Dairy Cow Ownership and Child Nutritional Status in Kenya

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Selected paper Presented at the 2003 AAEA Annual Meetings,
Montréal, Québec, Canada, July 27-30

Abstract:

This study examines the hypothesis that dairy cow ownership improves child nutritional status. Using household data from coastal and highland Kenya, three econometric model formulations are estimated. Positive impacts on chronic malnutrition are observed for coastal Kenya. No negative effects on acute or chronic malnutrition are found for either region.

Key words: Dairy, child nutrition, Kenya

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Introduction

Malnutrition continues to affect large numbers of children in the low-income countries of the world, despite reductions in the proportion of malnourished children in some regions during the last 30 years. In sub-Saharan Africa, an estimated one-third of children—more than 30 million—were underweight in 1995. In contrast to overall global trends, the number of malnourished children in sub-Saharan Africa has increased in recent decades. Moreover, a recent study indicated that between 43 and 55 million children in the region will be underweight in 2020—an increase of 38 to 77% (Smith and Haddad, 1999). In Kenya, child malnutrition continues to be a serious problem. Nearly one-third of children showed evidence of chronic malnutrition in the mid 1990s, and more than six percent were acutely malnourished (Mwangi, 2001). It is well-known that the causes of child malnutrition are complex and multidimensional, and that the aggregate impacts on individuals and the development process are large and long-lasting. Despite agreement on the scope and importance of the problem, there is no clear consensus of the most important causes of child malnutrition, and on which policies or programs would most effectively address it.

Latham (1997) noted that the underlying causes of child malnutrition (poverty, lack of knowledge, disease, inadequate food supplies) have not changed in the past 50 years, but that the interventions to address the problem tend to vary decade by decade. The 1990s saw progress in reducing the number of underweight children in some regions, but also a growing awareness of the importance of micronutrients (vitamins and minerals) in child growth (Underwood, 1998). Diets in many parts of Kenya are maize-based, bulky, and low in energy density. They are also high in fiber and phytate content, which reduces bioavailability of micronutrients (Neumann et al., 2002). The focus on micronutrients led to increasing interest in understanding the potential role of animal products to address micronutrient deficiencies, particularly for iron, zinc, iodine, vitamin A and vitamin B_{12} (Neumann, 1998), because "animal source foods have a positive impact on quality and micronutrient enhancement of the diet of women and children, and can prevent or ameliorate many micronutrient deficiencies" (Neumann et al., 2002).

As a result, a number of studies have examined the impact of animal product consumption on child growth performance. The studies suggest that under certain circumstances moderate animal product consumption, especially meat, can improve child growth and cognitive development, due to greater energy density of the diet and improved biological availability of the forms of micronutrients found in animal products (e.g., Allen et al., 1992; Marquis et al., 1997; Neumann et al., 2002). Although further study is merited (in part to address methodological limitations of previous studies) and the effect is not statistically significant for all groups of children in all studies, increased consumption of "animal source foods" appears to have the potential to result in improvements in child nutritional status (Nnanyelugo, 1984; Latham, 1997). To the extent that animal products improve diet quality and child growth, a key challenge is how to increase their consumption (especially by children), given that this depends critically on household decisions—which are in turn based on incomes and preferences (Senauer, 1990; von Braun et al., 1994).

Concurrently, efforts continue to identify opportunities to increase food production and income generation because both production and income are associated with improvements in household nutritional status (Low, 1991; von Braun et al., 1994). In selected regions of sub-Saharan Africa, one option for increasing food production and household incomes is dairy production and marketing. In much of East Africa, dairying by smallholder farm families is viewed by governments and development agencies as a means of increasing the production of needed nutrients and as a source of cash income to purchase other foods (Staal *et al*., 1997). The potential contribution of dairying to household welfare has led to efforts to develop new technologies and production practices that can be used by resource-poor households in the region. Cattle with European germplasm[1], either purebreds or crossed with local Zebu cattle, are the primary component of more intensive dairy production in sub-Saharan Africa, although use of complementary feeding and health inputs is common. Promotion of these technologies is often the focus of what has been termed 'dairy development'[2]. Because dairy cows[3] can increase milk production and household incomes by substantial amounts, they have been widely adopted in the cooler highlands of East Africa (particularly in Kenya and Tanzania).

In Kenya, the National Dairy Development Project (NDDP) actively promoted dairy cow ownership and use of related technologies in 24 districts over the course of 15 years. Despite the considerable resources devoted to dairy development, relatively little is known about the

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[1] This includes a number of cattle breeds, including Holstein, Jersey, and Brown Swiss, which originated in Europe.

[2] In contrast, the well-known dairy development efforts in India focused on development of transportation and marketing organizations and infrastructure through producer dairy cooperatives. Dairy development in Kenya built upon a well-developed number of dairy cooperatives, but the NDDP focused on increasing production.

[3] The term "dairy cows" herein refers only to purebred or crossbred cows with European germplasm, and does not include cows of local breeds that are also kept for milk production by some households in the region.

nutritional impacts of dairy cattle ownership. Four studies from East Africa have indicated a positive relationship between child nutritional status and dairy cow ownership. Hitchings (1982) found that child height was positively related to ownership of a milk cow if the milk tended to be used for the family's own consumption. In coastal Kenya, Leegwater et al. (1991) noted that the nutritional status of pre-school children in households participating in the NDDP (or their customers) had better nutritional status than children from the general population. Ownership of a cow in rural Uganda was found to be a strong predictor of child height-for-age, controlling for land area owned and education of the household head (Vella et al., 1995). In rural Rwanda, an index of dairy animal ownership had a strong positive impact on child height-for-age, controlling for maternal characteristics, household income, and environmental factors (Grosse, 1998b). Moreover, studies examining the role of non-dairy livestock (beef cattle, chickens, pigs, etc.) tend to indicate that ownership of these animals has no strong relationship with child nutritional status (Annan, 1985; Vella et al., 1995; Grosse, 1998a).

Despite the results from these studies, a number of limitations exist in the scope of the analyses and the methods used. First, the analyses often do not distinguish impacts by the type of cow owned. In many areas, both local and dairy cows are present, but typically the latter have been the focus of dairy development efforts. Second, the pathways by which dairy cow ownership results in nutritional benefits have not been formally examined in any of the studies. Thus, it is uncertain whether the impacts of dairy cow ownership arise primarily through consumption of milk from own production, or from higher incomes resulting from increased milk sales. Information about the pathways of impact would allow development of complementary policies or programs to enhance the nutritional impact of dairy development. Finally, methods employed were sometimes inconsistent with the analytical framework deemed appropriate by economists, which recognizes the importance of household decisions to determine food production, allocation of food, and child nutritional status. Thus, the reported impacts may be biased due to the statistical methods used.

This paper has two principal objectives. The first is to describe a conceptual framework to enhance understanding of the potential impacts of dairy cow ownership on household welfare, with an emphasis on child nutritional status. This framework will help to place the subsequent statistical analyses into context, and demonstrate the complexity of the pathways influencing child nutrition. The second is to examine the impact of cattle ownership generally, and dairy cow ownership more specifically, on the nutritional status of pre-school children in two regions of Kenya using household-level data and econometric estimation techniques. These estimates will address the question of whether dairy cow ownership has positive, negative, or limited impacts on child nutritional status. This information will offer insights into how to enhance the nutritional impacts of dairy development efforts in the region. The emphasis herein is on indicators of malnutrition more commonly associated with macronutrient deficiencies (such as energy and protein), rather than on micronutrients (although in some cases there are interactions between the two). This is appropriate given that protein-energy malnutrition (PEM) remains "the most important nutritional problem in…Africa" (Latham, 1997).

Conceptual Framework

Numerous conceptual frameworks have been developed to examine the causes and consequences of child malnutrition (e.g., UNICEF, 1990; von Braun et al., 1994; Grosse, 1998b). The conceptual framework developed herein emphasizes the main pathways by which dairy cow ownership may influence child nutritional status, and therefore omits or diminishes the importance of some factors described in previous frameworks. However, our framework explicitly acknowledges the presence of important feedback loops and key system state variables (also referred to as stocks) that have important implications for the dynamics of household welfare, including child nutrition (Sterman, 2000).

Child nutritional status is intertwined with child health status. This is depicted as two state variables, each that positively influences the other[4] (Figure 1). Child nutritional status is determined by the intake of nutrients by the child, as well as the current health status, because the presence of infection can influence intake, absorption, use and requirements of nutrients by the child (Latham, 1997). Nutritional status influences health because malnourished children often have weaker immune response and reduced resistance to disease due to decreased integrity of skin and mucous membranes. The three conditions necessary to support child growth include adequate household nutrient availability (from own production or purchases), appropriate child care and feeding practices (Engle et al., 1999), and health care sufficient to maintain child health status. The first two of these three primarily influence child nutrient intake, whereas the last influences both intake and utilization of nutrients. Nutrient availability for the other members of the household can have indirect impacts on child nutritional status, because the nutritional status of adults can influence food crop

[4] Some authors have argued that the more general term "health status" should be used rather than separating health and nutritional status. However, the distinction between the two can be helpful to represent how infection interacts with malnutrition.

production and wage labor (and therefore household cash income) and the amount and quality of care and feeding behavior.

The impacts of dairy cow ownership on child nutritional status can result from a number of different pathways. One pathway involves the competition between resources allocated to dairy cows versus food crops. Ownership of dairy cows (or an increase in their number) is expected to result in a decrease in the resources (especially the land area) devoted to food crops[5], which, other things being equal, would reduce household nutrient availability. However, dairy cows may also contribute to more rapid and efficient nutrient cycling, which could increase soil nutrient content and crop yields (Delve et al., 2001). Moreover, dairy cows increase milk production, which can result in an increase in both nutrient availability (if the milk is consumed) and household cash income (if the milk is sold).

The impact of an increase in household income from dairy production may be a crucial link in understanding the impacts of dairy cow ownership on child nutrition. If additional income is spent on food, this increases household nutrient availability, assuming that the household does not simply use higher incomes to purchase more expensive calories, protein, or micronutrients (Senauer, 1990; Kennedy, 1994). Additional income spent on health-related inputs can complement the impacts of increased food expenditures. The propensity of the household to spend additional income on food and health-related items is often associated with gender patterns of income control (Thomas, 1997; Tangka et al., 2000). If cow ownership reduces household income controlled by women (who tend to have higher propensities to spend additional income on food and health), then the nutritional impacts of cow ownership could be muted or negative. However, if additional income is invested in other productive assets, this may increase non-agricultural income and household income over time, suggesting positive impacts if some of that additional income is used to increase household nutrient availability.

Another potential pathway for negative impacts is through labor allocation (von Braun et al., 1994). Dairy cows may increase total labor demands on the household, including the caregiver for the children (or the children themselves in some cases). This has the potential to negatively affect the level of care and feeding provided by the caregiver (Huffman, 1987), in part through additional energy and protein demands worsening the nutritional status of the care giver. If the household makes use of hired labor to provide the additional labor

[5] The NDDP actively promoted a cut-and-carry forage system using improved grass species, which in the absence of specialized forage producers or underutilized land would imply competition with land devoted to other crops.

necessary to care for the cow, impacts on the children and caregiver may be limited. In addition, the presence of dairy cows increases the probability that children and other household members contract animal-borne diarrheal diseases (Grosse, 1998a), which would negatively influence both health and nutritional status.

Thus, the ownership of dairy cows can have both positive and negative impacts on child nutritional status, depending on which pathways dominate. This conceptual framework suggests that the ultimate outcome is in essence an empirical question. It also indicates that the impacts of dairy cow ownership on child nutrition overlap to a large extent with a number of larger development themes: technology adoption, commercialization of semi-subsistence agricultural production, and intrahousehold (gendered) distribution of work, income, and food.

The Study Areas

This study uses household-level data collected in two contrasting regions of Kenya, three districts in the lowlands of Coast province and two districts in the highlands. The coastal districts represent low agricultural potential areas, where dependence on non-agricultural income is high and the productivity of dairy cows is lowered by high temperatures, humidity, and disease. The highland sites generally represent those of greater agricultural potential, higher population density, and more favorable climatic conditions for dairy cows. Each of these sites is described in additional detail below.

Coast Districts

Coast Province covers over 80,000 square kilometers in the southeastern part of Kenya, constituting about 15% of the country's land area. Data for this study were collected in the districts of Kwale, Kilifi, and Malindi. Mean annual temperatures range from 24 to 27 °C, but maximum temperatures average over 30 °C during the hottest months, January to April. The high temperatures increase the heat stress on dairy animals, reduce feed intake, decrease milk production and lengthen reproduction cycles compared to the Kenyan highlands. Most rural households in the region engage in diverse agricultural and non-agricultural activities. The region is a food deficit area that imports staple foods from other parts of the country. Employment off-farm has become an important income source for rural households in this area, much of it associated with the development of the tourism industry in coastal Kenya. The coast is a milk deficit area; as much as 45% of the region's dairy consumption is supplied by other parts of Kenya. Consumer surveys indicate that purchases of fresh ('raw') milk are preferred over packaged pasteurized and UHT milk (Staal and Mullins, 1996). The strong demand for milk and higher farm prices have been taken as indicators of the potential for dairy development in the region. Low rates of dairy cow ownership have been attributed to the susceptibility of these animals to diseases common at the coast, particularly tick-borne diseases such as East Coast fever (theileriosis), anaplasmosis, and babesiosis. Theileriosis alone results in an annual mortality rate for dairy cows of about 30% (Maloo *et al.*, 1994).

Highland Districts

Data for this study were collected in Kangundo and Mwala divisions of Machakos district and in Bahati, Rongai, Molo and Njoro divisions of Nakuru district. Rainfall in Machakos district varies with altitude. Total annual rainfall ranges from slightly over 1,000 mm in some of the highlands to slightly less than 500 mm in the low-lying areas. Temperature varies between 20° C and 25° C throughout the year. Climatic conditions in Nakuru district are strongly influenced by altitude and physical features such as escarpments, lakes and volcanic peaks. There is considerable variation in climate throughout the district. The total annual rainfall ranges from 760 mm to 1,270 mm. The maximum temperatures are less than 30° C whereas the minimum is about 10° C. Agriculture is a major economic activity in Machakos district. Maize is the principal crop followed by pigeon peas, green grams, sorghum and cassava. The main cash crop is coffee. Livestock are a major economic activity in the district, with cattle and goats being the most important species. Nakuru district is an agriculturally-oriented district with most of the population depending on agriculture and livestock for income and employment. The leading food crops include maize, beans, wheat, potatoes and various fruits and vegetables. Cash crops grown in the district include tea, coffee, pyrethrum and flower production. The district is also a leading producer of milk and beef, with production by about 130,000 smallholders.

Methods

The analysis herein derives from the theoretical framework of agricultural household models (Singh *et al*., 1986; Alderman et al., 1994). These models assume that households maximize utility (according to a single set of preferences in the "unitary" model or multiple preferences in the "collective" models) subject to constraints on total income, time available, production technologies, and available land and capital. In addition, an implicit nutritional status production function is assumed, and the nutritional status of the household's children enters positively into the household's utility function. This implies that households have a demand for the nutritional status of the household's children, in a manner similar to its demand for other goods such as food, leisure time, and non-food goods. The mathematical expression of the model is:

$$\max U = U(X^a, X^m, X^l, Z^{HH}, Z^{head}, N^k)$$

subject to:

$$\sum_m P^m X^m + \sum_h P^h X^h + w^{Hired} L^{Hired} \leq P^a (Q^a - X^a) + w^{Non-farm} L^{Non-farm} + E$$

$$T = X^l + L^{Non-farm} + L^{Family} + H$$

$$Q^a = Q^a(L, A, K, DC, LC) \qquad (1)$$

$$L = L^{Family} + L^{Hired}$$

$$N^k = N(X^a, X^h, H; Z^{HH}, Z^{child}, Z^{head})$$

where:

X=Consumption (*a*=Agricultural; *m*=Not produced by household; *l*=leisure; *h*=health inputs)
Z=Exogenous characteristics (*HH*=Household; *head*=Household head; *Child*=Child)
P=Price (*m*=Not produced by household; *a*=Agricultural; *h*=Health inputs)
Q^a=Production of agricultural good (e.g., milk)
w=wage rate (Non-farm and Hired)
L=(Labor allocated to agricultural activity, *L*=Total, *Family* and *Non-family*=Hired)
T=Total household time available
H=Family labor allocated to child care and feeding
E=Exogenous income (e.g., gifts and remittances)
A=Land Area owned by the household
K=Capital Assets
DC=Dairy cows owned by the household
LC=Local cows owned by the household
N^k=Nutritional status of k^{th} child in the household

This model is not solved or estimated directly. Rather, it provides guidelines as to the variables that influence child nutritional outcomes and whether these variables are exogenous (not determined by household decisions) or endogenous (determined by household decisions). This latter distinction is important, because it affects the nature of the econometric estimation procedures. A reduced-form version of the model, which includes all relevant exogenous variables, is estimated to determine the impacts of the number of dairy cows owned on the child nutritional outcomes N^k. These models are interpreted as reduced-form demand equations for the child nutritional status. In contrast, other studies estimate health or nutrition production functions, which differ in that they include endogenous variables (e.g., nutrient intake) that provide additional insights into how N^k is determined (Kassouf, 1991). Reduced-form demand equations provide insights about the ultimate relationships between the exogenous variables and child nutritional status, but provide limited information about the structural relationships (or pathways) that generate these outcomes. Note that these reduced-form models do not depend on whether the “unitary” versus “collective” household model is assumed (Deolalikar, 1996). In many prior studies, child morbidity is included as an explanatory variable for child nutritional status (Bouis and Haddad, 1990; Randolph, 1992). Because morbidity is assumed to be simultaneously (endogenously) determined with child nutritional status, it is not included in the reduced-form equations. Thus, the estimated impacts of dairy cow ownership on nutritional outcomes implicitly include any indirect effects of cows on child morbidity.

The set of reduced-form estimations addresses whether dairy cow ownership has a statistically significant impact on child nutritional status, N^k. The reduced-form equations for N^k are of the form:

$$N^k = N(Z^{child}, Z^{head}, Z^{household}, P^m, P^a, P^h, w, A, K, DC, LC, E) \qquad (2)$$

Following the approach employed by Randolph (1992) to explore agricultural commercialization impacts on nutrition in Malawi, three alternative econometric specifications are used to examine the impact of the variables of interest on child nutritional status: OLS, Random Effects models, and Seemingly Unrelated Regression (SUR) models. The child nutrition model uses observations on individual children, and the basic econometric formulation for the model is:

$$N_{ik} = \sum_{r=0}^{R} \beta_{ir} X_{rk} + \varepsilon_{ik}\ ;\ \varepsilon_{ik} \sim iid\ N(0, I_{KT}\sigma_{\varepsilon}^2) \qquad (3)$$

where i refers to the anthropometric indicator (i = 1, 2) and k to the child, the subscript r to the rth explanatory variable (with X_0 equal to a vector of ones). If errors are assumed to be uncorrelated across nutritional indicators, or the explanatory variables are the same in the equations for both indicators, the appropriate estimator is OLS. However, the use of OLS ignores the panel nature of the data, and the assumption of no correlation between error terms across indicators is contradicted by both theory and empirical findings (Randolph, 1992).

Hence, an alternative model can be specified as:

$$N_{ik} = \sum_{r=0}^{R} \beta_{ir} X_{rk} + \varepsilon_{ik} \; ; \; \varepsilon_{ik} \sim iid \; N(0, \Sigma \otimes I_{KT}) \qquad (4)$$

to account for the contemporaneously correlated disturbances across equations for each nutritional indicator.

However, the SUR formulation still does not account for the panel nature of the data. The availability of multiple observations (i.e., children) for some households provides an opportunity to control for factors and characteristics ("effects")[6] not captured by the explanatory variables, but that contribute to heterogeneous responses between units of analysis at each level. To account for these types of effects, the model can be written as:

$$N_{ik} = \sum_{r=0}^{R} \beta_{ir} X_{rk} + \gamma_h + \varepsilon_{ik} \; ; \; \gamma_{\mathrm{h}} \sim iid \; N(0, \sigma_h^2) \text{ and } E(\gamma_{\mathrm{h}} \mid X_{rk}, \varepsilon_{ik}) = 0 \qquad (5)$$

This formulation is the random effects model, which assumes that household-level effects vary randomly between households but are constant for observations from individual households. Random effects can then be merged with the error term, and the appropriate estimator is GLS. The random effects model is preferred here over the alternative fixed effects model because the latter eliminates all explanatory variables that are invariant by household—including the variables of interest. Ideally, it would be desirable to combine the three model formulations to account for contemporaneously correlated errors across equations and random effects. However, for simplicity each formulation is estimated separately.

Data

Data to estimate the models described above were collected in each of the two regions, using similar data collection instruments and procedures. At the coast, a sample of N=198 households was selected in three districts of Coast province (Kwale, Kilifi, and Malindi) and 172 households in the Highland districts. For the Coast, the sampling frame was based on a census of all households in those districts owning dairy cows. This census was conducted in early 1997 by extension agents of the Ministry of Livestock Development and Marketing (MALDM) and indicated a total of 719 households with dairy cows. A total of 73

[6] One such unobserved effect is the genetic endowment of the individual child. However, only household-level random effects are controlled for here.

households with dairy cows were selected at random from the census of 719 households. Households without dairy cows were selected randomly from lists of 20 neighbors provided by each dairy-cow owning household. The sample of households for this survey was stratified by dairy cow ownership and division (the administrative unit below the district) because the divisions south and north of Mombasa differ substantially in infrastructure development and the degree of trypanosomosis challenge. A structured questionnaire was administered by MALDM extension agents in multiple visits to each household during February to April 1998. Of the 198 households surveyed, 184 were classified as "small holder" households. The others were expatriates or absentee owners whose principal source of income was a non-farm business located in an urban area. Of the 184 households, 77 owned no cattle, 44 owned only local cattle, and 63 owned at least one crossbred cow. Of these 184 households, 125 had children less than 72 months of age currently resident.

For the Highlands, data collection followed methods employed in a previous effort conducted in nine districts of Kenya. Ninety-two administrative divisions (sub-locations) in nine districts were selected for the previous study, and survey maps for each location were developed based on available GIS databases. Transect lines were drawn across two randomly-chosen landmarks, and every fifth household on the left and right alternately were selected for the sample. All sample households in the Machakos and Nukuru districts provided an initial sample for this study. Of these households, 177 with children aged 6 to 59 months were surveyed. The sample was divided among households with at least one dairy cow (87 households), those who owned only local cattle (16 households) and those who did not own any cattle (74 households). As at the Coast, a structured questionnaire was administered to these households during February to May 1999.

Exogenous and endogenous variables used in the regression analyses are summarized in Table 1. These variables include child characteristics, household head characteristics, and household characteristics. Child specific characteristics include age, sex, and birth order. Previous studies have found many of these variables to be statistically significant determinants of nutritional status (e.g., Kennedy, 1994, Haughton and Haughton, 1997; Tharakan and Suchindran, 1999). Linear and quadratic terms were included for child age based on patterns of mean nutritional status at various ages. The household head was the person identified by the survey respondent as the head of household. Household head characteristics include age (linear and quadratic terms), sex, and years of education. These variables reflect the human capital accumulation of one of the household's key decision makers.

For the highlands data, years of education was constructed based on categorical responses. The religious affiliation of the household head may also influence outcomes of interest, as previous work has indicated that households with Muslim heads consume more milk than households whose heads have other affiliations. Thus, a dummy variable was specified for the religious affiliation of the household head. At the coast, this dummy took the value of one for households in which the head was Muslim, and in the highlands (where there were no Muslims in the sample), a value of one indicated that the head was protestant (rather than Catholic or Seventh Day Adventist). An ethnic group dummy was specified in both regions, given the relationship between ethnicity, cattle ownership and milk consumption. At the coast, a value of one indicated that the household was a migrant to the coast. Members of ethnic groups that migrated to the coast tend to have greater experience with cattle than the coast's traditional ethnic groups. Thus, whether the household head was a migrant is relevant to cattle ownership and management decisions. In the highlands, a value of one indicated that the household head was Kikuyu.

The amount of land owned by the household will influence its production and allocation decisions, and therefore may influence child nutritional status. Moreover, the formality of tenure status for the land may also influence production decisions, so a dummy variable indicates whether or not the household has a title deed for its land. Household demographic factors will also affect observed nutritional outcomes. To capture this effect, the dependency ratio (number of household members divided by the number under age 16) is included as an explanatory variable. Price variables include the milk price, as indicated by the household based on transactions from either of two sources: the latest transaction reported by the household during the period immediately prior to the survey, or, if the household did not buy or sell during the last four months, the price at which the household believed milk or maize could be sold as of the survey date. The milk prices are considered exogenous because the market-level impacts of dairy cow ownership by a household are assumed to be negligible[7]. Data on other prices and wage rates were not available for the highland districts.

[7] This is in contrast to the importance of market-level impacts of dairy cooperative development in India analyzed by Alderman (1994).

Gift and remittance income is assumed to be exogenous to the household, and is counted among the other resources available to the household. A district-level dummy variable is included for each of the regions. For the coast estimations, this variable has the value one if the household was located in Kwale district, which has higher disease challenge, fewer non-agricultural employment opportunities, and less well developed transportation infrastructure. For the highland models, this dummy distinguishes between the two districts, taking the value of one for Machakos. These dummy variables capture a broad spectrum of effects, including access to health facilities, human and animal disease occurrence, transaction costs and infrastructure to support agricultural production and marketing. A dummy variable for water supply was included in the coast equations, and had the value one if the household's source was a pipe or well. The total number of local cattle is included as proxies for wealth and to examine whether cattle ownership per se has nutritional impacts. A focal point for this study, of course, is the number of dairy cows (defined as grade or crossbred animals) owned by the household. The number of cows is assumed to be predetermined. This assumption is based on the nature of dairy cows as a capital good, the fact that the diffusion process of the technology (Rogers, 1995) was essentially complete by the period of data collection, and empirical tests[8] supporting exogeneity. The number of dairy cows is therefore treated as an exogenous variable. Household cash income and cairy production consumption per adult equivalent, although not included in the econometric estimations, is shown in the descriptive statistics (Table 1).

The dependent variables in the econometric models are two anthropometric measurements commonly used as indicators of nutritional status for households in societies with significant levels of protein-energy malnutrition (Low, 1991; Quinn, 1992). Children are measured because they are presumed to be the most vulnerable members of the household, and thus provide a sensitive indicator for the household as a whole. The interpretation of anthropometric measurements is also easier for pre-school children than for older members of the household because there are fewer genetic differences among children in different ethnic groups and reproductive status of females can be ignored. The measures typically used include 'weight-for-height' and 'height-for-age'. A low value of weight-for-height indicates that the child is very thin for his or her stature, and thus provides a measure of acute malnutrition (often referred to as 'wasting'). A low value of height-for-age indicates that the

[8] In a simultaneous equations model, a t-test of the coefficient for $\psi=\sigma_{12}/\sigma_2^2$ tests whether correlation between the error terms in the two equations is zero (Greene, 2000). This test did not reject the null hypothesis of zero correlation with nutritional outcomes.

child is shorter than one would typically expect for a child of the same age because of the accumulated effect of periods of morbidity and inadequate food intake (often referred to as 'stunting'). The measures are typically converted to z-scores (the number of standard deviations from the mean of a reference population) using the U.S. National Center for Health Statistics (NCHS) growth percentiles as a reference (WHO, 1983). Because they are standardized measures, the z-scores can be compared for different age groups and for the two indicators of nutritional status (Quinn, 1992).

Anthropometric data for individual pre-school aged children and other child-specific data were collected from 125 households in three districts of coastal Kenya and from 177 households in the highlands (Table 2). Data were collected consistent with protocols established by the Central Bureau of Statistics of Kenya (which conducts annual regional nutritional surveys) and the Ministry of Health of Kenya, which operates field clinics in coastal Kenya. Staff from each of these government organizations participated in data collection. The anthropometric measurements for 119 children less than 61 months of age and 33 additional children between 61 and 72 months of age obtained in the field surveys were used to calculate 'height-for-age' (HAZ) and 'weight-for height' (WHZ) z-scores for each child[9]. Because the sample size at the coast was small, the observations for these older children were included in the econometric models, although it is common practice to include only children less than 60 months of age[10]. Although some studies exclude children under six months of age (particularly studies examining food intake), they were included in our analyses because it is conceivable that cattle ownership may have an influence on female time allocation and other factors that can influence the nutritional status of infants.

Results

Impacts of Cattle Ownership on Child Nutrition

A number previous studies of the impact of cattle or livestock ownership on child nutritional status have employed binary (i.e., zero or one; Vella et al., 1995) or categorical variables (e.g., Grosse, 1998b) to represent ownership status. Although subsequent analyses will include the number of cows or cattle owned by breed type, it is useful to employ a binary variable approach to make the results of the current study more comparable to previous ones.

[9] Z-scores compare the individual child to a reference population of the same age and sex, where z indicates the number of standard deviations away from the mean of the reference population. Low z-scores for height-for-age indicate chronic malnutrition; low z-scores for weight-for-height indicate acute malnutrition.
[10] The inclusion of these children did not have a qualitative effect on the results.

As noted previously, the impact of cattle ownership (and dairy cow ownership) on child nutritional status is estimated using three types of reduced-form econometric models. These models represent the household-level (reduced-form) demand for child nutritional status as a function of child characteristics, characteristics of the household head, and household characteristics. Thus, they provide limited information about the pathways by which cattle or dairy cow ownership affects nutritional status. Rather, they indicate the aggregate outcome of the various pathways (Figure 1) on the demand for nutritional outcomes. Two key questions are: 1) what is the overall impact of cattle or dairy cow ownership on child nutritional status, and 2) what other factors influence child nutritional status, either negatively or positively?

Consistent with the results of Vella (1995) and Grosse (1998b), ownership of cattle has a statistically significant positive effect on the mean height-for-age Z-score (HAZ) for children in the coast sample for all three model specifications (Table 3). The effects range from 0.60 to 1.12 standard deviations, which are large compared with the findings of Vella (1995) and Grosse (1998b). For the highland sample, the cattle ownership has positive effects on HAZ similar in size to those reported by Vella (1995) and Gross (1998b), 0.29 to 0.35. However, the effects are statistically significant at the 10% level only in the SUR and random effects models. Cattle ownership does not have a statistically significant impact on mean weight-for-height Z-score (WHZ) for any model formulation in either region. These results suggest that cattle ownership has potentially large positive impacts on longer-term child nutritional status (growth) but little or no impact on short-term nutritional status. This outcome may arise from the role of cattle as assets that can help to mitigate various nutritional shocks over time, but our approach does not allow explicit examination of this hypothesis.

Impacts of Dairy Cow Ownership on Child Nutrition

Analyses of the impacts of dairy cow and local cattle ownership use the actual numbers of each type of animal owned, rather than binary variables. The number of dairy cows owned by a household has no statistically significant effects on wasting (WHZ) in any of the three model formulations, either at the coast or in the highlands (Table 3). The coast models indicate a negative but statistically insignificant relationship, and for the highlands, the estimated coefficients are near zero and statistically insignificant. Dairy cows owned has a statistically significant positive impact on stunting (HAZ) only for the SUR model estimated with the coast data. Estimated coefficients for the other coast models and for the highlands are positive but not statistically significant. To the extent that the SUR model accurately captures impacts on HAZ, the impact on child nutritional status is non-trivial. The estimated coefficient implies that ownership of one cow would increase the nutritional status of children in the household by 0.26 standard deviations, with all other variables evaluated at the mean of the data. In practical terms, this implies that if all households owned the mean observed level of 1.69 cows per household, the percentage of children with moderate or severe stunting would be reduced from 54% to 32% for households currently owning no cattle. For households owning only local cattle, ownership of the mean number of dairy cows would reduce the percentage of moderate-to-severely stunted children from 36% to 22%. This is not to suggest that provision of dairy cows alone would have these effects, but they provide a context in which to interpret the estimated impact of dairy cow ownership on HAZ at the coast.

These empirical results are roughly consistent with Hitchings (1982) who found that in three zones of highland Kenya, dairy cows had a statistically significant impact on HAZ but not on WHZ. Similarly, Grosse (1998b) found that for rural households in Rwanda, ownership of dairy animals had a statistically significant effect of a similar order of magnitude on HAZ, but did not report results for WHZ. These results suggest that dairy cow ownership has minimal impact on short-term nutritional status (indicated by WHZ), but that dairy cows may have a positive impact on long-term nutritional status (indicated by HAZ). Given that previous studies (Nicholson et al., 2002) indicated dairy cow ownership increases household income and dairy product consumption, the lack of strong positive impacts implies either that the pathways relating household income or dairy product consumption with nutritional status contain significant "leakages," or that these pathways function but are offset by other negative effects (e.g., through labor allocation or disease transmission), or both. This highlights the need for additional information about the relationship among variables determining child nutritional status.

However, the finding of no negative effects of dairy cow ownership is relevant given concerns about tradeoffs in land allocated to forage versus food crops, zoonotic disease transmission and increased time allocated to cattle-related tasks (especially by women) when dairy cows are owned. In this sense, the results mirror those reported by Kennedy (1994) for cash crops more generally from a series of case studies on commercialization of agriculture. A key conclusion of these studies was that "none of the case studies reported…shows a clear negative effect of the commercial agriculture schemes on children's health and nutritional status." Thus, although cow ownership *per se* may have small impacts on HAZ, there appear to be no negative impacts on either nutritional indicator.

In general, the results from the three models are qualitatively similar. The complete set of coefficients (not reported herein) suggests that variables influencing child nutritional status differ at the coast and in the highlands. For example, at the coast, birth order is positively related to WHZ, perhaps due to dynamic wealth accumulation effects. In the SUR models with coast data, being a male child had lower short-term nutritional status controlling for other factors. Religion and ethnicity of the household head had large effects on WHZ, but household water supply from a pipe or well had the largest positive effect. Few other household characteristics were statistically significant determinants of WHZ. In the highlands, child age effects (both linear and quadratic) had a significant impact on WHZ, as did age of the household head. Male children had WHZ 0.30 standard deviations lower than female children, controlling for other factors, an effect also found by Deolilikar (1996) for child growth patterns in Kenya. Being Kikuyu had a large positive impact on WHZ, 0.50 standard deviations higher than non-Kikuyu ethnic groups.

Moreover, the variables affecting WHZ differ from those affecting HAZ, as has been noted in a number of studies (Randolph, 1992; Kennedy and Haddad, 1994; Tharakan and Suchindran, 1999). At the coast, children in female-headed households had significantly higher mean HAZ than their counterparts in male-headed households, 1.37 standard deviations higher. A similar gender effect has been noted in other studies in Kenya (Kennedy and Haddad, 1994) although Onyango et al. (1994) did not find this for a sample of households in Western Kenya. Education of the household head positively affects long-term nutritional status, with each year increasing HAZ by 0.10 standard deviations. The milk price also has a positive effect on HAZ at the coast, which provides an additional indication that increased milk production through dairy cow ownership has a positive impact (the most likely pathway is through increased cash income from milk sales). Local cattle ownership also has a positive effect on HAZ, perhaps due to wealth effects, but the impact per animal owned is relatively small. In the highlands, age-related variables for children and the household head had statistically significant effects on HAZ. As for WHZ, male children had lower HAZ when other factors were accounted for. Formal title to land and the household dependency ratio also had large positive impact on HAZ.

The variables used in this study control primarily for inherent characteristics of the children, the household head, and the household itself so that the impact of dairy cow ownership can be identified. As such, they provide primarily guidelines for areas of emphasis in future studies, rather than for how policies or programs might best bring about improvements in mean nutritional status. That is, these detailed results may raise more questions than they answer, such as "Why is the nutritional status of male children significantly lower than for female children?" or "What is the mechanism by which water supply improves nutritional status at the coast?" These results alone provide limited information about the responses to these questions. As Kennedy (1994) noted with regard to female headship, it is often not a characteristic *per se* that imparts a nutritional impact, but a "complex interaction" of numerous factors including that characteristic, expenditure patterns, and time use. However, the questions arising from consideration of these results may be useful in the design of more detailed and focused studies of the pathways influencing child nutritional outcomes.

The limited positive impacts of dairy cow ownership should be examined with reference to studies showing that consumption of dairy products positively influences child nutritional status (Neumann, 1998; Grosse, 1998a). As noted in Table 1, households with dairy cows consumed more milk than other households in both regions. Reduced-form econometric models (results not reported here) also indicated that the number of cows increases milk consumption by 1.2 liters per adult equivalent per week in the highlands and 0.5 liters per adult equivalent per week at the coast. Why does this increase in dairy product consumption not result in an improvement in child nutritional status? First, increasing overall household consumption may not result in more milk being consumed by children, especially if higher milk production alters the allocation of milk among household members. Information on child-specific milk consumption was not collected as a part of this research. Second, the amount of the increase may be insufficient to have a marked impact on wasting or stunting, although Neumann et al. (2002) have pointed out that relatively small amounts of micronutrients in animal products may have synergistic effects on macronutrient status. Finally, the benefits of increased milk consumption by children may be offset by other factors such as time devoted to care and feeding, reductions in other foods provided to children, or diarrheal disease related to proximity to livestock. To the extent that increasing dairy consumption of children is a nutritional objective, the limited effects of dairy cow ownership on household consumption suggest that strategies must be carefully designed in order to have significant nutritional impact. Additional information on household nutrient allocation, labor allocation, and child morbidity would help to determine which strategies to increase consumption are likely to most benefit children.

Conclusions and Implications

Dairy cow ownership has been actively promoted in Kenya in the past, and a number of previous studies have suggested that ownership can increase household-level milk production, milk consumption, and cash income. These impacts suggest that there is potential for positive impact on child nutritional status, but competition between dairy cows and food crops for the land and labor available to the household may negatively affect child nutrition. Impacts of dairy cow ownership have been little studied to date. Thus, the principal objective of this study was to examine the impact of dairy cow ownership in two regions of Kenya on the nutritional status of preschool children.

Consistent with two previous studies, cattle ownership appears to have a positive impact on child growth, both at the coast and in the highlands. Whether the household owned cattle has no statistically significant impacts—positive or negative—on short-term nutritional status. The contrast between the general magnitude and significance of the results for cattle ownership and dairy cow numbers suggests the need for additional information by which cattle (whether local or dairy) results in improvements in nutritional status.

The impacts of dairy cow ownership on weight-for-height were minimal in both regions. At the coast, dairy cows appear to have a positive impact on long-term growth, as indicated by height-for-age z-scores. Impacts on growth in the highlands were minimal. These results imply that promotion of dairy cow ownership through dairy development programs are unlikely to have negative consequences for child nutrition, consistent with earlier findings about the impact of agricultural commercialization in the crops sector (Kennedy, 1994). Clearly, additional information about the pathways by which dairy cow ownership and other factors influence child nutritional status—especially greater detailed information on the intrahousehold allocation of resources, income, and nutrients—would allow better informed interventions to enhance the nutritional benefits of dairy cow ownership. This is consistent with recommendation by Haddad (2000) that agricultural research designs should include elements to enhance positive nutritional impacts.

Given the differences between the regions in this study, household-level nutritional impacts appear to be site-specific. It is likely that there is no definitive answer to the question of whether dairy cow ownership has nutritional benefits for children. That is, the nutritional impacts will vary based on how dairy cow ownership changes key factors such as land and labor allocation, control of income and expenditures on food, and child morbidity. As von Braun et al. (1994) noted for agricultural commercialization, the challenge is to examine impacts in specific contexts, identify factors that enhance or reduce nutritional outcomes, and use this information to provide guidance for program and policy formulation.

Further, analyses of the role of livestock in child nutritional status can benefit from study designs that include multiple observations over time. Such designs would improve the ability to account for seasonal effects (Hoorweg et al., 1995) and growth rather than achieved growth status (Deolilakar, 1996). Moreover, they would provide insights into the dynamic and cumulative effects of cow ownership on household welfare that cross-sectional studies such as this one shed only limited light upon. Until such studies can be implemented, nutritional education programs designed to increase household awareness of the prevalence of stunting and household-level options to address it may be effective ways to enhance the nutritional benefits of dairy cow ownership.

Acknowledgements

The authors thank Ben Okumu, Mary Arimond, Lena Davidsson, Tom Randolph, and David Hall for helpful comments on previous versions of this paper.

Table 1. Descriptive Statistics for Sample of Children and Households Used in Econometric Analyses of Nutritional Impacts

		Coast Districts			Highlands Districts		
		None	Local	Dairy	None	Local	Dairy
Child Characteristics							
Birth Order	Mean	4.20	4.32	3.57	2.92[a]	3.79[a]	3.22
	s.d.	2.59	2.48	2.19	1.50	1.47	1.63
Sex (1=Male, 0=Female)	Mean	0.47	0.54	0.50	0.53	0.58	0.55
	s.d.	--	--	--	--	--	--
Age, months	Mean	42.61	35.36	42.00	30.16	30.11	31.80
	s.d.	18.20	18.47	19.92	14.68	12.31	14.78
Household Head Characteristics							
Age, years	Mean	52.04	53.70	51.64	40.47[ab]	51.58[ac]	44.96[bc]
	s.d.	12.87	13.99	12.61	12.03	14.26	12.73
Sex (1=Male, 0=Female)	Mean	0.90[b]	0.93	0.98[b]	0.83	0.89	0.84
	s.d.	--	--	--	--	--	--
Education, years	Mean	3.76	3.36	5.02	1.43	1.68	1.38
	s.d.	4.11	4.52	4.79	0.87	1.11	0.93
Religion dummy[1]	Mean	0.47	0.29	0.34	0.59[b]	0.68	0.73[b]
	s.d.	--	--	--	--	--	--
Ethnic group dummy[2]	Mean	0.04[b]	0.04[c]	0.16[bc]	0.52[a]	0.16[ac]	0.53[c]
	s.d.	--	--	--	--	--	--
Household Characteristics							
Land area owned, ha	Mean	5.43[ab]	10.30[c]	15.56[bc]	2.42[ab]	8.37[a]	6.09[b]
	s.d.	4.78	5.42	13.84	3.36	8.16	7.35
Tenure Status (1=Title deed, 0=No title deed)	Mean	0.63[ab]	0.89[a]	0.95[b]	0.48[b]	0.42[c]	0.65[bc]
	s.d.	--	--	--	--	--	--
Dependency ratio	Mean	2.45	2.17	2.37	1.41[ab]	1.58[a]	1.52[b]
	s.d.	0.79	0.77	2.09	0.31	0.33	0.41
Milk price, KSh/liter	Mean	27.74	29.77[c]	25.65[c]	21.72[ab]	25.65[ac]	17.34[bc]
	s.d.	6.35	6.27	7.67	5.94	7.82	5.33
Gift and remittance income, KSh/month	Mean	56.39[b]	24.40[c]	228.21[bc]	240.40	289.47	224.41
	s.d.	245.37	118.22	534.81	621.70	618.82	597.05
District dummy[3]	Mean	0.53[b]	0.32	0.30[b]	0.31[ab]	0.79[ac]	0.15[bc]
	s.d.	--	--	--	--	--	--
Water dummy[4]	Mean	0.00[ab]	0.46[ac]	0.23[bc]			
	s.d.	--	--	--			
Total local cattle owned	Mean	0.00[ab]	8.04[ac]	2.14[bc]	0.00[ab]	5.00[ac]	0.46[bc]
	s.d.	0.00	4.62	3.21	0.00	5.12	1.41
Number of dairy cows	Mean	0.00[b]	0.00[c]	1.68[bc]	0.00[b]	0.00[c]	3.76[bc]
	s.d.	0.00	0.00	1.16	0.00	0.00	4.27
Endogenous Variables							
Total cash income, KSh/month	Mean	3,323[b]	3,018[c]	9,987[bc]	3,467[b]	4,098[c]	7,161[bc]
	s.d.	2,879	2,616	8,205	3,097	3,120	8,903
Dairy consumption per adult, liters/week	Mean	0.37[b]	0.35[c]	0.97[bc]	1.84[b]	2.24[c]	6.45[bc]
	s.d.	0.42	0.45	1.42	1.42	1.93	7.75

[1] For Coast, 1=Muslim, 0=Other. For Highlands, 1=Protestant, 0=Catholic or Seventh Day Adventist.

[2] For Coast, 1=Migrant Ethnic Group, 0=Mijikenda. For Highlands, 1=Kikuyu, 0=Other.

3 For Coast, 1=Kilifi or Malindi District, 0=Kwale District. For Highlands, 1=Machakos District, 0=Nakuru District.

4 For Coast, 1=Piped water supply, 0=Well, roof catchment, river, or other. Data on water supply system not available for Highlands.

Note: Letters next to means indicate statistically significant differences at the 5% level among cattle ownership groups within the given region. Key:

a=no cattle and local cattle statistically significantly different
b=no cattle and dairy cows statistically significantly different
c=local cattle and dairy cows statistically significantly different

Table 2. Nutritional Status of Pre-school Children and Cattle Ownership Status, By Region

	Coast Districts			Highland Districts		
	No Cattle	Local cattle	Dairy Cattle	No Cattle	Local cattle	Dairy Cattle
Weight-for-height (WHZ)						
Mean Z-score	-.37	-.57	-.40	-.32	-.67[c]	-.20[c]
s.d.	1.16	1.37	1.24	.99	.97	.97
Number of Children	70	18	56	99	19	127
Percentage of children[1]						
Normal	72.9	72.2	76.5	74.7	57.9	84.3
Mild wasting	21.4	16.7	15.7	22.2	36.8	12.6
Moderate wasting	2.9	5.6	2.0	3.0	5.3	1.6
Severe wasting	2.9	5.6	5.9	0.0	0.0	1.6
Height-for-age (HAZ)						
Mean Z-score	-2.05[ab]	-1.01[a]	-1.57[b]	-1.71[b]	-1.24	-1.35[b]
s.d.	1.38	2.01	1.33	1.50	.82	1.23
Number of Children	70	28	53	99	19	127
Percentage of children[1]						
Normal	21.4	35.7	32.1	23.2	36.8	31.0
Mild stunting	24.3	28.6	30.2	32.3	34.6	34.7
Moderate stunting	31.4	28.6	22.6	29.3	21.3	24.1
Severe stunting	22.9	7.1	15.1	15.2	7.9	10.2

[1] Categories of wasting and stunting are based on z-scores, where z > -1.0 is normal, -1.0 < z < -2.0 is mild malnutrition, -2.0 < z < -3.0 is moderate malnutrition, and z < -3.0 is severe malnutrition (Quinn, 1992).

Note: Pre-school children are those 0-72 months of age for the Coast, 0-60 months of age for the Highlands.

Note: Letters next to means indicate statistically significant differences at the 5% level among cattle ownership groups within the given region. Key:

a=no cattle and local cattle statistically significantly different
b=no cattle and dairy cows statistically significantly different
c=local cattle and dairy cows statistically significantly different

Table 3. Estimated Impacts of Cattle Ownership[1] on Indicators of Child Nutritional Status, By Region

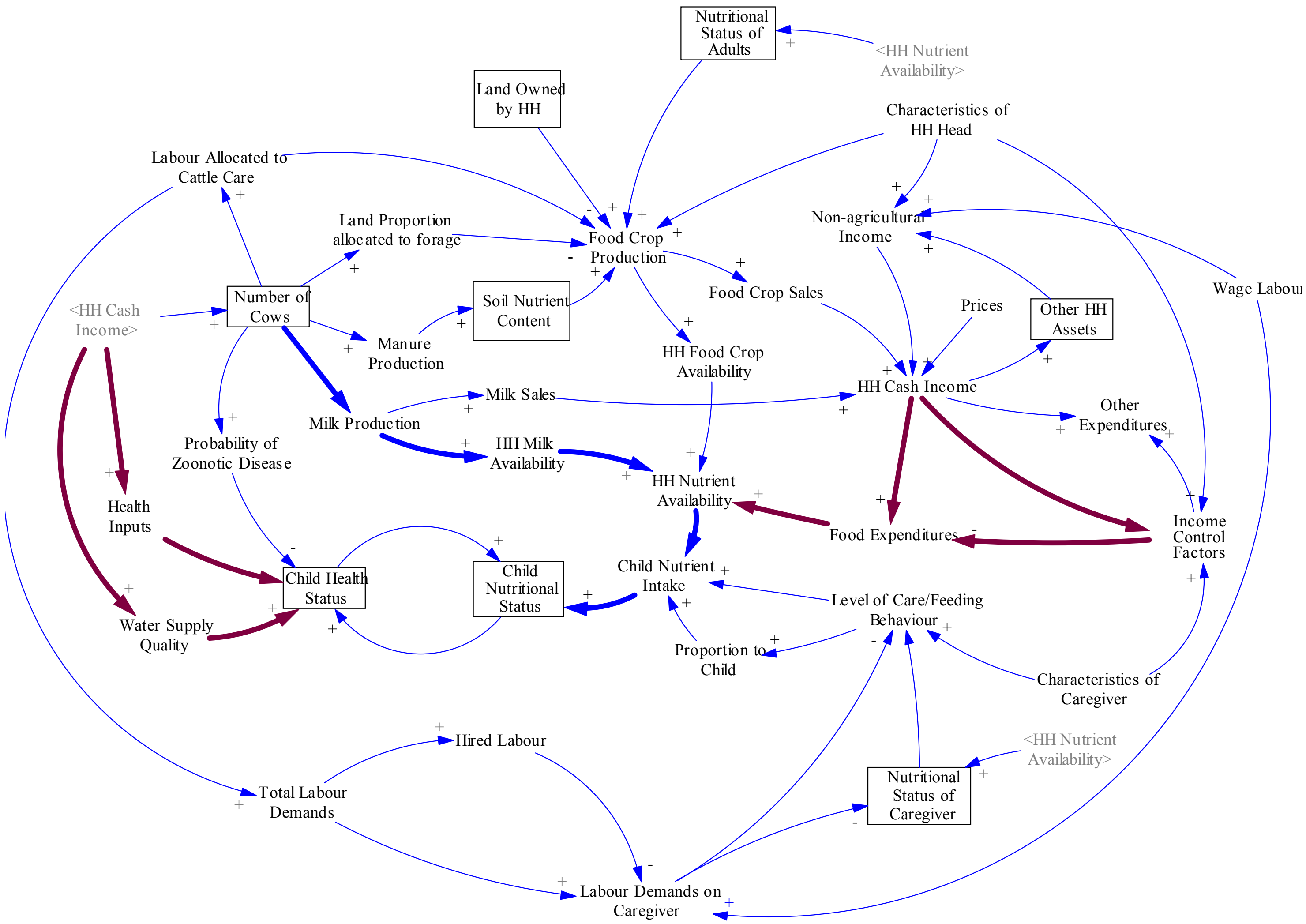
Model	WHZ		HAZ	
	Coast	Highlands	Coast	Highlands
OLS Models				
Coefficient	-0.17	0.06	1.10	0.29
s.e.	0.28	0.13	0.31	0.20
t-statistic	-0.67	0.45	3.53	1.49
SUR Models				
Coefficient	-0.13	0.04	0.60	0.29
s.e.	0.23	0.12	0.23	0.17
t-statistic	-0.57	0.32	2.59	1.72
REM Models				
Coefficient	-0.17	0.03	1.12	0.35
s.e.	0.36	0.15	0.41	0.21
t-statistic	-0.48	0.20	2.71	1.68

[1] Binary variable equal to one if the household owns local or dairy cattle and zero otherwise.

Table 4. Estimated Impacts of Dairy Cow Numbers Owned on Indicators of Child Nutritional Status, By Region

Model	WHZ		HAZ	
	Coast	Highlands	Coast	Highlands
OLS Models				
Coefficient	-0.16	0.02	0.19	0.03
s.e.	0.12	0.02	0.14	0.03
t-statistic	-1.38	0.84	1.34	1.16
SUR Models				
Coefficient	-0.12	0.01	0.26	0.03
s.e.	0.10	0.02	0.11	0.02
t-statistic	-1.21	0.91	2.42	1.41
REM Models				
Coefficient	-0.11	0.02	0.17	0.04
s.e.	0.15	0.02	0.20	0.03
t-statistic	-0.73	0.84	0.89	1.10

Figure 1. Conceptual Model of Impacts of Dairy Cow Ownership on Child Nutrition



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