Valuation of cow attributes by conjoint analysis: A case study of Western Kenya

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Abstract

Better dairy production could reduce poverty and improve nutrition in western Kenya, but the requisite technologies have not been widely adopted. This study collected dairy cow attributes from 630 households to evaluate what factors influence smallholder farmers to adopt technologies. Conjoint analysis was used to compute the marginal rate of substitution between attributes, marginal willingness to pay, and marginal willingness to accept. Two ethnic groups had the highest willingness to pay for cattle with a high milk yield and low feed requirement. The highest marginal rate of substitution for cattle with a high disease resistance and a low feed requirement was from households with off-farm income, from areas with a good agro-climate, and from areas where cattle had cultural functions. The results suggest that farmers are more likely to choose cross-bred than high grade cows, and that extension services have little effect on their adoption of dairy technology. Kenya's breed policy and infrastructure may need to be revised to reflect farmers' needs.

Keywords: Conjoint analysis; valuation of cow attributes; dairy production; Kenya

Une meilleure production laitière pourrait réduire la pauvreté et améliorer l'alimentation de la partie occidentale du Kenya, cependant les technologies nécessaires n'ont pas été largement adoptées. Cette étude a réuni les attributs des vaches laitières de 630 ménages afin d'évaluer les facteurs qui poussent les petits fermiers à adopter des technologies. On a utilisé une analyse conjointe pour calculer le taux marginal de substitution entre les attributs, la bonne volonté marginale de payer et la bonne volonté marginale d'accepter. Deux groupes ethniques ont été les plus décidés à payer pour le bétail à rendement élevé en lait et nécessitant moins de besoins quant à l'alimentation. Le taux marginal de substitution le plus élevé concernant le bétail possédant une grande résistance aux maladies et nécessitant moins de besoins quant à l'alimentation est ressorti des ménages ayant d'autres revenus que ceux de la ferme, des zones propices à l'agriculture et des zones où le bétail avait une fonction culturelle. Les résultats suggèrent que les fermiers sont plus à même de choisir des vaches croisées que des vaches

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pedigrees et que les services d'extension ont peu d'impact sur leur adoption des technologies laitières. La politique du Kenya concernant l'élevage et l'infrastructure devraient être réexaminées afin de refléter les besoins des fermiers.

Mots-clés: *Analyse conjointe; évaluation des attributs des vaches; production laitière; Kenya*

1. Background

Smallholder farmers in sub-Saharan Africa form the bulk of livestock producers. However, most of them are resource poor and vulnerable to environmental degradation because of over-dependence on natural resources, especially where the resources are poorly managed. According to Bebe (2003), 60% to 80% of farm income in sub-Saharan Africa is based on nutrient mining, and the cost of replenishing these nutrients is 32% of the average net income. Available evidence shows that dairy production has the potential to enhance livelihoods and reduce poverty in less developed countries (LDCs). For example, Delgado et al. (1999) show that dairy production contributes 60% of the total household income in these countries. Bebe (2003) found that crop–dairy integration produces a nutritionally superior product (milk) and fosters an environmentally sustainable farming system where crop residues are fed to cattle and manure is used to increase soil fertility. Such a system, based on zero-grazing technologies (feeding and general management of an animal in a confined area), increased milk yield by a factor of 40 between 1980 and 1992 in the Kenyan highlands (Bebe 2003). Dairy can thus provide a viable pathway out of poverty for resource-poor smallholder farmers.

Western Kenya, comprising Western and Nyanza Provinces, is home to Kenya's poorest people. According to Engel's Law, households that allocate a large share of their income to food are considered poor (Ritson 1977). Using this criterion, rural Nyanza is the most poverty-stricken area in Kenya, with 78% of the expenditure per adult equivalent allocated to food, followed by rural Western Province at 75% (Government of Kenya 2003). Another poverty indicator is the Food Poverty Line, which the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) have put at 2250 calories per adult per day. Five districts of western Kenya, Nyamira, Vihiga, Nandi, Bungoma and Kakamega, have over 50% of their respective populations below the Food Poverty Line. Further evidence of the endemic poverty levels in Western Kenya is provided by the Absolute Poverty Line, which is obtained by adding the Food Poverty Line to a minimum mean value of non-food requirements. The FAO/WHO put the Absolute Poverty Line at KES1239 (1239 Kenyan shillings) per adult equivalent per month for rural areas in Kenya. Rural Nyanza leads in absolute poverty, followed by the rural Coast and Western Provinces – in these areas over 55% of the population is in absolute poverty (Government of Kenya 2003). Further, Jama et al. (1998) state that about 51% of farmers in western Kenya are resource poor and practice subsistence agriculture. The existence of high poverty levels in Western Kenya is worrying because the agro-climate, as measured by PPE,[1] and market access, with population density as proxy, are favorable for dairy production – whose potential for poverty reduction has been demonstrated.

[1] PPE is an index comprising precipitation over potential evapotranspiration, and represents rainfall, altitude and temperature.

Waithaka et al. (2002) and Omore et al. (1999) provide ample evidence of low levels of dairy development in Western and Nyanza Provinces. The two provinces produce less than 9% of the national milk output, with Western Province having the lowest milk production per capita. The farming system is dominated by crop husbandry with low food crop yields because the soil fertility is low and the use of inorganic fertilizers and manure has been below the recommended rates (Jama et al. 1998; Ojiem et al. 1998; Salasya et al. 1998; Waithaka et al. 2002). The main cash crops, especially sugar cane in Western and Nyanza Provinces, offer low and unreliable income (Waithaka et al. 2002). Paradoxically, Waithaka et al. (2002) have shown that the potential for dairy development in the area is high. Besides having an agro-climate and population density similar to the relatively wealthier districts of Kiambu and Meru that have a milk surplus, households in Western Kenya have relatively larger land holdings than those in Kiambu and Meru.

Instead of adopting high grade improved dairy breeds (IDBs), households in Western Kenya predominantly raise Zebu cattle which produce about a liter of milk per day. The few existing IDBs produce about seven liters per cow per day, with a possible production of 15 liters or more depending on feed and environment. There is high dependence on natural pastures, low use of Napier and other planted fodder, and low use of locally available concentrates. The situation in the study area is therefore one of the paradoxical occurrences of high poverty levels amid low levels of dairy development despite the suitability of the area for dairy production.

The above discussion suggests that raising the level of dairy development could increase incomes, improve nutrition, make the farming system more sustainable and help reduce the poverty that characterizes most parts of Western Kenya. This development would, however, require households in this area to embrace improved dairy technologies. A study by Makokha (2005) on factors influencing the adoption of such technologies established the following about Western Kenya:

i. Households invested little effort to increase milk production despite the existence of a large milk market and partially unmet milk demand.

ii. Households with off-farm income did not invest it in improving dairy production.

iii. Large land holdings were not associated with the adoption of improved dairy technologies.

iv. Adoption levels of dairy technologies varied across household, spatial and institutional factors.

These findings suggested that relieving the usual constraints associated with low adoption of technologies may not overcome the problem of low adoption of dairy technologies in Western Kenya. Instead some other underlying factors may be influencing their adoption in this area. Given the traditional keeping of local Zebu cattle, this study hypothesized that technology characteristics, specifically attributes of dairy cows, may be important for determining the levels of adoption of the improved dairy cattle. As has been observed by Scarpa et al. (2003) and Adamowicz et al. (1994), livestock is raised for both market and non-market reasons in developing countries. An evaluation of dairy cow attributes by various households was therefore undertaken to shed light on some of the underlying factors responsible for the low adoption of dairy technologies. Understanding these factors would provide information for designing strategies to improve dairy production in this area.

The objective of this study was to determine the value that households attached to dairy cow attributes in Western Kenya, to help understand the low adoption levels here. The null hypothesis was that socioeconomic factors did not influence the value they attached to these attributes.

2. The theoretical framework

As observed above, the utility from keeping cattle in developing countries is derived from their multiple functions, both market and non-market. Therefore, livestock have both market and non-market values and market prices alone will not reflect the full value of livestock to households in these countries. Because livestock serve different functions for different households, this means households will exhibit different preferences for livestock attributes across regions, countries, communities and production systems (Scarpa et al. 2003).

According to the new consumer theory, goods are not the direct objects of utility; rather it is from their attributes that consumers derive utility (Sy et al. 1993; Karugia 1997; Tano et al. 2003). Utility is assumed to be linearly related to product attributes (Sy et al. 1993), and can be decomposed into separate utilities (Tano et al. 2003).

Preferences can be measured in terms of utilities (U) for individual attributes that, when added together, measure the total preference for various attribute combinations (Gan & Luzar 1993). The marginal utilities can be represented by:

$$\frac{\delta U}{\delta S_g} = V_g + Z_{bg} \tag{1}$$

where S is the set of main effect variables representing product attributes, Z represents the factors that influence households' adoption decisions, V_g is the change in utility when only product attributes change, bg is the variation in utility associated with changes in the interaction between Z and the attribute levels, and g is the attribute level. Adoption of a technology can be influenced by the attributes of a technology, farm and farmer (household) characteristics as well as institutional and spatial factors. Table 1 shows the factors hypothesized to influence the valuation of cow attributes, which in turn may influence the adoption of dairy technologies.

Table 1: Factors hypothesized to influence valuation of cow attributes

Factor	Hypothesis
Farmer characteristics	
Land size	Adesina and Zinnah (1993) and Kaliba et al. (1997), among others, depict farm size as a proxy for wealth/resource availability because land is positively correlated with wealth in the LDCs. Households with more land have the resources to invest in capital-intensive technologies like dairy. In some cases, more land may mean a lower probability of adopting some technologies (Kaliba et al. 1997), because these households are less likely to stall-feed cattle, rather leaving them to graze freely. The influence of more land on WTP is therefore indeterminate.
Labor availability and dependency ratio (= no. of dependants : no. of adult household members)	Rearing of IDBs is labor-intensive. Taking household size as a proxy for labor supply may cause ambiguity because large households may have more dependants than laborers (Staal et al. 2002). Nicholson et al. (1998) and Irungu et al. (1999) report a negative influence of household size on Napier production. The dependency ratio is therefore more appropriate. A high dependence ratio also reflects a high proportion of children to adults in the household, hence a higher requirement for milk. Households with a higher dependence ratio had a lower WTP for cows with a high feed requirement but a higher WTP for cows with a high milk yield.
Age	A proxy for risk aversion. Nicholson et al. (1998) report a negative influence of age on adoption of IDBs, because older farmers' higher risk aversion to adoption of IDBs and their higher cultural values reduced the probability of their adopting IDBs. Older households therefore had a lower WTP for cows with high disease resistance.
Household head's experience of dairy rearing	The household head's experience in rearing dairy was used, and it was hypothesized that more experience in dairy technologies increased the probability of adopting IDBs. The hypothesis is that more experienced households had a higher WTP for cows with low disease resistance, high feed requirement and high milk yield.
Education	Education may enhance the capacity for adoption by enabling easier access to information, reducing uncertainty, and increasing allocative efficiency. Education is particularly important where extension services are less intense (Feder et al. 1985). Educated households therefore had a high WTP for cows with low disease resistance, high feed requirement and high milk yield.
Gender	Men in the LDCs have better access to resources, which gives them a greater productive capacity than women (Kaliba et al. 1997; Staal et al. 1997; Adesina et al. 2000; Staal et al. 2002) because they can adopt capital intensive technologies like IDBs. However, Tangka et al. (2000) state that women are more likely than me to invest in technologies that have a positive impact on family health. In addition, income controlled by women may have a greater impact on child nutrition and health than income controlled by men (Sadoulet & de Janvry 1995). This therefore gives women an incentive to engage in market-oriented dairy farming for more income. From these studies the influence of gender on adoption of dairy technologies is inconclusive. Gender may also interact with other factors. The influence of male or female household heads on WTP for cows with low disease resistance, high feed requirement and high milk yield is therefore indeterminate
Income	Regular income and credit are the households' most common sources of capital. Cash availability increases land and labor productivity by facilitating the introduction of new and more productive ways of converting resources into products. However a higher income may also lead to investment in more profitable off-farm enterprises, which may lower on-farm investment (Shiferaw & Holden 1998). Income could be endogenous to adoption of dairy technologies, because income may influence adoption, which may in turn generate higher income as shown in Nicholson et al. (1998). This suggests that the influence of income on adoption of dairy may depend on its importance and the development level of dairy technologies on the farm. The influence of households with high income on WTP is indeterminate. Availability of off-farm income may either make more cash available for investing in the farm or influence the household to change their priorities and make investment in the farm not a priority. The influence of households with off-farm income on WTP is indeterminate.
Ethnic affiliation and cultural values	Different ethnic groups have different cultural practices and beliefs, and these influence their ability to determine technology appropriateness. Nicholson et al. (1998) recognize the influence of ethnicity on the adoption of IDBs in coastal Kenya, because of the different culture and beliefs of the indigenous and the migrant population. Prevalence of Zebu in some parts of western Kenya is associated with cultural practices and prestige, where herd size is more valuable than herd quality (Waithaka et al. 2002). The ethnicity of the household head was therefore hypothesized to influence adoption of improved dairy breeds.
Institutional characteristics	
Extension	Adesina and Zinnah (1993), Kaliba et al. (1998) and Baidu-Forson (1997) report that extension positively influences the adoption of technologies. Educated households therefore had a higher WTP for cows with low disease resistance, high feed requirement and high milk yield.
Credit	Credit availability, either formal or informal, offers farmers an economic platform from which to acquire other resources. However, not all households without access to credit are credit-constrained. Credit should therefore be offered to credit-constrained farmers and not only to those who can provide collateral (Oluoch-Kosura & Ackello-Ogutu 1998; Staal & Jabbar 2000). Households with access to credit had a higher WTP for cows with high feed requirement and low disease resistance.
Spatial and environmental characteristics	
Distance to the nearest urban centre	If milk is sold to areas far away from the homestead, then the distance to the nearest urban centre becomes a proxy for milk market access. Makokha (2005) establishes that milk is sold in the neighborhood.
Population density	The higher the population density, the smaller the land available per household (which means less pasture) and hence the higher the likelihood of adopting technologies that increase returns to land (Staal et al. 2002). A high population density may also mean a higher access to milk markets, especially in cases where adoption rates for IDBs are low. Households in areas with a higher population density have a higher WTP for cows with high milk yield and low feed requirement.
PPE	A higher PPE (greater than 1) was hypothesized to increase the probability of adopting IDBs due to the increase in pasture and water availability. At the same time a high PPE is accompanied by more livestock diseases. Households in the LDCs rely on planted fodder for livestock. Households in high PPE areas have a higher WTP for cows with high feed requirement and a lower WTP for cows with low disease resistance.

At a constant utility level, the marginal rate of substitution (MRS) for two attributes can be measured if all attributes are held constant except the two. Given the utility function:

$$U = b_1 X_1 + b_2 X_2 + \qquad (2)$$

where X_1 and X_2 are attributes, while b_1 and b_2 are coefficients, constant utility means:

$$\delta U = b_1 \delta X_1 + b_2 \delta X_2 + ...+ = 0 \qquad (3)$$

Rearranging the equation above gives the MRS as:

$$\frac{\delta X_1}{\delta X_2} = \frac{-b_2}{b_1} \qquad (4)$$

If b_1 is the price of the product, the ratio becomes the marginal willingness to pay (mWTP) if it is positive and marginal willingness to accept (mWTA) if negative. These parameters can be measured through the use of the conjoint analysis method.

Conjoint (CJ) analysis is one of the stated preference (SP) methods that has been widely used in the valuation of product attributes. However, some studies have cast doubt on the reliability of stated preference methods for providing WTP measures (Stevens et al. 2000; Goldar & Misra 2001). For example, in applications of the contingent valuation (CV) method, respondents may say they are willing to pay for an item such as environment improvement when they will in fact not do so if faced with a real situation. The CV method has also been found to be inadequate in the valuation of single attributes in a multi-attribute good (Kuriyama 1998; Scarpa et al. 2003). However, this bias has been mitigated by providing more information and designing experiments to mimic real market situations. The CJ method is such an improvement. With this method, respondents answer survey questions as if they were placed in a real market situation. Unlike the CV method where respondents state their WTP, the CJ method involves ranking product profiles (different combinations of attributes). The method provides data from which WTP is estimated at the data analysis stage.

As demonstrated by authors such as Adamowicz et al. (1994) and Hensher (1994), the strength of a properly executed CJ is its ability to reduce collinearity between variables representing attributes. The orthogonal design used in this study uses technology profiles that are independent of one another, by recognizing main effects only and assuming non-significance of interaction effects among the levels. A main effect means there is a consistent difference between levels of a factor. For instance, we would say there is a main effect for milk yield if we find a statistical difference between the ranking of the low and high milk yield levels at all levels of other attributes. The main effects designs assume that individuals process information in a strictly additive way, such that there are no significant interactions between attributes (Hensher 1994). Inclusion of price as an attribute allows for the estimation of marginal utility of money, and facilitates computation of marginal willingness to pay (mWTP) for the other attributes considered in the analysis (Mackenzie 1992; Gan & Luzar 1993).

The maximum amount of money an individual is willing to pay for a commodity is the WTP, an indicator of the value attached to that commodity. This is a price above the effective demand price, and is an externality not included in the market price. The mWTP is related to the concept of opportunity cost (Markandya 2000). A high mWTP for fodder may reflect land scarcity or the value of the next best activity on the land. Individuals may state higher mWTP values if they believe it would be difficult to get the good at a later date (List 2004). The mWTP/mWTA measures can be equal only in a perfectly competitive environment (Markandya 2000). Disparities in the two measures mean that individuals do not value benefits or perceive costs the same way. Information asymmetry increases the WTP/WTA gap (List 2004), and it is an externality that causes inefficiency in resource use. The mWTP and mWTA are therefore good measures for social costs and indicate imperfections in markets. Markets allocate resources, and disparity between market prices and mWTP may therefore be a measure of efficiency in the allocation of resources in an economy.

Tano et al. (2003) used CJ analysis to establish the important attributes in developing breed improvement programs in West Africa. They highlighted low literacy levels and the multiple functions performed by cattle in West Africa as important determinants of attribute values. The results showed that disease resistance, fitness for traction and reproductive performance were more important than beef and milk production attributes. He also found spatial differences in valuation of attributes. The study provided information that can be used in conservation programs for certain cattle breeds that are at risk of extinction. The study by Tano et al. (2003) is similar in several ways to the study reported in this paper. Both studies report the usefulness of CJ analysis in quantifying preferences for cattle attributes. In both, the differences in preferences for attributes are reported according to different socioeconomic and spatial characteristics, meaning that different socioeconomic groups value cattle attributes differently because of their different circumstances. Both studies highlight the multiple functions of cattle in Africa. The similarities imply that one cannot generalize the results across geographical areas and different farming systems and that different intervention strategies are therefore necessary for different areas. Unlike the study by Tano et al. (2003) however, this study provides estimates of the values of cow attributes and highlights economic trade-offs in breed choices. This information is useful to adopters, researchers and policy makers. Researchers can use this information to determine important attributes to incorporate in breed improvement programs, while policy makers will understand the socioeconomic and institutional factors that influence the adoption of dairy technologies.

3. Methods

The data used in this study were derived from a sub-sample of 630 households from a sample of 1575 households, grouped across seven districts according to three spatial factors considered to be critical in dairy production: market access, agro-climate (PPE) and population density. The sub-sample was spread across five districts in Western Kenya: Bungoma, Vihiga, Nandi, Kisii and Rachuonyo, which were selected because they represent the area well in terms of the three spatial factors and the biophysical and socioeconomic characteristics. Each household was geo-referenced, and GIS-derived variables for household-specific estimates of market access, PPE and population density were generated using the procedure described in Staal et. al. (2002).

The attributes that households consider important in cows were identified in an earlier study by Waithaka et al. (2002). These were disease resistance and feed requirement (both categorized as high, medium and low), milk yield (with levels of 1, 5 and 15 liters of milk/cow/day), and the price of a cow (with levels of KES4000, 15,000 and 28,000). The CJ procedure of the statistical package for social scientists (SPSS) was used to generate orthogonal main effects profiles. The procedure allows for the specification of a minimum number of cases of profiles to be presented to respondents. In general a full factorial design with three attribute levels can be written as $3^{(k)}$, where k is the number of attributes. The minimum orthogonal design for the $3^{(4)}$ design gives 27 profiles. The probability that respondents will give inconsistent ranking increases as the number of profiles increases (Mackenzie 1992; Hensher 1994). Blocking was used to reduce the number of profiles presented to individual respondents so as to minimize respondents' fatigue. To avoid biased results, blocking should have equal representations of the attribute levels (Mackenzie 1992; Hensher 1994). The blocking factor is treated as another factor in the design (Green & Srinivasan 1990; Mackenzie 1992). Blocking the 27 profile combinations resulted in nine statistically equivalent blocks, each with three profiles. Adding two profiles to each block, one with all attribute levels typical of a high grade cow and the other with all attribute levels typical of a Zebu gave five profiles in each block. The two extreme profiles acted as the floor and ceiling of the profiles in each block, thus ensuring that parameter estimates have a common origin and scale unit (Adamowicz et al. 1994). The high grade cow has high milk yield, high feed requirement, a high price and low disease resistance, while the Zebu has low milk yield, low feed requirement, a low price and high disease resistance. Lazari & Anderson (1994) also included the extreme profiles in their CJ analysis of various food products, where two profiles were added to each block, one with all food products at low levels and the other with them at high levels. Each of the 630 respondents was presented with one of the nine blocks and asked to rank the five profiles in the block. Data on household characteristics were also collected. Variables for the relevant factors that influence households' decision to adopt a particular breed of dairy cow were delineated through principal component analysis.

The ordered probit model (OPM) was used to analyze the data. Given a decision maker's theoretical utility (Y*), the OPM is based on the assumption of the existence of the following relationship as stated by Greene (2000);

$$Y_i^* = \alpha_{1.......n-1} + \beta X_i + \varepsilon_i \quad (5)$$

where; Y_i^* is an unobservable utility, X are observable factors comprising a matrix of effect coded attribute levels, household characteristics, and interaction variables of the attribute levels and household characteristics, $\alpha' s$ are threshold parameters, n is the number of categories of the dependent variable, and β are marginal utilities. The threshold concept is central to the economic theory of consumer behavior, which states that a buyer ranks alternatives when the utility of one alternative exceeds a threshold level of 'satisfaction' (Sy et al. 1993). Finally, ε_i is

the error term. For better interpretation, the coefficients are changed to marginal probabilities, where they are interpreted as effects of one unit change of the independent variable on the cumulative normal probability of the dependent variable. The likelihood ratio (LR) statistic, the Wald chi-square statistic, and the percentage of correct prediction of the outcome are used in model testing. The LR and Wald statistics are chi-square statistics used to test for the null hypothesis that each of the coefficients is equal to 0. The probit model is a maximum likelihood estimation (MLE) method that predicts the highest probability of obtaining the results, guaranteeing that the estimated probabilities lie in the 0-1 range, and that they are non-linearly related to the explanatory variables (Feder et al. 1985; Gujarati 1995). The dependent variable (rankings) takes increasing or decreasing intensity discrete values.

Profile rankings were treated as dependent variables, while the effect-coded attribute levels and household characteristics were independent variables. Two attributes, disease resistance and feed requirement, had 3 effect-coded levels each, but the medium level of each attribute was omitted to avoid the dummy variable trap. Each level had its column, and code 1 was for the level present in the ranked combination, 0 for the other levels absent in that combination, and -1 for the column of the omitted attribute level. The other attributes, milk yield and cow price, were continuous variables. For the categorical household variables, 1 was for the characteristic present in the household, while -1 was for its absence. Continuous household variables were recorded as they appeared. Effect-coding enables direct measurement of marginal utilities (Tano et al. 2003).

4. Results and discussion

Table 2 presents summary statistics of the characteristics hypothesized to influence valuation of cow attributes in Western Kenya. According to Makokha (2005), 98% of the households in the study area (n=1575) did not receive credit for dairy or any food crop production. Credit was therefore dropped from the analysis. Distance to the nearest urban centre was also dropped because most households sold milk in the neighborhood, thus leaving population density as a proxy for milk market access. Principal component (PC) analysis was undertaken on the variables in Table 2 to reduce multicollinearity amongst variables. These results are presented in Table 3.

Table 2: Summary statistics of variables hypothesized to influence valuation of cow attributes

Continuous variables	Variable description	Mean	SD	Min	Max	n
age	Age of household head in years	51.40	14.19	22	93	630
education	Education of household head in years	7.74	4.40	0	18	630
Lnd	Land size of household in acres	4.04	5.12	0	63.5	630
hhN	Number of household members	6.67	2.74	0	23	630
PPE	Precipitation over evapotranspiration	1.05	17	0.73	1.35	625
popn	Population density (persons per km^2)	630	406	124	1648	604
TNU3	Distance to the nearest urban center in km	2.02	2.61	0	12.31	625
Categorical variables	**Variable description**			**1 (%)**	**-1 (%)**	**n**
gender	1=male, -1=female			79	21	630
trd	1=households that value the Zebu for bride price, gifts, and social status, -1=otherwise			17	83	630
kisii	1=Kisii household head, -1=otherwise			26	71	630
Nandi	1=Nandi household head, -1=otherwise			10	90	630
Luo	1=Luo household head, -1= otherwise			15	85	630
Luh	1=Luhya household head, -1= otherwise			48	52	630
dairy12	1=had dairy 12 years ago, -1= otherwise			30	70	630
trans	1=had transport, -1= otherwise			64	36	630
labor	1=had hired labor, -1= otherwise			61	39	630
off-farmYRank	1=had off-farm income, -1= otherwise			34	66	630
EXXT	1=received extension on livestock, -1= otherwise			39	61	630
hINC	1=income more than Ksh 5,000, -1= otherwise			37	63	630

Table 3: Principal component analysis for variables used in attribute valuation

Variable	PC_1	PC_2	PC_3	PC_4	PC_5	PC_6
dairy 12 years ago	0.40	0.18	0.01	-0.63*	-0.28	0.07
household income	0.05	-0.04	0.62	-0.19	-0.28	0.31
PPE	0.86*	0.05	0.04	0.09	-0.06	-0.03
popn	0.83	0.03	0.02	0.06	-0.06	-0.035
land size	-0.32	-0.01	0.22	-0.57*	-0.20	-0.16
gender	0.02	0.04	0.65*	0.07	0.17	-0.19
Luhya	0.42	-0.82*	0.02	0.29	-0.05	0.05
Luo	-0.89*	0.05	-0.06	0.10	-0.12	0.07
Nandi	-0.03	-0.02	-0.07	0.82*	0.22	-0.06
Kisii	0.27	0.89*	0.09	0.16	-0.01	-0.08
education	0.11	0.11	0.77*	0.06	0.05	0.12
cultural values	-0.29	-0.14	-0.16	-0.03	-0.06	0.49
extension	-0.17	-0.29	0.21	-0.09	-0.61*	-0.35
dependence ratio	-0.02	-0.11	0.23	-0.19	0.66*	-0.14
importance of off-farm income	-0.07	-0.16	0.19	0.11	0.05	0.76*

Variables with an asterisk in each column of Table 3 were found to be highly correlated with their respective PCs and only one of the variables marked with an asterisk was picked. Each of the columns had two variables highly correlated to the respective columns, apart from columns 4 and 6 that had three and one variable respectively, correlated to the columns. Therefore column 4 had one of the three variables picked while column 6 had the only variable with an asterisk picked.

To examine possible endogeneity, the Heckman specification test was conducted using the larger sample of 1575 households. Table 4 shows a test run to detect interdependence between adoption of improved dairy breeds and extension.

Table 4: Heckman Test for the equations on adoption of improved dairy breeds and extension as simultaneous equations

Adoption of dairy	
	Robust coefficients
education	0.01(0.005)*
Income	0.12(0.05)**
Nandi	0.47(0.07)***
Kisii	0.15(0.06)***
PPE	0.74(0.17)***
off-farm income	ns
population	0.0002(0.00007)***
population density	-0.006(0.002)**
constant	-0.49(0.18)***
Extension	
	Robust coefficients
education	ns
income	0.37(0.094)***
Nandi	0.40(0.16)*
Kisii	-0.22(0.1)**
PPE	0.95(0.31)***
land size	ns
population	ns
population density	ns
constant	-1.78(0.32)***
No. of observations	1009
Wald (chi-square)	114.61

* significant at 10 % level, ** significant at 5% level, *** significant at 1% level

Note: Wald test of independent equations (rho = 0): chi-square (1) = 0.67 Prob>chi-square=0.4138. The non-significance of the Wald test statistic shows that rho=0, meaning that the two equations are independent.

Formal education of the household head, income level, two ethnic groups (Nandi and Kisii), PPE and population showed a positive association with adoption of the improved dairy breed, while income, Nandi and PPE had a positive association with extension services. The results show non-significance of the Wald test statistic, meaning that the two equations are independent, therefore it can be assumed there is no endogeneity between the adoption of the improved dairy breeds and access to extension.

Table 5 shows marginal utilities and attribute valuations estimated from the OPM (ordinary probit model) without consideration of the household characteristics, while Table 6 presents the estimates with such characteristics taken into account. The model presented in Table 5 represents the typical household in the study area. It ignores any heterogeneity in the population.

Table 5: Marginal utility estimates and cow attribute valuations by a typical household

Attributes	Marginal utilities from the attributes	Marginal WTP/WTA (Ksh)
Low disease resistance	-0.32(0.03)***	-16,000
Price	-.00002(2.46(10^{-6}))***	
Milk yield	0.17(0.005)***	8,500
Low feed requirement	0.09(0.03)***	4,500
High disease resistance	-0.02(0.03)	
High feed requirement	-0.30(0.03)***	-15,000
Likelihood ratio 1707*, No. of observations 3146, Degrees of freedom 14**		

Note: * significant at 10 % level, ** significant at 5% level, *** significant at 1% level

Table 6: Marginal utility estimates and cow attribute valuations by households with different characteristics

Attribute ● household characteristics interactions	Marginal utilities from the attribute ● household characteristics interactions	Marginal WTP/WTA (Ksh)
Milk yield ● Kisii	0.10(0.01)***	3,333
Milk yield ● trd	-0.03(0.01)***	-1,000
Milk yield ● Nandi	0.08(0.02)***	2,666
Milk yield ● high PPE	0.03(0.01)***	1,000
Extension ● milkyield	0.02(0.01)**	666
Low feed requirement ● Kisii	0.31(0.16)**	10,333
Low feed requirement ● Nandi	0.64(0.22)***	21,333
High feed requirement ● high PPE	-0.25(0.13)*	8,333
High feed requirement ● off-farm income	-0.39 (0.13)***	-13,000
High feed requirement ● education	0.03 (0.01)***	2,000
High disease resistance ● off-farm income	0.29 (0.14)**	9,666
Low disease resistance ● off-farm income	-0.23 (0.13)*	-7,666
Low disease resistance ● high PPE	-0.23 (0.13)*	-7,666
Likelihood ratio 1938*, No. of observations 3126, Degrees of freedom 59**		

* significant at 10 % level, ** significant at 5% level, *** significant at 1% level
Notes:
● means interaction
The negative values in the third column are the mWTA values.

For a typical household, apart from the coefficient for the high disease resistance, all the other coefficients were significant with the expected signs. The significant and positive sign of the coefficient for milk yield means that households gave a higher rating to the animal profile with higher milk yield. Conversely, households gave a lower rating to the profile with a higher price for the cow. The mWTP for a cow with a higher milk yield was KES8500 for the typical household. It is worth noting that this value is almost the same as the difference between the price of the Zebu and the dairy cross-breed, and more than the difference in price between the dairy cross and the high grade cow. The actual market price of the Zebu ranged from KES4000 to 8000, that of the dairy cross from KES13,000 to 15,000, and that of the high grade from KES25,000 to 30,000. This therefore suggests that the move from having a Zebu to having a dairy cross is practical and affordable, while there is less evidence for incentives to move from a dairy cross-breed to a high grade breed.. The mWTP for a cow with a low feed requirement was KES4500, while KES15,000 was the mWTA for a cow with a higher feed requirement (the negative sign in Table 4 indicates that this is the reduction in price a farmer would need in order to accept a cow with a higher feed requirement), and a mWTA of KES16,000 for one with a lower disease resistance. Therefore milk yield is the most important positive attribute (because it had the highest mWTP), while low disease resistance was the most important negative attribute, reflecting risks from cattle diseases prevalent in Western Kenya.

The overall mWTP for a particular household characteristic was obtained by adding the marginal utilities of the attributes of the typical household in Tables 5 to the marginal utilities obtained when the attribute was interacted with the household characteristic as shown in Table 6. For instance the mWTP for high milk yield for a household in Nandi was KES11,166 (8500+2666) and KES11,833 (8500+3333) for high milk yield for a household in Kisii. Households located in areas with greater agro-climatic potential (a PPE greater than 1) demonstrated an increased mWTP for high milk yield by KES1000 (an increase from KES8500), suggesting they understood that improved cattle were more likely to respond with higher yields in zones with higher potential. Households which received extension services were willing to pay an additional KES666 for a cow with a higher milk yield, suggesting that farmers with access to knowledge services accorded some greater value to the ability to produce more milk, perhaps because of increased understanding of dairy production.

As shown in Tables 5 and 6, households in Kisii and Nandi exhibited a high mWTP for cows with a low feed requirement. This may be because households in Kisii operate on very small parcels of land owing to the high population density. Fodder production in the study area is dependent on rain, therefore seasonal, yet most households did not have the technology to smooth out fodder availability all year round. This explains why these households had a higher preference for cows with a low feed requirement and a lower preference (higher mWTA payment) for a cow with a high feed requirement in high PPE areas, where fodder production is more favorable. This emphasizes the need to exploit the opportunities for preserving fodder when it is abundant, having outside sources of feed to avoid dependence on rain-fed fodder, and increasing fodder production per unit area.

The results further show that the more educated household heads had a higher mWTP for a cow with a high feed requirement than those with a lower education. This could be because formal education enhances the ability to acquire and process information that is needed to access more feed for cattle. However, households with off-farm activities had a lower preference (higher mWTA payment) for a cow with a high feed requirement, which may suggest that those who work away from the homestead most of the time may not have the labor available to gather fodder and/or graze the cows. Households with off-farm activities and those in high PPE areas had a higher mWTA payment for cows with a low disease resistance. Households with off-farm activities may have a higher opportunity cost for their time when attending to animal health aspects, therefore would prefer cows with a high disease resistance.

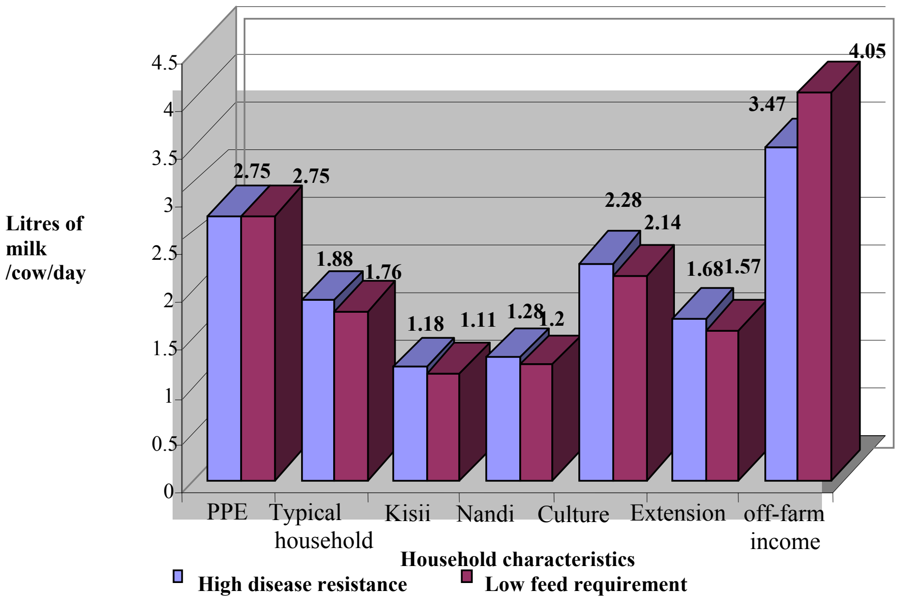

Figure 1: Milk trade-offs for other attributes

Figure 1 shows trade-offs between milk yield and other attributes. It is important to look at the MRS of milk yield for other attributes because milk yield was the most important attribute and because breed choice is about making attribute trade-offs. The MRS of milk yield for an attribute was obtained by dividing the marginal utility for that attribute by the marginal utility for milk yield. For instance, from Table 5, the MRS of milk yield for higher disease resistance for a typical household was: -(-0.32/0.17) = 1.88 liters/cow/day. This means that, holding other attributes constant, a typical household traded off 1.88 liters of milk/cow/day for higher disease resistance. It also traded off -(-0.30/0.17) =1.76 liters/cow/day for a lower feed requirement. With respect to the typical household, households in Nandi and Kisii showed the lowest milk trade-offs for high disease resistance and a low feed requirement. This means that, compared to the typical household, they would not easily give up a cow with a high milk yield for higher disease resistance and a higher feed requirement. Households in high PPE areas, households that valued cows for cultural functions and those with off-farm income would easily give up a cow with a high milk yield for higher disease resistance and a lower feed requirement. The milk trade-offs from households that received extension services were only slightly higher than those from a typical household. This result could suggest that extension was not effective in promoting dairy technologies to significantly lower these trade-offs. Research investments to lower the milk trade-offs identified above would encourage households to adopt technologies that would increase milk yield.

5. Conclusions

Although a productive dairy enterprise has the potential to reduce poverty in Western Kenya, the requisite technologies to improve the sector have not been adopted largely because they do not meet the needs of smallholder farmers. This study has shown that higher milk yields are clearly desired by all. Further, a shift from Zebu cattle to cross-breeds may be much more feasible for farmers than moving to high grade animals. This is reflected in the price farmers are willing to pay for a higher milk yield, but also in their reluctance to accept animals with high feed requirements and low disease resistance, attributes associated more with high grade dairy cows than with crosses. Yet there is no reliable system to deliver cross-bred semen on a reliable basis in Kenya. At present, government support is limited to genetic services supplying high yielding animals. Interventions to sustainably supply cross-breeds appropriate for the target area, and also to generate technologies to increase fodder production per unit of land and to enhance feed efficiency are clearly indicated.

The results have suggested that extension agents did not make a large impact in educating households on the benefits of high milk yielding cows, although some impact was measured. This presumably reflects the low quality of government extension services, which are generally recognized as not having been adequately funded, but also the cultural aspects that hinder the adoption of high yielding cows. Current efforts in Kenya to develop public–private partnerships for extension services, such as with private dairy processors, and also attempts to improve farmer organizations' capacity to identify and source their own information and technology needs (e.g. Farmer Field Schools), may in time provide better support for further uptake of improved dairy technology. Farmer groups and cooperatives could play a central role in the knowledge systems, by facilitating networking and joint learning.

Overall, this study shows that differences in technology attributes, in this case those of dairy cows, are likely to result in differentiated demand by farmers for that technology, and points to the need to target interventions to suit different settings. The livestock breeding policy and the institutions for implementing it will have to reflect this need.

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