Household-level economic and nutritional impacts of market-oriented dairy production in the Ethiopian highlands

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Abstract

Previous farm-level studies have shown that adopting improved feeding and management strategies improves livestock productivity and, in particular, increases the milk production and income of resource poor smallholder mixed-crop and livestock farmers. This paper analyses the impact of the introduction of crossbred cow and improved feeding and management technologies in the Ethiopian highlands in terms of direct changes in household income, patterns of food and non-food expenditure, and caloric intake.

Using a recursive econometric model that takes into account the seasonal variability of consumption patterns, the analysis indicates a positive relationship between household income and adoption of the improved dairy technologies. The incremental increase in household income translates directly into higher expenditure on food and non-food items. Caloric intake is also positively related to adoption of crossbred cows and improved feed technologies. This indicates the significant role that improved smallholder livestock technologies can play in improving food security and nutrition as well as alleviating poverty.

Introduction

Improving human nutrition, including micronutrient status, is a critical element in achieving food security. Interest is mounting in food-based approaches (dietary change) for combating macronutrient and micronutrient deficiencies; food-based approaches are often more sustainable than supplementation [1] . Increased consumption of livestock and dairy products can make a unique and critical contribution to human nutrition, because of low levels of animal and fish consumption among the poor and the relatively high bioavailability of minerals and vitamins contained in animal products. Consumption of animal products can also increase the bioavailability of minerals and vitamins in plant foods consumed at the same meal.

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Market-oriented dairy technology research carried out by the International Livestock Research Institute (ILRI) and its partners aims to develop and diffuse crossbred cow technologies for increased milk and meat production that can be adopted by resource-poor smallholder peri-urban farm households. The successful introduction of crossbred dairy cows requires complementary technologies adopted on the farm, including improved cattle management, feed production, and feeding systems. The technologies developed in Ethiopia are expected to increase the productivity and sustainability of the production systems surrounding Addis Ababa, but they are suitable for resource-poor smallholder mixed farming systems in peri-urban areas of other developing countries.

The introduction of crossbred cows and complementary feed and management technologies for increased dairy production results in commercialization of smallholder farms. Milk in peri-urban areas is a cash crop, and integration into the market occurs. Such intensified, market-oriented dairying has the potential to make smallholder systems more viable and sustainable. The introduction of these technologies substantially raises milk production and incomes where development efforts are market-oriented and demand-driven.* When market-oriented dairying is introduced, the household may consume some of the milk. The increased income from milk sales may also be spent on more and better quality food and result in improved nutrition and health. Consumption of more dairy products usually has a positive effect on human nutrition and health [1] .

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* Shapiro B, Ashenafi M. The intrahousehold impacts of market-oriented dairy production on food consumption and nutritional status: evidence from the Ethiopian Highlands. Unpublished research report. Addis Ababa, Ethiopia: International Livestock Research Institute, 1998.

The objective of this paper is to quantify the links between the adoption of new dairy technologies, increased household income, expenditure on food and non-food, and improved human nutrition as measured by caloric intake in the Holetta area of Ethiopia.

The farming system

The study site is located in the Ethiopian highlands about 40 km west of Addis Ababa, in the vicinity of a small town called Holetta. The altitude of the research area is about 2,600 m above sea level. The average annual rainfall is 1,100 mm, with mean daily temperatures under 20°C. The main rainy period, known as the *meher* season, starts in mid-June and continues to September. The short rains *(be1g)* from February to April break up the soil. The farmers in Holetta depend on the *meher* rains to plant crops. The farming system in the study area is classified as a mixed-crop and livestock system, with livestock playing an important role for provision of food (milk and meat), draft power, and dung, which is used for fertilizer and fuel.

The Holetta area is characterized by variable soils, with a predominance of red-brown soils with a low water-holding capacity on the slopes and poorly drained, heavy, dark clay soils (vertisols) in the valleys. Three types of soils can be identified on household plots: vertisols, light and mixed upland soils, and heavy upland soils with vertisol properties. The average household owns about 0.35 hectares of vertisol land, 0.95 hectares of the light mixed upland soil land, and 0.95 hectares of the heavy upland soil land. In Ethiopia land is distributed in such a way that farmers receive separate plots of each of the three major land types. In addition, the household has access to communal grazing resources and may own about a hectare of grazing land.

Farmers produce a wide range of cereal and legume crops on small parcels of land. The production is geared towards satisfying household food requirements as well as provision of feed in the form of straw and hay for livestock. The main crops are barley in the *belg* season and wheat, teff, oats, and horse beans in the *meher* season. Other minor crops include field peas, chickpeas, linseed, sorghum, and rapeseed. Farmers usually use manure, urea, and diammonium phosphate for soil fertility management. These inputs are used either individually or in combination, depending on availability, type of soil of the plot, and the crop grown.

Beside crops, the household keeps a herd of animals, mainly consisting of dairy cows, at least two oxen for plowing, heifers, bulls, goats, sheep, and chickens. Because of the dependency on animal traction for crop production, keeping at least a pair of oxen and a follower herd (heifers and bulls) for replacement is necessary, despite the feed shortage. To ease the feed shortage, dairy-draft crossbred cows and adoption of on-farm forage production are encouraged. This technology allows the farmer to reduce the herd size while maintaining the capacity for both animal traction and milk production. However, farmers are reluctant to use crossbred cows.

Holetta is one of the areas where crossbred cows were introduced to increase dairy production to meet the increasing demand of the neighbouring urban areas and to improve farmers' incomes and nutrition. However, the practice of growing fodder crops for animals is rare, and there is an acute shortage of the high-quality feeds necessary for maintaining crossbred cows. Some of the newly introduced feeds intended to alleviate this problem include fodder beet, oat-vetch intercrop, and leguminous trees.

The empirical econometric model

This study addresses the impact of crossbred cows and feed technologies, first through changes in household patterns of production and incomes. Higher incomes, in turn, allow higher food expenditures and thus greater caloric intakes, indicating better access to food and improved nutrition; and higher expenditures on non-food, indicating better access to private health care as well as a demand stimulus for labour in the nonfarm and service sectors. These issues and outcomes are modeled as part of the farm household's utility function, following Bouis and Haddad [2], Behrman and Deolalikar [3], and Kumar [4].

Let X (i = 1,2,..., 5) define subsets from the vector of relevant household, farm, and area characteristics that influence adoption, expenditure, and consumption decisions. Household socio-economic characteristics include education, share of farm income in total income, family size, and age and sex of the household head. Among farm characteristics are farm area, access to extension services, and proximity to market. The following system of recursive equations captures the direct and indirect impacts of crossbred cow technologies:

Income equation:

$$Y= f (A X_l, d_t) \quad (1)$$

Food expenditure equation:

$$C_f= (Y, X_2, d_t) \quad (2)$$

Non-food expenditure equation:

$$C_{nf} = f (Y X_2, d_t) \quad (3)$$

Caloric intake equation:

$$1=f (C_{f,} X_3, d,) \quad (4)$$

where Y = the household cash income, which includes sale of farm products and off-farm income

A = the number of crossbred cows owned by the household

X_i = a vector of relevant exogenous variables affecting income, food expenditure, nonfood expenditure, and caloric intake

C_f and C_{nf} = respectively, expenditure on purchased food and non-food (including farm inputs)

d_t = a seasonal dummy variable

1 = the per capita caloric intake

Household income here does not include the value of all farm output that is consumed by the household and is not marketed. Similarly, expenditure on food does not include the value of food produced on the farm, but only that purchased. However, caloric intakes do include food from all sources, purchased and non-purchased.

In the above system of equations, X~. defines the relevant subset of exogenous variables such that the equations are fully identified. Because of the likelihood of the simultaneity of some of the right-hand variables and the dependent variable, variables on the right-hand side of each individual equation may be tested for simultaneity by using Hausman's test [5] at each stage in the system. If the test rejects the null hypothesis of no simultaneity, an instrumental variable technique is used.

Source of data

The data for this study were provided by a collaborative dairy technology project involving the Ethiopian Agricultural Research Organization (EARO) and the ILRI. One major objective of the project is to develop technologies to enable resource-poor smallholder mixed-crop and livestock farmers to participate in market-oriented dairying. Another major objective is to test the use of crossbred dairy cows for traction, as well as milk production.

Pairs of crossbred dairy cows were introduced on 14 farms in Holetta in 1993, half for milk production only, and half for traction as well as milk production. In 1995 and early 1996,120 more crossbred cows were introduced into an additional 60 households that were all using the cows for traction in addition to milk production and breeding. Willingness and ability to pay the initial fixed cost and the costs of maintaining the crossbred cows were the major criteria used for selection of the participating households. Although the initial 14 farmers were relatively rich, the last 60 farmers were selected from a list of farmers in three wealth groups: poor, medium wealth, and rich (table 1). Sixty control households using traditional practices of local Zebu cows for milk production and oxen for traction were included in the household surveys beginning in mid-1995. The number of control farmers in each wealth group is roughly equal to the number of crossbred cow owners in the same wealth group. Within each wealth group, participating and control households were comparable, selected on the basis of the same criteria.

The sample used in the analysis reported here consists of 84 farm households. These households include both those that were using the new technologies and those following traditional practices. Data collection carried out in 1997 included land use, labour allocation and activity times, draught power use and source, input use, output use, and price data on a biweekly basis.

Households were visited monthly to obtain a recall of food intake for the previous day. The quantities of the main ingredients used for various recipes were recorded at the household level, as well as the numbers of persons consuming this food. The per capita average caloric intake was then calculated by summing the calorie content of the ingredients, netting out leftovers, and dividing by the numbers of people eating. Caloric intake was averaged for three days (one per month) to calculate the quarterly average intake used here.

The market-oriented dairy technology provides mainly milk but also provides butter and cheese, which can have significant impacts on the nutritional and health status of children. Members of households with crossbred cows on average consumed 17% more

TABLE 1. Average household family size and holdings of land and livestock according to wealth group

Wealth group	No. in household	Farm area (ha)	Livestock (TLUs)[a]
Crossbred cow owners (adopters)			
Poor	6.00	1.77	5.94
Medium	4.71	2.79	8.27
Rich	7.06	3.50	11.93
Non-adopters			
Poor	5.85	1.75	4.39
	6.95	2.00	7.97
Medium			
Rich	8.71	2.88	10.37

Source: ILRI nutritional survey in Holetta, Ethiopia, 1997.
a. TLU, Tropical Livestock Unit.

calories, 24% more fat, and 13% more protein than members of households owning non-crossbred cows. The households with crossbred cows spent about 7% more on food purchases, and in addition, they allocated more land to growing high-protein pulses and consumed about 30% more pulses (tables 2 and 3).

Results and discussion

The results reported here are preliminary, and more refinement is under way to include other explanatory

TABLE 2. Average monthly income and expenditures of households with and without (control group) crossbred cows

Variable	Crossbred cow owners	Control group
Total monthly income (Birr)[a]	225.0	131.0*
Per capita food expenditure	14.9	12.4*
Per capita non-food expenditure	129.6	67.8*
Farm inputs per household	41.4	28.1*

Source: ILRI nutrition survey, 1997. * p < .05. a. 8.10 Birr = US$ 1.

variables in the equations. Although we do not anticipate major changes, the magnitude of some of the coefficients reported here and their levels of significance may change.

The relationship between per capita income and adoption of crossbred cows and improved feeds is presented in the first column of table 4. In this regression equation, per capita income is a function of the number of crossbred cows owned expressed in tropical livestock units (TLUs), household size, dependency ratio, farm area, and proportion of arable land owned by the household. These variables reflect the resource base of the household. In addition, travel time to the nearest market, use of fertilizer, use of crossbred cows for traction, and three dummy variables to capture

TABLE 3. Average daily intake of selected nutrients by households with and without (control group) crossbred cows

Intake	Crossbred cow owners	Control group
Calories (kcal)*	2,332.0	1,959.0
Fat (g)*	19.6	15.8
Protein (g)*	70.3	62.1
Carbohydrates (g)	458.6	438.8
Retinol (pg)*	38.8	27.1
Iron (pg)*	74.2	65.6

Source: ILRI nutrition survey, 1997. *p<.05.

TABLE 4. Parameter estimates of relationships between income, food expenditure, non-food expenditure, and caloric intake

Variable	Dependent variable [a]			
	Income	Food expenditure	Non-food expenditure	Caloric intake
1st quarter (Jan-Mar)	0.7987*	0.4843*	-0.0379	0.2511*
2nd quarter (Apr-Jun)	0.8409*	0.6961*	0.5170*	0.2941*
3rd quarter (Jul-Sep)	0.5573*	0.6439*	0.5334*	0.2049*
No. of crossbred cows (TLUs)[b]	0.0643*	-	-	0.0236*
Use of crossbred cows for traction (yes/no)	0.0329	-	-	-
Farm area[a]	0.6762*	-	-	-
Cereal area[a]	-	-	-	0.2991
Pulse area[a]	-	-	-	0.1405
Travel time to market	-0.0009	-0.2196*	-0.2589**	-
Household size	-0.1994*	-0.1052*	0.0066	-0.0426*
Dependency ratio	-0.0304	-0.0875**	-0.5434	-0.2240
Proportion of good land	-0.0108	-	-	-
Fertilizer use	-0.0002	-	-	-
Predicted income[a]	-	0.1885*	1.0069*	-
Food expenditure[a]	-	-	-	0.8530
Farm income share[a]	-	-0.3614*	-0.3865*	-
Knowledge, attitude, and practices[a]	-	0.2932	0.1473	0.0146
Constant	3.1701*	3.6331*	0.2734*	7.4918*
R^2	0.334	0.356	0.324	0.305

a. Variables defined in natural logs.
b. TLU, Tropical Livestock Unit.
* Significantly different from zero ($p \leq .001$).
** Significantly different from zero ($p \leq . .005$).

the seasonal variability of income are included. Variables such as age and education of the head of the household, usually used to explain adoption decisions of the households, were omitted here because of the statistically significant correlation between these variables and household size.

The regression results show that ownership of crossbred cows and farm area are the principal positive determinants of per capita income in the study area. This is not surprising, since ownership of crossbred cows translates directly into higher milk production and marketed surplus, and land area is an indicator of marketed surplus of farm products. There is also significant seasonal variation in per capita income. Income is usually higher following harvest in the first quarter of the year.

With proper management, milk production per crossbred cow can increase to five to seven times that of traditional cows. The total monthly income of adopting households is 72% higher than that of non-adopting households (table 2). However, not all of this difference can be attributed to adoption of the technology. Other differences between adopters and non-adopters, such as farm size and household size, are important determinants of the income of farming households.

Also shown in table 4 is the estimation of two second steps in the recursive model, the relationship between per capita expenditures on food and non-food as functions of predicted income, household size, dependency ratio, travel time to the nearest market, and share of farm products (crops) in total income and three seasonal dummy variables. In addition to usual household needs, such as clothes, health care, and social expenditure, non-food expenditure includes farm production expenditures, such as improved seeds, fertilizer, feeds, and tools. Because of the detected endogeneity, the predicted per capita income from the above income relationship rather than the observed income is used here as an explanatory variable

Predicted income is positively related to both types of expenditure (table 4). This indicates that the incremental increases in income, resulting from adoption of the dairy technology, translate directly into consumption of higher quantities of food, food of better quality, or both, as well as higher levels of expenditure on non-foods. The per capita expenditures on foods and non-foods by adopting households exceed those by households without crossbred cows by 20% and 91 %, respectively, although, again, only part of the difference can be attributed to the adoption of crossbred cows.

Per capita caloric intake is predicted as a function of the number of crossbred cows owned by the household, area allocated to cereal and pulses, household

size, dependency ratio, food expenditure, nutritional and health knowledge, and attitudes and practices of the mother, in additional to seasonal dummies. The area allocated to cereals and ownership of crossbred cows have positive effects on total caloric intake. Adopting households consume 19% more calories than non-adopting households (table 3). Besides calories, these households consume significantly more fat, protein, retinol, and iron. As above, only part of this difference can be attributed to the adoption of crossbred cows.

Generally, the coefficient of determination, R^2, for the above equations is relatively low, ranging from 0.31 to 0.36. This should not be surprising in cross-sectional data from a sample of farmers with substantial variability in management ability, risk aversion, and resources. Variables accounting for some of this diversity, such as managerial capacity and risk attitudes, are not observable and, hence, cannot be included here.

Conclusions

This study investigated the household-level consequences of market-oriented dairy production based on the introduction of crossbred cows and complementary feed and management technologies. These technologies are being tested on the farm in a collaborative dairy technology project involving the Ethiopian Agricultural Research Organization (EARO) and the International Livestock Research Institute (ILRI). The analysis supports our hypothesis that adoption of livestock technologies can improve the food security and welfare of poor households and contributes significantly to the alleviation of poverty through higher food production and income, which translates into higher expenditures on food and nonfood and consumption of more energy.

This may improve the nutritional status of the household members. Important questions that future research needs to address are whether higher household income would necessarily mean better nutrition for all household members (e.g., distribution between adults and children and between males and females) and whether diets have gained in quality. The first question requires analysis of the intrahousehold allocation of benefits from the adoption of technology and measurement of micronutrient status (e.g., using blood serum). The second question requires disaggregation of calories into those obtained from livestock, cereals, and non-staple plant foods. Further refinement of the analysis would also include the value of food consumed out of own-production in estimates of household income, as well as total food expenditures.

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