used data from Indian Ministry of Agriculture and Food to estimate the profit function for the small and large farms, and to compare the relative efficiency between the two farm groups. The categorisation of farms was on the basis of acreage. Farms of less than ten acres were termed as "small farms" whereas those with more than ten acres were termed as "large farms". The results showed that small-scale farms were more economic efficient than large farms. The results implied that in agriculture the supervisory role of the owner-manager of the farm might be crucial for attaining high levels of economic efficiency. Kilungo (1998) estimated the profit function for the smallholder dairy farmers in Kiambu District in Kenya. The average herd size was found to be 1.2 cows per farm per year. Dairy farms with greater herd size than the average were categorised as large while those with less than the average were categorised as small. The results showed that, both farm groups were equally efficient. These results were attributed to the use of similar quantities of fixed factors of production, which could even include the non-measurable factors such as diligence and entrepreneurship of the small farmer.

The profit function model was used in this study to determine the minimum significant number of bushes the smallest economic farm size should have in the smallholder sub-sector. The analysis was done for the whole sample of 259 smallholder tea farmers. This task was undertaken implicitly by factoring into the model a nominal number of tea bushes, by use of a dummy variable.

Given a farm-firm with a production function with the usual neoclassical properties: -

$$V = F(X_1,\ldots\ldots,X_m\,;\ Z_1,\ldots,Z_n) \qquad (1)$$

where

V = output;
X = variable inputs; and
Z = fixed inputs.

Restricted profit function (defined as current revenues less current total variable costs) can be written as follows:

$$P' = p\,F(X_1,\ldots, X_m\,; Z_1,\ldots,Z_n) - \sum_{j=1}^{m} q'_j X_j \qquad (2)$$

where:

P' = profit;

p = unit price of output; and
q' = unit price of the j^{th} variable.

The fixed costs are ignored, since they do not affect the optimal combination of the variable inputs. Suppose that a farm maximised profits given the levels of its technical efficiency and fixed inputs, the marginal productivity conditions for such a farm are:

$$p\,\delta(X;Z)/\delta X_j = q'_j = 1,\ldots\ldots, m \qquad (3)$$

By using the price of output as the numeraire, we may define $q_j = q'_j/p$ as the normalised price of the j^{th} input. Equation 3 can then be rewritten as

$$\delta F/\delta X_j = q_j = 1,\ldots., m \qquad (4)$$

By substituting equation 4 above into equation 2, Lau and Yotopolous (1971) used the profit function intrinsically allowing inter-farm differences in the ability to equate the value of the marginal products of the variable factors to their prices, that is to maximise profits. Within the framework of production theory, they derived an estimating profit function via the Cobb-Douglas production function, which could be used to measure economic efficiency and its components, between different farm size groups. To derive the working profit function model, one can start from a Cobb-Douglas or for that matter from any other form of a function. However, the analysis was casted in terms of the Cobb-Douglas function because it appears superior through tests of alternative functional forms (Yotopoulos & Nugent, 1976).

For the Cobb-Douglas case, the logarithmic profit function for each farm group (Yotopoulos & Nugent, 1976) is given by

$$\ln \pi^1 = \ln A^{1*} + (1-\alpha^*) \ln p + \alpha^*_1 \ln q'_L + \beta^*_1 \ln K + \beta^*_2 \ln T \qquad (5a)$$

$$\ln \pi^2 = \ln A^{1*} + (1-\alpha^*) \ln p + \ln (A^{2*}/A^{1*}) + \alpha^*_1 \ln q'_L + \beta^*_1 \ln K + \beta^*_2 \ln T \qquad (5b)$$

where:

π's = money profit;
q'_L = money wage rate per day;
p = price of output; and
1 and 2 = farm categories.

If prices of outputs differ only across districts or regions, then district or region dummy variables can be inserted to capture the effect of differences due to ($\ln A^* + (1-\alpha^*) \ln p$). This manipulation also allows for inter-district or interregional differences in the efficiency parameter in A^*. Hence the final estimating equation (Lau & Yotopolous, 1971) consisted of

$$\ln \pi = \alpha_o + S + \alpha^*_1 \ln q'_L + \beta^*_1 \ln K + \beta^*_2 \ln T \qquad (6)$$

where:

π = farm profit in money terms: (excluding interest on capital and land rent);
q'_L = money wage rate per day;
K = interest on fixed capital;
T = cultivable land;
S = dummy variable (differentiating farm categories);
α_o = constant; and
$\alpha^*_1, \beta^*_1, \beta^*_2$ = estimation parameters.

Equation 6 above was adopted for analysis in this study. The basic estimation equation in linearised double log form for green leaf production was presented as

$$\text{Log (TGM)} = \beta_0 + \beta_1 \log(NB) + \beta_2 \log(FC) + \beta_3 \log(LC) + D \qquad (7)$$

where:

TGM = tea gross margin per farm;
NB = number of tea bushes per farm; and
FC = cost of fertiliser per hectare per year per farm;
LC = labour cost per manday;
D = nominal number of bushes (with a value of 1 above a defined number and 0 below it);
β_0 = constant term; and
$\beta_1, \beta_2, \beta_3$ = estimation parameters.

Tea gross margin is tea gross output value less the total variable cost of tea in the year. Total variable cost of tea was the sum of fertiliser cost, cost of weed control, cost of pest control, cost of disease control and the cost of labour used in the course of the year. A common conceptual problem is how to determine the cost of family labour. The general principle is to value family labour at its opportunity cost; that is the benefit the family must forgo to participate, in tea production. The wage rates for labour in many developing countries may not accurately reflect the opportunity cost of shifting labour from one enterprise to another. However, for some farm enterprises like tea, there are peak seasons at planting, harvesting and plucking, when most rural workers can find employment in farms. At those seasons, the market wage paid to rural labour is a good estimate of its opportunity cost and its marginal value product.

Therefore, the market wage rate could be accepted as the economic value of rural labour (Gittinger, 1982). However, during off peak seasons, tea farmers lay off casual labour due to reduced green leaf plucking. As a result, there is surplus labour. The opportunity cost of labour during this period is less than the wage rate and is not ease to determine. Due to these difficulties, most studies (Kilungo, 1998; Lau & Yotopoulos, 1971 and Sidhu, 1974) have all used the market wage rate as the opportunity cost of family labour. This study also assumed that, most of the tea is plucked during the peak season when the market wage paid to casual labour is a good estimate of the opportunity cost of family labour. Therefore, the wage rate of labour (LC) was the product of total amount of green leaf (kg) in each farm per year and the plucking cost per kilogram divided by the total number of man-days (hired and family) used in the year. Fertiliser cost was computed on per hectare rather than per bag basis.

This is because farmers do not purchase fertiliser from the existing markets. The Kenya Tea Development Agency-which manages the tea industry in Kenya, imports all the fertiliser required by farmers and transports it to the respective factories where farmers pick it at a uniform price per bag. Thus, the cost of fertiliser input at the factory point does not reflect interfarm price differences. However, fertiliser cost/ha captures interfarm variations adequately. The number of mature tea bushes per farm was the only fixed factor. It was expected to explain profit better than the area under tea. Interest on fixed capital was ignored because in small-scale farming, it accrues to all the enterprises on the farm and not on tea enterprise alone.

The dummy variable was assigned a value of 1 for farms above a defined nominal number of bushes and 0 below it. Then, a regression equation was run for the profit function model with the dummy included as one of the explanatory variables. This procedure was repeated for all the tea farms from 500 bushes to 14 999 bushes. There were five cases below 500 bushes and were considered to be too small. There was one case above 14 999 bushes and was considered to be too large. Cases outside the 500-14 999 range were taken as outliers and were excluded from the analysis. The number of bushes variable was then plotted against the significance level of the dummy coefficient in the respective regression models. However, all the regression results could not be

presented here due to the enormous volume of the work. Nevertheless, the regression results of the maximum and minimum significance levels of the dummy coefficient were presented.

3. RESULTS AND DISCUSSIONS

The results showed that the coefficient of multiple regression was between 0.618 in Tables 1, 3 and 5, and 0.633 in Table 2. This coefficient gives the proportion of the total variation in the dependent variable explained by the predictors included in the model. The results showed that the independent variables explained between 61.8 % and 63.3 % of the total variation in the short run profit among the smallholder tea farmers. The corresponding measure for the adjusted R- Square was between 0.610 and 0.626. Further, the profit function model revealed that the F-value was between 83.994 and 89.583 with a significant level of 0.000 for all the cases presented. Therefore, the hypothesis that all coefficients (except β_0) are equal to zero, should be rejected since the F-values were highly significant. The Eigenvalues and variance proportions for the regression coefficients showed that there was no collinearity among the independent variables. The frequencies of standardised residuals were approximately normal. The normal probability plot confirmed this whereby the expected cumulative values were converging on the 45 degree diagonal line. These results lead to the conclusion that the profit function fitted the data quite accurately.

Table 1: Profit function regression results for smallholder nominal number of bushes between 500 to 599

Log TGM		Log Linear Model			
Variable	**β_1**	**S.E. β_1**	**Beta**	**t**	**Sig t**
Constant	0.951	0.514		1.851	0.066
Log NB	0.318	0.104	0.191	3.052	0.003
Log FC	0.427	0.091	0.206	4.714	0.000
Log LC	0.641	0.054	0.640	11.830	0.000
D	0.012	0.135	0.005	0.092	0.927
Multiple R	0.786				
R^2	0.618				
Adjusted R^2	0.610				
Standard Error	0.368				
ANNOVA	**Sum of Squares**	**df**	**Mean square**	**F**	**Sig. F**
Regression	45.569	4	11.392	83.997	0.000
Residual	28.211	208	0.136		
Total	**73.780**	**212**			

The results on the test of influence of predictors on short run farm profits indicated that the coefficients of the fertiliser cost per hectare and labour wage rate were positive and significant ($P < 0.001$) for all the cases. This implied that they positively and significantly influenced tea farm profits. It further meant that there is room for farmers to increase the use of the respective inputs to the optimal levels, just at the point where additional input use would reduce the profits. The number of bushes coefficient was positive and significant ($P < 0.01$) for bushes 500-599 in Table 1 and 3 800-3 999 in Table 3. In Tables 4 and 5, it was significant ($P < 0.001$) for bushes 8 000-8 999 and 10 000-10 400 respectively. However, it was insignificant in Table 2.

Table 2: Profit function regression results for smallholder nominal number of bushes between 900 to 949

Log TGM		Log Linear Model				
Variable	β_1	**S.E.** β_1	**Beta**	**t**	**Sig t**	
Constant	1.277	0.509		2.508	0.013	
Log NB	0.150	0.106	0.090	1.419	0.157	
Log FC	0.420	0.088	0.203	4.763	0.000	
Log LC	0.661	0.053	0.661	12.584	0.000	
D	0.292	0.100	0.154	2.924	0.004	
Multiple R	0.795					
R^2	0.633					
Adjusted R^2	0.626					
Standard Error	0.361					
ANNOVA	**Sum of Squares**	**df**	**Mean square**		**F**	**Sig. F**
Regression	46.682	4	11.671		89.583	0.000
Residual	27.098	208	0.130			
Total	**73.780**	**212**				

The significance level of the dummy coefficient was monitored at varying levels of the number of bushes. Since the profit function is transformed into a logarithmic function before estimation, the null hypothesis test becomes one of determining whether or not the coefficient of the dummy variable is significantly different from zero. Therefore, the results in Table 1 mean that within the range of 500-599, the dummy coefficient was 0.01240 with a significance level of 0.927. The relationship between the number of bushes and the significance level of the dummy coefficient for the whole sample was plotted in Figure 1.

Table 3: Profit function regression results for smallholder nominal number of bushes between 3800 to 3999 bushes

Log TGM		Log linear model			
Variable	β_1	**S.E.** β_1	**Beta**	**t**	**Sig t**
Constant	0.961	0.584		1.644	0.102
Log NB	0.318	0.122	0.191	2.605	0.010
Log FC	0.428	0.090	0.207	4.731	0.000
Log LC	0.640	0.053	0.639	12.051	0.000
D	0.006	0.091	0.004	0.062	0.950
Multiple R	0.786				
R^2	0.618				
Adjusted R^2	0.610				
Standard Error	0.368				
ANNOVA	**Sum of Squares**	**df**	**Mean Squares**	**F**	**Sig F.**
Regression	45.569	4	11.392	83.994	0.000
Residual	28.211	208	0.136		
Total	**73.780**	**212**			

Table 4: Profit function regression results for smallholder nominal number of bushes between 8000 to 8999 bushes

Log TGM		Log linear model				
Variable	β_1	**S.E.** β_1	**Beta**	**t**	**Sig t**	
Constant	0.764	0.510		1.498	0.136	
Log NB	0.382	0.093	0.229	4.086	0.000	
Log FC	0.425	0.089	0.206	4.770	0.000	
Log LC	0.650	0.053	0.649	12.291	0.052	
D	-0.258	0.132	-0.093	-1.954	0.052	
Multiple R	0.790					
R^2	0.625					
Adjusted R^2	0.617					
Standard Error	0.365					
ANNOVA	**Sum of Squares**	**df**	**Mean Squares**		**F**	**Sig. F.**
Regression	46.077	4	11.519		86.488	0.000
Residual	27.703	208	0.133			
Total	**73.780**	**212**				

It was observed that as the number of bushes increased from 500-599 in Table 1 to 900-949 in Table 2, the significance level of the dummy coefficient decreased from 0.927 to a minimum level of 0.004. From this point, it increased with the increase in the number of bushes to a maximum level of 0.95 at the range of 3 800-3 999 bushes in Table 3. It then decreased erratically with increase of the

Table 5: Profit function regression results for smallholder nominal number of bushes between 10000 to 10400 bushes

Log TGM		Log Linear Model				
Variable	β_1	S.E. β_1	Beta	t	Sig t	
Constant	0.922	0.511		1.805	0.073	
Log NB	0.328	0.091	0.197	3.615	0.000	
Log FC	0.429	0.090	0.207	4.764	0.000	
Log LC	0.643	0.054	0.642	11.927	0.000	
D	-0.053	0.179	-0.014	-0.295	0.768	
Multiple R	0.786					
R^2	0.618					
Adjusted R^2	0.610					
Standard Error	0.368					
ANNOVA	Sum of Squares	df	Mean Squares		F	Sig. F
Regression	45.580	4	11.395		84.048	0.000
Residual	28.200	208	0.136			
Total	73.780	212				

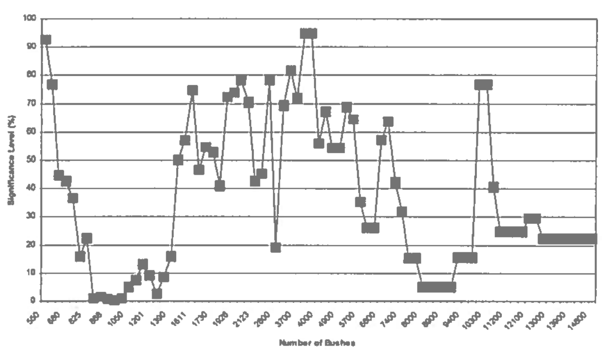

Figure 1: Significant number of bushes in the smallholder tea sub-sector

number of bushes and reached another minimum level of 0.052 at 8 000-8 999 bushes in Table 4. As the number of bushes increased farther, the significance level increased again and reached another maximum level of 0.768 in the range of 10 000-10 400 bushes in Table 5. Finally, it dropped and stabilised at 0.222 in the range of 12 500-14 999 bushes as shown in Figure 1. At 15 000

bushes and above, the dummy variable was automatically deleted from the model.

Furthermore, the dummy coefficient had a positive sign from 500-599 bush range in Table 1 and above. Hence, farms with bush numbers greater than this range are relatively more efficient. The sign turned negative from 2 000-2 099 bush range which means that farms with bushes below 2 000 are relatively more efficient. This scenario can be expressed in inequality forms as $500 \leq X$ and $X < 2000$ where X is a defined number of bushes. The two inequalities can be expressed together as $500 \leq X < 2000$. Within this inequality, the subset of efficient number of bushes can be expressed as $850 \leq X \leq 1\,106$ and $1\,200 \leq X \leq 1379$. The two inequalities represent ranges of "economic farm sizes" in smallholder tea. Any farm with tea bushes below the first range could conveniently be termed as "uneconomic farm size".

The optimal economic number of bushes was 900-949 with minimum significance level of 0.004. From 3 500 bushes and above, the coefficient of the dummy variable turned positive. This meant that farms with bush numbers greater than 3500 are relatively more efficient. However, the sign turned negative from 4000 bushes up to 12 500-14 999 bush ranges. Hence farms with bush numbers less that 14 999 are relatively more efficient. This relationship can also be expressed in an inequality form as $3\,500 \leq X \leq 14\,999$. Within this inequality, the subset of bush numbers which is negative and significant is $8\,000 \leq X \leq 8\,999$. The negative sign meant that farms with bush numbers within the significant inequality range and below are more efficient. This inequality pinpoints the second set of efficient farm sizes. It also represents the range of optimal economic farm sizes with the minimum significance level of 0.052. Any farm in the range of 3 999-14 999 bushes with a nominal number of tea bushes below 8 000-8 999 range could conveniently be termed as an "uneconomic farm size". These results imply that farms with bush numbers within the first significant inequality range i.e. $850 \leq X \leq 1\,106$ and/or $1\,200 \leq X \leq 1\,379$ or the second significant inequality range i.e. $8\,000 \leq X \leq 8\,999$ are more profitable, that is more economic efficient, at all observed prices of the variable inputs, given the distribution of the fixed factors of production. The most efficient and significant bush numbers among all the smallholder tea farms was found at 900-949 bushes which influenced short run profits significantly ($P \leq 0.01$). It was concluded that tea farms with bush numbers within these three inequalities are more successful in responding to the set of prices they face (price efficiency) and/or because they have higher quantities of fixed factors of production, including entrepreneurship (technical efficiency).

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HOW TRANSACTION COSTS INFLUENCE CATTLE MARKETING DECISIONS IN THE NORTHERN COMMUNAL AREAS OF NAMIBIA

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In this article a non-linear dynamic model is applied to determine the influence of transaction costs on the marketing decisions of cattle owners in the Northern Communal Areas of Namibia. The article tests the hypothesis that a producer's choice between alternative marketing options is influenced by transaction costs. The study shows that a number of transaction cost variables (herd size, distance from auction points, information and risk) have a significant effect on the proportion sold to Meatco and thus indirectly on the choice of marketing channels.

1. INTRODUCTION

Cattle owners in the Northern Communal Areas (NCA) of Namibia can sell their animals into the 'informal' or indigenous market, or they can sell to the government-owned parastatal, Meatco. Exports from the NCA are constrained by the veterinary cordon fence whereby both animals and the slaughtered meat has to be quarantined before leaving the area as a precaution against diseases such as foot-and-mouth. The main consumer market in the NCA is in the central areas. Cattle marketed in the NCA originate from the western and eastern extremes as well as from cross-border trade with Angola. Meatco operates two modern abattoirs in the NCA, while slaughtering and marketing facilities in the informal marketing chain are rudimentary. Meatco buys cattle at various buying points stretched over the whole of the communal areas from West to East. The cattle are transported from these buying points to quarantine camps a considerable distance away from the abattoirs where the cattle are ultimately slaughtered. A detailed analysis (Vink *et al*, 1999) shows that Meatco operates at a loss in these areas, hence cattle owners' decisions to sell are important to a more efficient design of the Meatco operations.

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