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Spatial Planning Competitiveness Integrants in Dairy Production and Commercialization of Smallholder Dairy Value Chain Development in Uasin Gishu County, Kenya

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Abstract: Many rural households in developing economies majorly depend on smallholder farming activities. In Kenya, smallholder dairy farming grows at 4.1% in contrast to 1.2% for agriculture sector as a whole. Uasin Gishu County is the leading milk producer in Kenya with 70% subsistence, 20% semi-commercialized and 10% commercialized smallholder farming respectively. However, dairy production in this County is experiencing structural changes towards intensification and commercialization. Commercializing smallholder dairy value chain is critical in providing ways out of poverty and for sustainable rural development. Studies have shown that competitiveness of smallholder dairy production varies with intensification from free grazing, semi-zero grazing or zero grazing. This is true for Uasin Gishu County where rapidly declining household land sizes is contributing to increased intensification and commercialization in dairy production. Inefficiency of milk production leads to the sub-sector being uncompetitive in the market due to relatively high cost of milk production and low output. The objective of this paper is to establish the influence of competitiveness of dairy production on commercialization of smallholder dairy value chain development. Social survey research design was used to obtain both secondary and primary data. A sample size of 384 smallholder dairy producers was studied out of a population of 50,457 respondents. Cobb-Douglas stochastic frontier production function was used to estimate the technical and economic efficiency of smallholder dairy production while the profit function was utilized to measure the gross margin and profit of dairy production. Results indicate that presence of technical and economic inefficiencies had influence on milk production. Technical and economic efficiency increased with the level of intensification of milk production. The elasticity of milk production was an increasing function of cost of feeds and equipment in the three production systems with statistical significance at 5%.

Keywords: Competiveness, Dairy Production, Commercialization, Smallholder Dairy Value Chain Development, Uasin Gishu County

1. Introduction

Previous studies have shown that competitiveness of smallholder milk production varies with intensification approach from free grazing, semi-zero grazing or zero grazing [2, 3, 19, 25, 29, 30]. Researchers have suggested that improvement in efficiency and profitability is one of the key factors for the survival of dairy farms [2, 7, 17, 18, 19, 29, 30]. Inefficiency of milk production leads to the sub-sector being uncompetitive in the market due to relatively high cost of milk production and low output. In addition, low levels of profit leads to poor living standards for smallholder dairy farmers. The sub-sector thus becomes unattractive to investment, limiting its potential to provide employment and food security. This is true for Uasin Gishu County where rapidly declining household land sizes is contributing to increased intensification and commercialization in dairy production. However, the influence of competitiveness of dairy production on commercialization of smallholder dairy value chain development requires empirical evidence. The pillars supporting commercialization of dairy value chain development include the technical interventions that should enhance capacity and knowledge, productivity and competitiveness, and market access [3, 28]. This paper addresses the productivity and competitiveness component by considering the spatial planning competitiveness integrants in smallholder dairy production and commercialization in Uasin Gishu County of Kenya. The aim of this paper is to account for the influence of indicators of competitiveness in dairy production on commercialization of smallholder dairy value chain development in Uasin Gishu County, Kenya. The smallholder dairy producers in Uasin Gishu County are categorized in the commercialization index as 70% subsistence; 20% semi-commercialized; and 10% commercialized [14]. Adoption of improved livestock technologies is central to transformation of farming systems and a path out of poverty in developing countries [22]. The technology adoption will result in increased milk production so that surplus milk is sold in the market. In addition, technologies that enhance cost reduction will further lead to commercialization of milk production [17]. This indicates that the needs for commercialization of smallholder dairy value chain development is inevitable yet has not reached the level enabling producers benefit from increased income and stimulate rural development [11, 13, 15, 16]. The Country and the Uasin Gishu County in particular has huge potential for commercial-orientated smallholder dairy value chain development [14, 16].

2. Methodology

The section explores the study area, the research design and data analysis methods.

2.1. Area of Study

Uasin Gishu County is situated in the Rift Valley region of Kenya. It has total area of 3,327.8 Km^2. It lies between longitude 34°50′ and 35°37′ east and 0°03′ and 0°55′ north. Uasin Gishu is made up of six Sub-Counties namely: Soy; Turbo; Kapsaret; Kesses; Ainabkoi and Moiben [14, 16]. The county is the leading milk producer in Kenya. It is mainly characterized by subsistence (70%) oriented smallholder dairy producers with the remaining producers under semi-commercialized (20%) and commercialized (10%) [14, 16].

2.2. Research Design and Method of Data Analysis

This paper used cross-sectional research design. A sample size of 384 smallholder dairy producers was studied out of a population of 50,457 respondents. Methods of data analysis included: The Cobb-Douglas stochastic frontier production function used to estimate the economic efficiency of smallholder milk production. Following [8], the model is expressed as:

$$Y_i = x_i\beta + (V_i - U_i)i = 1\ldots N. \qquad (1)$$

Where: Y_i = logarithm of the milk production of the i-th farm;

X_i = a kx1 vector of the logarithm of the input quantities of the i-th farm; β = a vector of unknown parameters; V_i = random variables which are assumed to be $N(0, \sigma_V^2)$, and independent of the Ui; U_i = non-negative random variables which are assumed to account for technical inefficiency in production, and are assumed to be $|N(0, \sigma_U^2)|$.

Gross margin analysis involved computing of the variable costs and revenue of milk production [21]: Gross Margin = Revenue - Variable costs. According to [21], production of goods and services by firms cannot be done when total variable cost is greater than total revenue.

However,

$$GM = R - TVC. \qquad (2)$$

Where: GM = Gross Margin; R = Revenue; TVC = Total Variable Cost.

This means that the gross margin derived by a smallholder farm is a measure of its performance and revenue in this study considers the value of the milk produced on the farm. In the case of milk revenue: R = p.q. Where: R = Revenue; p = Price of milk per litre; q = Milk output (litres). Profit is given by total income less total costs of milk production. The gross margin and profit were calculated per liter for the three milk production systems.

3. Results and Discussions

3.1. Commercialization of Smallholder Dairy Value Chain Development

Competitiveness of dairy production was measured using technical and economic efficiency and commercialization using profitability function. The Cobb-Douglas stochastic frontier production function was used to estimate technical and economic efficiency. The profit function used the value of milk produced to measure income while the costs included variable costs and depreciation costs of equipment and housing.

3.2. Technical Efficiency

The distribution of the estimated input-oriented technical efficiency scores is presented in table 1 below and is discussed as follows: The results show that the technical efficiencies vary from one milk production system to another. In Uasin Gishu County, the computed technical efficiency for the zero-grazing system varied between 0.29 and 0.97 in the minimum and maximum value respectively, with a mean value of 0.70 and standard deviation of 0.24. The semi-zero grazing system had computed technical efficiency of 0.14 as the minimum value and 0.89 as the maximum value with a mean value of 0.57 and standard deviation of 0.32. The technical efficiency for open grazing system varied between 0.10 and 0.79 as the minimum and maximum values respectively, with a mean of 0.79 and standard deviation of 0.2. In comparison, these results show that the zero grazing system had higher mean technical efficiency than open grazing and semi-zero grazing systems. Therefore the dairy producers need to put more effort in utilization of the inputs that increase milk yield (such as feeds, equipment and labor) in Uasin Gishu County so as to minimize inefficiency. In addition, technical efficiency increases with intensification. The technical efficiency scores are compatible with the findings of [23] that revealed a technical efficiency of 0.82 for milk production in India. The concept of technical efficiency is based on the identification of a production frontier representing the maximal combination of outputs attainable given the available set of inputs [1, 5, 9, 21, 26]. Technical efficiency expresses the ability to derive maximum output from a given set of inputs. Households operating on the frontier are considered technically efficient, while those located below the frontier are considered inefficient. The assumption of homogeneous inputs and outputs is necessary when input quality is not observed [22]. This assumption is important as quality attributes of both inputs and milk are variable in Uasin Gishu County.

Table 1. *Input-oriented technical efficiency scores of the stochastic frontier production function.*

Efficiency scores (%)	zero grazing		semi-zero grazing		open grazing	
	Frequency	%	frequency	%	frequency	%
>0≤10	0	0	0	0	0	0
>10≤20	0	0	9	6.13	13	7.88
>20≤30	5	5.68	7	5.34	4	2.42
>30≤40	10	11.36	16	12.21	35	21.21
>40≤50	7	7.97	18	14.5	56	33.94
>50≤60	18	20.46	23	17.56	45	27.28
>60≤70	13	14.88	27	20.61	5	3.03
>70≤80	16	19.18	25	19.08	7	4.24
>80≤90	11	12.5	6	4.58	0	0
>90≤100	7	7.97	0	0	0	0
Total	88	100	131	100	165	100
Min	0.29		0.14		0.1	
Max	0.97		0.89		0.79	
Mean	0.70		0.57		0.48	
Std. Dev	0.24		0.32		0.20	

The technical efficiency results in the three milk production systems show the presence of inefficiency. Many studies have shown that inefficiency is the rule rather than the exception [5]. This finding is important because the main consequence of technical inefficiency is to raise production costs, making farms less competitive. [26] analyzed the technical efficiency of milk production in dairy cattle farms in Slovakia for the period 2006 to 2010. The evaluated herds reached 96% of technical efficiency in milk production on average and the value was statistically significantly influenced by the feed costs only. The negative influence of this factor indicates inefficient utilization of feeds (balance of feeding ration, losses of storage, reciprocal substitution of feeds) or inefficient utilization of its production potential in relation to the given output level. Farmers need to examine the best practices of efficient peer farms to increase their overall technical efficiency. [31] assessed the scale and technical efficiencies of southeastern U.S. cow-calf farms using stochastic production frontier techniques to estimate input-oriented technical efficiency scores. They found an average efficiency of 0.86, implying a technical inefficiency level that is 14% on average, or that the average southeastern cow calf farm could reduce about 14% in inputs to produce the same output as an efficient southeastern farm on the frontier. The results also show that approximately 80% of the farmers achieved technical efficiency levels of 80% or higher. These results are higher than those found in the current study.

3.3. Stochastic Production Frontier Results

Table 2 below shows that the overall significance of the Cobb Douglas stochastic frontier production model given by the estimated sigma squared (δ^2) of 0.05 for zero grazing; 0.63 for semi zero grazing; and 0.63 for open grazing were significantly different from zero at 5% level. This indicates a good fit and the correctness of the specified distributional assumption of the composite error term. The variance ratio, gamma (γ), explains the total variations in output from the frontier level of output attributed to technical inefficiencies. The value of γ was 0.95 for zero grazing, 0.80 for semi zero grazing and 0.79 for open grazing and this implies that 95%, 80% and 79% respectively of variation in milk output is due to inefficiency. This means that the technical inefficiency effects are significant at 5% level in the stochastic frontier production function. These results are consistent with the findings of [23] that 80% of the differences between observed and the maximum production frontier output were due to difference in dairy farmer's level of technical efficiency in Pondicherry, India. Similarly, [1] found a highly significant gamma statistic that indicated the presence of a high systematic inefficiency and implied that 95% of the variations in milk production could be attributed to inefficiencies.

Table 2. *The maximum likelihood estimates (MLE) for technical efficiency of the stochastic frontier production function.*

Parameter		Zero Grazing	Semi-Zero Grazing	Open Grazing
		ML estimates	ML estimates	ML estimates
		Coefficient (T-Ratio)	Coefficient (T-Ratio)	Coefficient (T-Ratio)
Constant	β_0	6.55	4.62	7.38
		(8.25)	(4.22)	(15.25)
Feeds	β_1	0.15**	0.30**	0.09 **
		(2.53)	(2.69)	(-7.44)
Herd -Replacement	β_2	0.03	0.09	0.12**
		(-0.42)	(-0.08)	(1.12)
Health management	β_3	0.28 **	0.14**	0.11
		(-6.03)	(3.20)	(-0.99)
Housing	β_4	0.20 **	0.26 **	0.18
		(-6.33)	(-1.12)	(-0.98)
Equipment	β_5	0.11**	0.27**	0.40**
		(1.96)	(5.00)	(9.11)
Labour	β_6	0.27**	0.11**	-0.08
		(7.00)	(0.92)	(-3.67)
Sigma-Squared	δ^2	0.05**	0.63**	0.63**
		(6.03)	(2.92)	29.31)
Gamma	Υ	0.95**	0.80**	0.79**
		(9.54)	(22.63)	(91.44)
Log (Likelihood)	Θ	14.12	(34.22)	(33.90)
LR Test Statistic		6.63	7.02	8.92
Mean Efficiency		0.70	0.57	0.48

** = significant at 5% level.

The elasticity of mean value of milk output in the zero grazing system is an increasing function of feeds, equipment and labor while in the semi zero system it is an increasing function of feeds, health management and labor. The result shows that for open grazing system the elasticity of mean value of milk output is estimated to be an increasing function of feeds, herd replacement and equipment. For instance, a 1 percent increase in herd replacement, and holding other things constant would increase milk output by 0.12 percent. These results are consistent with the findings of [4, 6, 12, 24, 31, 33] that the longer term competitiveness of dairy production systems depends on labor, land and infrastructure over time. At farm level, housing and equipment provide the appropriate infrastructure to support milk production and improve technical efficiency. With a finding of 78% mean efficiency, [1] recommended that the scope to increase efficiency of milk producers mainly depended on structural enhancements in the long run such as introducing high yield breeds.

The results of the current study demonstrate that zero grazing has a greater technical efficiency than semi-zero grazing while open grazing has the lowest level of technical efficiency. [4]. reported similar results that intensive dairying offers the highest returns to a household unit. Mean technical efficiency among farmers practicing zero grazing, semi-zero grazing and open grazing systems was 0.70, 0.57 and 0.48 respectively. Therefore, the scopes for technical efficiency improvement are 30% for zero-grazing, 43% for semi-zero grazing and 52% for open grazing systems.

The parameters of the production frontier are feeds, herd replacement, health management, housing, equipment and labor. The elasticity of milk production was an increasing function of feeds and equipment in the three production systems with statistical significance of 5%. Therefore, increasing the quantity of feed and equipment will lead to higher milk output. Labor significantly and positively influenced milk output in both the zero grazing and semi-zero grazing systems and negatively in the open grazing system. The labor requirements increase with intensification. Herd replacement was a significant maximum-likelihood estimate of the production frontier in the open grazing system only while health management was significant in both zero grazing (-0.14) and semi-zero grazing (0.24). The elasticity of frontier output with respect to housing were negative in all the systems but significant in the zero grazing (-0.22) and semi zero grazing (-0.18).

3.4. Economic Efficiency

As shown in Table 3 below, the economic efficiency for the zero grazing production system ranges from 18% to 98% with a mean of 62%. The presence of economic inefficiency indicates that there is potential to increase output gains without increasing input use. This implies that if farm households were to be fully efficient they will achieve a cost saving of 38%. On the other hand, if the average farm household in the sample was to achieve the economic efficiency level of its most efficient counterpart, then the average farm household could realize a 36% cost saving. A similar calculation for the most economically inefficient household reveals a cost saving of 80%. Economic efficiency for semi-zero grazing production system ranges from 15% to 91% with a mean of 50%. These farmers have an opportunity of saving costs by 50 percent so as to achieve full efficiency. On the other hand, if the average farm household was to achieve the economic efficiency level of its most efficient counterpart, then they could realize a 45% cost savings (that is, 1–[50/91]). A similar calculation for the most economically inefficient household practicing semi zero grazing reveals cost saving of 84% (that is, 1– [15/91]).

Economic efficiency for open grazing production system ranged from 11% to 80% with a mean of 50% (Table 3). This implies that, on average, if farm households using this production system were to be fully efficient they will achieve a cost saving of 50%. On the other hand, if the average farm household in the sample was to achieve the economic efficiency level of its most efficient counterpart, then the average farm household could realize a 37.5% cost saving (that is, 1–[50/80]). A similar calculation for the most economically inefficient farm household reveals cost saving of 86% (that is, 1– [11/80]). [33] Confirmed the presence of economic inefficiency effects in milk production by using the generalized likelihood ratio test with the estimated gamma parameter (γ) of the cost function being 0.78 indicating that 78.1% of the variation in the total cost of production among the farmers was due to the presence of economic inefficiency.

The zero grazing system had a minimum and maximum economic efficiency of 0.18 and 0.98 respectively; with a mean of 0.62. The other two milk production systems had lower values. Semi-zero grazing system recorded a minimum and maximum economic efficiency of 0.15 and 0.91 respectively and a mean of 0.50. Open grazing system had the lowest economic efficiency scores with a mean of 0.40, a minimum score of 0.11 and a maximum value of 0.80. Therefore zero grazing is more superior than semi zero grazing and open grazing with respect to economic efficiency. These results imply that not all producers are able to minimize necessary costs for the intended production of outputs. [2] estimated independent stochastic cost frontiers for various groups of farms in Spain to calculate their levels of efficiency. The empirical results showed that intensive farms were closer to their cost frontier than extensive ones, suggesting a positive relationship between intensification and efficiency. The current study has given similar conclusions because zero grazing units have greater mean economic efficiency compared to both semi-zero grazing and open grazing. Producers do not always optimize their production functions [9, 20, 32, 35, 36]. The production frontier characterizes the minimum number of necessary combinations of inputs for the production of diverse products, or the maximum output with various input combinations and a given technology. Producers operating above the production frontier are considered technically efficient, while those who operate under the production frontier are denoted technically inefficient [9]. Milk producers can be supported to acquire knowledge and/or resources necessary to shift from inefficient to efficient production.

Table 3. *The maximum likelihood estimates (MLE) for economic efficiency of the stochastic frontier cost function.*

Efficiency scores (%)	**zero grazing**		**semi-zero grazing**		**open grazing**	
	frequency	**%**	**frequency**	**%**	**Frequency**	**%**
>0≤10	0	0.00	0	0.00	0	0.00
>10≤20	8	9.09	11	8.99	19	8.73
>20≤30	12	13.63	22	15.73	20	16.67
>30≤40	15	17.04	30	11.24	36	17.46
>40≤50	8	9.09	27	13.48	40	22.22
>50≤60	13	14.77	24	8.99	22	15.08
>60≤70	12	13.63	7	13.48	13	11.90
>70≤80	10	11.66	5	16.85	15	3.17
>80≤90	5	5.68	4	10.11	0	0.00
>90≤100	5	5.68	1	1.12	0	0.00
Total	88	100	131	100	165	100
Min	0.18		0.15		0.11	
Max	0.98		0.91		0.80	
Mean	0.62		0.50		0.40	
Std. Dev	0.21		0.27		0.25	

3.5. Stochastic Cost Frontiers Results

The maximum likelihood estimates (MLE) for economic efficiency of the stochastic frontier cost function is shown in Table 4 below. Overall significance of the model, given by the estimated sigma squared (δ^2) was 0.42 for zero grazing, 0.88 for semi zero grazing and 0.91 for open grazing. The δ^2 were significantly different from zero at 5% level for the three dairy production systems, meaning that there was a good fit and correctness of the specified distributional assumption of the composite error term. Gamma (γ) showed that 99%, 84% and 90% of the variation in milk output was due to inefficiency under zero grazing, semi-zero grazing and open grazing systems respectively (Table 4).

These results show that the economic inefficiency effects are significant at 5% level in the stochastic frontier cost function. They are consistent with the findings of [23, 32]. The amount of milk production increases by the value of each positive coefficient as the cost of each variable is increased by one unit. Similarly, the amount of milk production declines by the value of each negative coefficient as the cost of the respective variable is increased by one unit. Feeds constitute the largest component of the cost of milk production in the zero grazing system and a unit increase in the cost of feeds will increase milk production by 0.37 units. A large proportion of the feeds used in zero grazing systems are purchased relative to the costs incurred for feeds in open and semi zero grazing systems. Semi zero grazing and open grazing systems had negative feed cost coefficients of -0.23 and -0.61 respectively with open grazing coefficient being significant. [33] reported a coefficient of 0.38 for the cost of feed that was significant at 5% level. The feeds include pastures, fodder, hay, silage, concentrates, minerals, other supplements and water. Further work needs to be carried out on the quality of the feeds used in milk production in Uasin Gishu County as it appears variable. Herd replacement costs comprise of artificial insemination (AI) charges, payment of bull services and purchase of heifers. Most of the small scale farmers used either AI or bull schemes as they could not easily afford to buy a heifer. In the zero grazing and semi zero grazing systems, herd replacement costs influenced milk output positively and significantly with coefficients of 1.26 and 0.30 respectively.

Table 4. *The maximum likelihood estimates (MLE) for economic efficiency of the stochastic frontier cost function.*

Parameter		zero grazing MLE coefficient (t-ratio)	semi-zero grazing MLE coefficient (t-ratio)	open grazing MLE coefficient (t-ratio)
Constant	β_0	-0.21	7.61	12.22
		(-0.40)	-6.45	-9.89
Feeds	β_1	0.37	-0.23	-0.61**
		-1.87	(-1.92)	(-1.9)
Herd –Replacement	β_2	1.26**	0.30**	0.30
		-2.23	-2.84	-1.01
Health Management	β_3	0.01**	-0.06	0.03
		-1.11	(-0.18)	-0.17
Housing	β_4	-0.10	0.56**	0.40**
		(-0.88)	-2.88	-1.23
Equipment	β_5	0.21	0.11	0.16**
		-1.54	-0.51	-3.12
Labour	β_6	-0.01	0.11**	0.12
		(-0.20)	-3.54	-2.67
Sigma-Squared	δ^2	0.42**	0.88**	0.91**
		-6.27	-8.24	-6.25
Gamma	Υ	0.99**	0.84**	0.90**
		-90.05	-25.37	-26.32
Log (likelihood)	Θ	-14.23	-75.11	-87.90
LR Test Statistic		66.34	47.90	99.19
Mean Efficiency		0.59	0.50	0.40

** = significant at 5% level.

Also in open grazing system, the coefficient for herd replacement was positive at 0.30. Small scale dairy farmers are known to keep zebu cross breeds that have low milk production levels. AI is recommended for use by the dairy farmers so as to improve the genetic traits for milk production and animal performance aspects such as longevity in the herd, number of calving and resilience to certain diseases. Health management costs had a positive and significant coefficient in the zero grazing system, a negative coefficient in the open grazing and a positive but insignificant coefficient in semi zero grazing system. Disease control and management is critical in livestock production. The small scale farmers are faced with tick borne diseases that include East Cost Fever, heart water and red water among others. In addition, there are noticeable diseases like foot and mouth disease, lumpy skin disease and anthrax.

There are also management diseases like mastitis and management conditions like hypo-calcaemia and hypo-magnesia. Prevention and control of diseases and conditions are important for a productive dairy herd. Housing costs had significant and positive coefficients in semi-zero-grazing (0.56) and open grazing (0.40) (Table 4). Investment in housing will thus increase the amount of milk produced. Housing reduces the loss of feeds during supplementary feeding. It is also needed for storage of feeds such as hay for use during the dry season. Housing costs had a negative coefficient (-0.10) in zero grazing system as the cows are already under an enclosure. Equipment costs are critical in dairy production as they can substitute for labor in the case of motorized chuff cutters. The equipment also help to reduce milk loses through spillage and spoilage (e.g. milk cans). There is a need for credit provision for smallholder dairy farmers to access dairy equipment and increase milk production. The labor costs had significant coefficients in semi zero grazing and open grazing systems while it had a negative but insignificant coefficient in the zero grazing system. Labor is needed for grazing and collecting feed, processing feed and feeding, planting, weeding and manurefodder and milking. Other labor needs are marketing milk, spraying/dipping, cleaning the shed and fetching water for the animals. Considering that milk production is a labor intensive enterprise, there is a need to increase the capital so as to substitute for labor and reduce the labor costs. However, where the opportunity cost of labor is very low, the labor costs are cheap especially when it is unskilled labor. There is a need to increase the amount of investment in dairy production so as to benefit from the increasing returns to scale across the three dairy production systems in Uasin Gishu County. These results are consistent with that of [32] whose coefficients for equipment and labor use in milk production was 0.10 and 0.20 respectively. Increased investment in these inputs is expected to increase milk production.

3.6. Gross Margin and Profit of Milk Production

The gross margin and profit of producing one liter of milk was calculated for the three systems. Gross margin refers to the total income derived from an enterprise less the variable costs incurred in the enterprise. It enables producers to evaluate their existing enterprise performance, and for those who are contemplating investing in a new enterprise, it provides a guide to estimating the viability of the contemplated investment. Data collected on various components of the variable and fixed costs of production was classified into various categories for ease of analysis (table 5).

Table 5. *Gross Margin and Profit per Litre of Milk in the three production systems.*

Item	Milk production system		
	Zero Grazing	**Semi- Zero Grazing**	**Open Grazing**
	Amount (Kshs)	**Amount (Kshs)**	**Amount (Kshs)**
Revenue			
Milk price/liter	32.39	28.67	22.09
Variable costs			
Feeds	13.82	11.78	10.85
Herd replacement	0.25	0.21	0.17
Health management	0.98	0.92	0.38
Labour	7.76	6.71	4.9
Total variable costs	22.8	19.63	16.31
Gross margin	9.58	9.04	5.78
Fixed costs			
Depreciation on housing	1.25	0.18	0.12
Depreciationon equipment	0.08	0.14	0.07
Total fixed costs	1.33	0.32	0.19
Total production cost	24.14	19.95	16.49
Net margins	8.25	8.73	5.59
Returns on investments	34.17%	43.74%	33.90%

The feeds used by the milk producers included pastures, fodder, hay, silage, other roughage, dairy meal, other supplements and water. The cost of pastures was estimated using the value of renting pastures for 1 cow per month. The opportunity cost for own labour as well as fixed costs associated with dairy enterprises were included in the analysis. The milk consumed by the household and the calf, and that which was sold was considered in the study as contributing to the revenue of the dairy enterprise.

Table 5 shows that in the zero grazing system, the cost of milk production was Ksh. 24.14/liter. The gross margin and profit was Ksh. 9.58/liter and Ksh. 8.25/liter respectively. This production is associated with high cost of feed and labour. The zero grazing system gives 34.17% return on investments. The positive economic benefits are strongly supported by the milk price of Ksh. 32.39/liter. The relatively high milk price for zero grazing system compared to open grazing system suggests that this type of production system is common in urban and peri-urban settings with better market access. These results are consistent with [4, 10, 27, 29, 34].

The major costs of production are feeds and labour, just like in the zero grazing system. Open grazing system had a gross margin of Ksh. 5.78/litre and a profit of Ksh. 5.59/litre as shown in table 5 above. Here, the capital investment levels appear to be low. The return on investment was 33.90%. Producers using open grazing system faced a low milk price. But the cost of labor and feed was similarly low. A comparison of the three milk production system shows that the semi-zero grazing system is the most profitable (Ksh. 8.73/litre), followed by zero grazing (Ksh. 8.25/litre) and finally by the open grazing system (Ksh. 5.57/litre). Households practicing the zero grazing system incurred higher variable costs than the open grazing system. As expected, the cost of milk production was higher for the more intensive dairy production systems. Consequently, the gross margin in the zero grazing system was lower. These results are consistent with those of [24] showing that in a zero grazing system, "on average, revenues significantly exceeded costs and the dairy enterprise returned a profit'. Using gross margin analysis, [34] showed that dairying is an economically viable enterprise in the short-run, with the non-zero grazing system having higher gross margins and therefore, a financial advantage. This study has shown that semi-zero grazing had the highest gross margin. By giving an example of zero grazing for farmers selling milk through the Githunguri Farmers' Cooperative Society in Kenya, [34] indicated that this system can perform well under conditions of collective marketing, good linkage to markets in terms of processing, access to production information, credit as well as other benefits. Therefore, if the zero grazing system is faced with similar milk price levels like open grazing, then the latter would be more profitable. Intensification of milk production needs to be accompanied by an efficient milk marketing system. The present study corroborates with that of [6] where herd replacement, herd health management and depreciations costs are minimal in the three milk production systems.

This study found out that feed costs are the largest in the three production system compared to the other costs. Feeds constitutes 57.25%, 59.05% and 42.74% of the cost of milk production per litre in zero grazing, semi-zero grazing and open grazing system respectively. Feeding constitutes the largest portion of the costs of milk production in market-oriented dairy farming and dairy animals in Kenya are underfed, resulting in low milk yields [27]. Thus the United States Department of Agriculture uses feeds cost to estimate Livestock Gross Margin-Dairy (LGM-Dairy) which is a risk management tool that enables dairy producers to purchase insurance against decreases in gross margin [7].

The feed costs are lower in the open grazing system, but farmers then become susceptible to the effects of seasonal weather patterns. The price of milk that dairy producers receive is variable. A farm-gate price of Ksh 14 - Ksh 22 per litre and the informal market at Ksh 18- Ksh 26 per litre was reported by [34]. These milk prices are comparable to those received by the milk producers in this study.

4. Conclusion and Recommendation

The results of the analysis indicate that presence of technical and economic inefficiencies affected milk production hence influenced commercialization of smallholder dairy value chain development. Technical and economic efficiency increased with the level of intensification of milk production. The elasticity of milk production was an increasing function of cost of feeds and equipment in the three production systems with statistical significance of 5%. Labor significantly influenced milk output in zero and semi-zero grazing system while it negatively did so in the open grazing system. In view of the above results, the National and County Governments in consultation with other relevant stakeholders in the dairy value chain should formulate policies, and plan projects and programs that increase the level of intensification in milk production to enhance technical and economic efficiency and profit thus improving the competitiveness of smallholder dairy value chain development; increase technology adoption to lower per-unit cost of production, increase milk supply, and raise incomes of smallholder dairy producers; promote reforms in the institutional arrangements by liberalizing input markets, developing basic infrastructure and facilitating access to yield increasing technology which can, ultimately, reduce costs, improve on productivity and farm profit; encourage smallholder dairy producers to undergo literacy and training programs that would substantially lead to an increase in efficiency of dairy production and hence in the volume of output at the current level of technology and reduce the cost of credit so that entrepreneurs can invest more capital and enhance technical efficiency.

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