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THE EFFECT OF CHANGES IN DAIRY PRODUCTION TECHNOLOGY ON CONSUMPTION AND INTRA-HOUSEHOLD LABOUR ALLOCATION: A CASE STUDY OF FARM HOUSEHOLDS IN NORTH-WESTERN SHOA

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ABSTRACT: One of the agricultural policy goals in Ethiopia is to arrest the declining trend in dairy production. The response of the Ethiopian Government to these concerns has been the promotion of the crossbreeding of exotic cows with indigenous Zebu cows. A question for policy makers is whether such intervention is reversing the trend and benefiting the rural people. This study examines its effects on changes in dairy production technology, prices of outputs and labour on consumption and intra-household labour allocation. A farm household model is the analytical framework used to generate predictions about the responses of farm households based on comprehensive data collected from 60 households. The result of the analysis predicts a high scope for the government output price and technological intervention policy to affect consumption. However, labour allocation is not likely to be affected by prices, but is likely to be affected by a change in technology.

1. INTRODUCTION

In Sub-Saharan Africa (SSA) there is a concern about the rising degree of food insecurity and one area of emphasis is the degree of self-sufficiency in milk. This has also declined overtime, adding to the overall problem (Massow, 1989). Moreover, rapid increase in population, both in rural and urban areas, has raised demand for milk and consequent need for improved and sustainable milk production (Varvikko, 1992).

The central highland areas of Ethiopia have high potential for crop and livestock production compared with other agro-ecological zones (Gryseels, 1988). This indicates that cattle production, including dairying, could provide a means of increasing food production in these areas (Varvikko, 1992). The Ethiopian government, encouraged by the favourable agro-climatic environment in the highlands and positive experience with crossbred cows (CBCs) (Kiwuwa, 1983; Olsson, 1986), Schaar, 1981) has adopted a policy of crossing Freisian sires with indigenous Zebu cows Anon (1986). This technical change in production has, as its goal, a positive effect on production and consumption decisions of households.

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Although technological interventions are expected to generate net benefits to farm households, they can have different implications for individual household members. There is some controversy regarding the economic gains of the rural poor from technological changes in agriculture. A review of studies by Binswanger and von Braun (1991) show that introduction of new technology resulted in higher farm production and profit to the adopters and expanded employment opportunities to the rural poor in most cases. However, they also reviewed studies where farm households failed to gain from technological change because of adverse institutional features (Binswanger and Braun, 1991).

von Braun (1988) and Puetz and Webb (1988) found irrigation technology and commercialization of rice to improve production and income of Gambians although it increased the demand for labour and work burden of the women (von Braun, 1988; 1989). Moreover, an impact assessment of new practices on the welfare of women in Burkina Faso found this new practices demanded more labour but the compensation the men paid the women (in the family) for latter's additional labour raised women's income level by about 224 percent Lawrence (1993). A similar finding was noted by (Lale, 1986).

Estimates of elasticities of consumption, labour demand and supply with respect to changes in farm technologies, wages and prices in multiple crop environment are limited. The following are estimates reported for some areas: own price elasticity of consumption of rice in Korea and sorghum in Nigeria are 0.01 and 0.19, respectively, assuming farm profits variable; and -0.08 and -0.05, respectively, assuming farm profits are constant (Singh, 1986). On-farm employment elasticities with respect to milk yield and price of labour are -0.62,-0.67, and -0.70 for Indian households rearing buffalo, indigenous cows, and crossbred cows, respectively (Lawani, 1990). Response elasticities of on-farm labour supply, own consumption of paddy, and consumption non-farm goods, to an increase in the price of paddy (wage rate) are 0.08 (-0.07), -0.04 (0.06) and -0.27 (0.29), respectively, assuming profits are constant, but -0.57 (0.12), 0.38 (-0.08) and 1.94 (-0.35) respectively, assuming farm profits are variable; and elasticities of own consumption of paddy, consumption of non-farm goods and labour supply to a change in farm technology, treating farm profits variable, are 0.42, 2.21 and -0.65 respectively while the elasticity of labour demand to an increase in price of paddy, wage rate and farm technology are 1.61, -0.47, and 1.61 respectively for households in Malaysia (Barnum, 1979).

In general these studies show that innovations such as crossbred cows require additional labour inputs, and that consumption of food and non-food items depends on income and prices of goods and services (Lawani, 1990). A rise in prices of commodities and incomes affect consumption of normal good negatively and positively, respectively. The net effect of simultaneous change in incomes and prices on consumption is that the profit effect is stronger and outweighs the price effect (Barnum, 1979; Singh, 1986).

In Ethiopia, an attempt to explore the effects of changes in technology, particularly in dairying, have focused on economic viability, acceptability of the technological package and productivity. However, few studies have assessed the effect of the introduction of the new breeds and complementary feed technologies on consumption and intra-household labour allocation. This study, therefore, focuses on (a) the effect of the introduction of CBCs on intra-household labour allocation, (b) the impact of CBC adoption on consumption of various commodities and (c) the policy implications of changes in variables exogenous to the households (technology, wages and prices) on household labour supply and employment expansion (the demand for hired labour).

2. THE THEORETICAL MODEL AND THE ISSUE OF ESTIMATION

The way in which farm households respond to technological interventions is the basis for determining the relative impact of alternative technologies. If, for example, an improved technology is introduced, will the income, and thus the consumption of the household rise? Will the demand for labour increase? And if so, will the increase in labour demand be met from household labour resources (men, women, or children), or will there be an increase in demand for hired labour? In order to answer these questions it is crucial to understand the microeconomic behaviour of farm households (Singh, 1986).

There are three possible ways in which household decision making might be viewed:

1. The household head as a dictator
2. The household head as an altruist
3. Co-operation/conflict between household members

The first possibility is that the household head acts as a dictator. He is the one who controls the labour supply of children and adult women and exploits their labour to his own personal advantage. Community pressure is said to maintain these traditional roles, to prevent rebellion by other family members, and to ensure that decisions are made by the household head in a dictatorial fashion.

A second view is that, the household head seeks to maximize the entire family's welfare or utility. The household decision making comes from the head, as in the exploitation case, but there could be consultation of adult members before making decision. This theory does not reveal the potential for conflicts and the different interests of household members.

The co-operation/conflict view suggests that household members decide simultaneously in areas of co-operation (pooling their available resources) and in areas of conflict (dividing total available benefits) Lawrence (1993).

Although the co-operation conflict pattern is the most consistently observed human and economic transaction of African households, it appears that altruism is the most apparent behaviour of households in the study area because in North-western Shoa Zone of Ethiopia there are no private plots for individual household members. All able household members work on family plots and share the benefits the household makes, the head being the major decision maker. Therefore, this study assumes altruistic behaviour of households to be most pertinent in the highlands of Ethiopia.

On the basis of altruistic behaviour of households, the model of Barnum and Squire (1979) was chosen to serve as a framework to generate predictions about the responses of farm households to changes in market variables (technology, prices, and wage rates). This model was particularly taken because its assumptions are relatively valid to the study area than other farm household models (Ellis, 1988). The rest of the section presents the basic model and discusses the issue of estimation.

2.1 The Basic Farm Household Model

The basic model has the following assumptions:

a) the household is considered as a single decision making unit,
b) households can hire in and out labour at the given market wage,
c) land available to the household and other capital inputs (livestock) are fixed for the production cycle,
d) home production activities (Z-goods) and leisure are combined with consumption items in order to maximize household utility,
e) the choice of the household is between own consumption of agricultural production and sale of agricultural production to purchase and consume non-farm consumption goods,
f) more than one variable input is assumed,
g) the household is a price taker for most inputs (if other than labour are accommodated), outputs and non farm consumption goods,
h) the household allocates its time to:

    i) home activities (including leisure),
    ii) off-farm and farm production,
    iii) wage employment.

2.2 The Model Structure

It is assumed that for any production cycle, the farm household maximizes a utility function:

$$U = U(C_d, C_a, C_m, C_v) \quad [1]$$

where the consumption commodities are dairy products (C_d), other agricultural goods (C_a), non-farm goods and services (C_m) and leisure (C_v). Utility is maximized subject to three constraints - cash income, time and production technology.
The income constraint is specified as:

$$P_m C_m = P_d(Q_d-C_d) + P_a(Q_a-C_a) - W(L_d-H_d) - W(L_a-H_a) + A \qquad [2]$$

The time constraint is specified as:

$$T = C_v + H_d + H_a \qquad [3],$$

and the technology constraint as:

$$Q_d = Q_d(L_d/F,X) \qquad [4]$$
$$Q_a = Q_a(L_a/F,X) \qquad [5]$$

Where

P_m, P_d and P_a	are price of non-farm goods and services, dairy products and other agricultural goods respectively.
Q_d and Q_a	are dairy products and other farm outputs respectively.
C_m, C_d and C_a	are consumption of non-farm goods and services, dairy products and other agricultural goods respectively.
(Q-C)	is marketed surplus.
W	is wage rate.
L_d and L_a	are total labour inputs allocated to dairy and other agricultural activities, respectively.
H_d and H_a	are household labour allocated to dairy and other agricultural activities respectively (so that L-H, if positive, indicates hired labour and, if negative, indicates household labour supplied out or household consumption of leisure).
A	is non wage, non agricultural, other net income.
F and X	are fixed land area and number of cows, respectively.
T	is total amount of household time available for allocation to work and leisure.

The above three constraints can be collapsed into one constraint. Substituting the production technology constraints into the cash income constraint for Q_a and Q_d, and substituting the time constraint into cash income constraint for H results in a single constraint of the form:

$$P_mC_m + P_dC_d + P_aC_a + WC_v = P_dQ_d(L_d/F,X) + P_aQ_a(L_a/F,X) - W(L_a) - W(L_d) + WT + A$$

or:

$$P_mC_m + P_dC_d + P_aC_a + WC_v = p + WT + A \qquad [6]$$

Where

$$\pi = P_dQ_d(L_d/F,X) + P_aQ_a(L_a/F,X) - WL_a - WL_d \qquad [7]$$

π is the measure of farm profit. The left side of equation 6 shows household expenditure on three groups of goods plus leisure and the right hand side constitutes Becker's concept of full income.

Equations 1, 4 and 7 are basic equations. Equations 1 and 7 show that households can choose consumption levels of the four types of commodities and the total labour demand in agricultural production, respectively.

$$\frac{\partial \Pi}{\partial L_a} = P_a \frac{dQ_a}{dL_a} - W \qquad [8]$$

By differentiating the profit function in equation 7 we get the first order conditions for profit maximization:

All the variables in equation 8 are exogenous except labour. Therefore, the other variables influence the household choice of labour. Equation 8 can be solved for L as a function of prices (P and W), the Dummy variable (D) (which takes a value of 1 if the household has CBC and 0 if the household has only LBC), output (Q), number of cows (X) and the fixed area of land (F). The solution for L can be expressed as:

$$L^*_d = L^*_d(P_d, W, D, X, F) \qquad [9]$$

$$L^*_a = L^*_a(P_a, W, D, X, F) \qquad [10]$$

Substituting the solution for L^* into equation 6, the value of full income is obtained. Therefore, equation 1.6 can be rewritten as:

$$P_mC_m + P_dC_d + P_aC_a + WC_v = Y^* \qquad [11]$$

where Y^* (= p + WT + A) is the value of full income obtained when profit is maximized using L^*.

The demand functions for the four consumption commodity choices (C_m, C_d, C_a and C_v) in the utility function can be estimated by maximizing the utility function subject to the new version of the full income constraint (11).

The first order conditions are:

$$\frac{\partial U}{\partial C_m} = \lambda P_m$$

$$\frac{\partial U}{\partial C_d} = \lambda P_d$$

$$\frac{\partial U}{\partial C_a} = \lambda P_a$$

$$\frac{\partial U}{\partial C_v} = \lambda W \qquad [12]$$

and , $P_mC_m + P_dC_d + P_aC_a + WC_v = Y^*$ [11]

This is the standard condition from consumer demand theory. Solving equations 11 and 12 gives the demand curves of the form:

$$C_i = C_i(P_m, P_d, P_a, W, Y^*) \qquad [13]$$

Where $i = m, d, a$

Thus, the demand for commodity i depends on prices, wage and income. Household income is determined by household production decisions. Factors influencing production will change Y^* and the change in Y^* in turn affects consumption behaviour, under the assumptions that make the model recursive. Y^* is defined in terms of exogenous variables and is a function of the production function (Q) and labour allocated (L).

The full income equation is reformulated as:

$$Y^* = p(P, W ; a_i, X) + WL_1 t + A \qquad [14]$$

Where a_i is the technological parameter of the production function,
X is number of cows,
t is time available per able household member,
L_1 is able workers from the household members,

It follows that exogenous changes influencing output and labour usage will also affect Y^*. In order to investigate the role of family members in peasant economies, the unit of analysis has shifted from the household level down to that of household members and labour within the household is disaggregated by age and sex into child labour (l_c), adult male labour (l_m) and adult female labour (l_f). Thus, household labour supply L^* is the sum of men, women and children labour supplies ($L^* = \Sigma L^*_i$) and C_v is the sum of men, women and children leisure ($C_v = \Sigma C^i_v$) where " i " denotes men, women and children.

2.3 Estimation

In the empirical analysis, this study assumed recursiveness of the household model. For recursiveness to hold, three assumptions are necessary: first, there exists a market for all commodities (produced and consumed); second, such commodities are homogenous; and, third households are price takers (Singh, 1986: 89).

Normally if the error terms of input and commodity demand equations are uncorrelated, the entire system of equations would be statistically recursive. Thus, the input demand and commodity demand functions could be estimated separately. The practical advantage of separate estimation of both types of demand functions is that fewer parameters are needed. This would be important if the equations are non linear in the parameters. Single equation estimation of recursive models is also advantageous for it economizes on data requirements. To estimate a single equation, data is required for only one endogenous variable and for other exogenous variables, but not on all endogenous variables (Singh, 1986).

Therefore, this study assumed recursiveness of the model for the purpose of estimation (considering the sufficiency conditions of recursivness to be valid for the study area). A non-linear single equation was linearized and estimated for both commodities and labour demand functions. The estimation is carried out using the ordinary least square method.

3. TYPE AND SOURCE OF DATA AND METHOD OF DATA COLLECTION

3.1 Types of Data

This study employed cross sectional and time series farm-level data on production, consumption and labour allocation for 60 farm households in North-western Shoa. Two groups of households were considered. The first group were 30 households owning CBCs and the other 30 were LBC owners.

In order to estimate a complete set of commodity and input demand equations, data on household grain records, consumption expenditures, inputs, outputs, labour allocation, prices of farm and off-farm consumption commodities, wage for labour, and other sources of income were collected.

3.2 Sources of Data and Methods of Data Collection

The data on most of variables of interest for those who own CBCs were obtained from Livestock Policy Analysis Programme of the International Livestock Research Institute. The data for LBC owners were collected by the researcher. Structured questionnaires were employed to collect data for both groups of households. The selection of 30 CBC owners was carried out using stratified random sampling of 10 Peasant Associations (PAs) in three *Woredas* (Degem, Mukaturi and Debre-Tsege) of North-western Zone of Shoa.

The same questionnaire was used to collect data from LBC owners. The selection of 30 LBC owners was done by randomly choosing neighbouring households from the same PAs and *Woredas* from which the sample CBC owners were chosen.

All data are for calendar year 1993. However, there is a difference in the way the data were obtained for both groups of households. For CBC owners, the data were collected every week, for one year starting January 1993. For LBC owners, incomes and expenditures for 1993 were reconstructed from memory of farmer through interview using the structured questionnaires.

In order to minimize measurement or response error of the data from LBC households, besides the data collection which was based on what household heads recalled about 1993 income, consumption and labour allocation, etc., detailed data on LBC owners were collected for two months starting February 1994. This was carried out to know and verify the pattern of consumption and labour allocation of these households. These two variable groups were the most difficult ones for households to recall because they occurred more frequently during the year.

In computing full income for both groups of households, the estimates of home production was based on the harvest of 1993. Although consumption during 1993 was dependent on the crop harvest of 1992, this information was not available and it was assumed that the harvest of 1992 was similar to that of 1993. Moreover, in determining the reference year, the issues raised by Honthakker and Prais, quoted in Abebe (1989), were taken into consideration in computing income from production (Abebe, 1989; and Honthakker, 1971). Income of the household from crop production was, therefore, computed using the 1993 crop yield quantity.

Estimates of household expenditure are included both in consumption expenditure and production costs. Quantities of own production consumed were derived by subtracting sales, wages paid in kind, and crop shared out from production and by adding the net amounts obtained from the household grain record sheet (food aid, barter, gift and loan), wages earned and crop shared in-kind. Net changes in storage could not be determined because a considerable number of households were reluctant to disclose such information. Hence, net changes in storage were assumed to be zero. Quantities of own-production consumed were converted into values by multiplying them by average farmgate prices.

Items consumed by households were aggregated into eight groups of food, non food and household leisure. It was important to restrict the number of explanatory variables by aggregating consumption items, to avoid a degrees of freedom problem and to gain more precision in estimates (Strauss, 1993).

In aggregating commodities and computing group sales and purchase prices, only the most important items for the household were considered. The importance given to each consumption item was based on the budget share. Households were assumed to purchase goods of the same quality in different amounts because of differences in income and prices.

It was found from the survey results that farm households in the study area use only two markets and thus face basically uniform market prices for individual commodities. Thus, individual commodity prices were computed as the arithmetic means of the market prices collected over the year. Seasonality of prices was ignored since prices were not found to vary greatly over the study period. Average individual prices of similar commodities were then aggregated into average prices to form commodity groups.

Although the market prices in the study area do not vary, it is believed that the transaction costs incurred to obtain commodities does between households. These transaction costs would include differences in transport, time and information costs. Although commodities consumed by the sample farm households not vary greatly, the expenditure share of individual commodities does vary from household to household. Furthermore, the crop mixes of sample households was not found to vary greatly. The variation in commodity shares can thus be assumed to be due to differences in the transaction costs. To introduce this source of price variation into the data, average prices for commodity groups were weighted by the share of total household expenditure on each good in the consumption analysis. In the labour allocation analysis prices were weighted by the share of total household sales of each output group.

Price data is taken from the 1993 ILCA Market Survey. For goods and services not considered in ILCA's Market Survey, 1986-1990 data obtained from a series of statistical bulletins of CSA were employed to estimate 1993 prices. First, the average retail prices of goods and services in Rural Northern Shoa were obtained for the period 1986-1990 and the average rate of change for each good and service was computed using these data. Then, the 1993 prices were estimated using the computed average rate of change.

Household labour supply data for CBC owners for dairying, crop production and marketing were obtained from the ILCA survey. The labour allocation data for LBC owners were computed from CBC owners labour allocation data. The computation of annual labour supply of these households for dairying and marketing of farm products for the year 1993 were carried out on the basis of the two months data (February and March 1994) collected. Labour supply data for crop production were estimated following the labour allocation pattern of the other 30 CBC owner households for which annual labour data were available.

This study made the strong assumption that all farms employ the same technology, producing the same type of crops and cultivating the same area of land and supply the same amount of labour. The supply of family labour could vary across households due to variation in household characteristics (total size and age composition of households), area cultivated and the type of crops they grow. Since the labour data for LBC households was not available, their labour supply for a certain crop land per hectare was approximated by the average labour required per hectare for CBC owner farms which produced that crop. Wages were expressed in Birr/day.

Household demographic and related data such as household major (full-time) and minor (part-time) occupations, age composition, sex, educational level, relation of each household member to the household, marital status of household members is collected by the author. In order to know the family size and total available labour in the household, this information was converted into man-equivalents to obtain total standardized household labour units.

Land was measured as total cropped area in 1993, in hectares. It was only annual crop fields that were measured. Information on the differences in the quality of cropped land was not available.

4. RESULTS OF THE STUDY

4.1 Consumption Responses of Agricultural Households

Agricultural household models assume that agricultural households will determine the level of consumption of groups of commodities that will provide members with maximum utility given the amount of household income available (including dairy profits), time and the technology in use. One key hypothesis tested in this study is that the farm households make rational consumption decisions in response to changes in dairy technology and such decisions are a function of profits from dairying, prices of consumption items, and the prevailing agricultural wage.

This study grouped consumption items into eight categories: 1) major staple crops (barley, *teff* and wheat); 2) other crops; 3) non-dairy livestock and livestock products; 4) non-farm goods and services; 5) milk; 6) butter; 7) cheese; and 8) leisure. This disaggregation of commodities was made to assess the consumption response of households to broad categories of commodities.

Consumption is hypothesized to be a functions of the following variables:

$$C_i = C_i(P_{a1}, P_{a2}, P_l, P_m, P_k, P_b, P_c, W, Y^*) \quad [15]$$

Where: C_i = consumption of commodity i (measured in Birr),
- i = a1, a2, l, m, k, b, c, and v
- a1 = major staple crops (barley, *teff* and wheat),
- a2 = other crops,
- l = non-dairy livestock and livestock products,
- m = non-farm goods and services,
- k = milk, b = butter, c = cheese,
- v = leisure, P_i = price of consumption items,
- W = price of leisure,
- Y^* = profit from dairying.

The price of leisure (2.75 Birr/day) is the average wage rate households face in the rural labour market.[1] This is the opportunity cost of leisure. The rate is assumed to vary across households by the share of leisure consumption in total consumption. It is computed as:

$$W = \frac{2.75}{(C_v \times 2.75)/(\sum C_i \times P_i)}$$

Like the price for leisure, households also face the same unit average price for the other seven groups of consumption items. These items are also assumed to vary across households according to transaction costs that are embedded in the consumption shares. The same weighing algorithm is employed for commodity prices.

$$P_i = \frac{P_i}{(C_i \times P_i)/(\sum C_i \times P_i)}$$

Where P_i is average purchase price of good *i*

The level of consumption of each group of commodity, including leisure, depends on prices of commodities consumed, the opportunity cost of leisure (termed 'wage') and dairy profit. The profit from dairy is in turn dependens on the rural wage, prices of consumption items, and the technology used in dairying.

Households allocate their time for farm work, wage employment and leisure. For the purpose of utility maximization in the model, households time devoted to the production of non-farm goods (home produced or Z-goods) and leisure are combined into one consumption item termed simply as *leisure*. Leisure is considered to be a normal good. The income effect of leisure is assumed to be positive and that of Z-goods negative. The income effect of leisure is also assumed to outweigh the negative income effect of Z-goods.

Total household leisure is derived in this study as a residual by subtracting total time the household allocates to crop and livestock production (including marketing) from total time available. The formula employed to derive total household leisure time is:

$$C_v = \begin{pmatrix}\text{Total number of}\\ \text{days available}\end{pmatrix} - \left(\frac{\begin{matrix}\text{Total hours worked for}\\ \text{crop production}\end{matrix}}{1.50 \text{ hours}}\right) - \left(\frac{\begin{matrix}\text{Total hours worked for}\\ \text{livestock production}\end{matrix}}{4.20 \text{ hours}}\right)$$

Where: C_V = *Household leisure days.*

The length of work hours/day for different activities and each type of household member is different[2] The average annual number of working days available for crop production and livestock production, in the study area, are 185 and 365 days, respectively.

The hypotheses regarding the factors affecting consumption or demand for consumption items is shown by comparing own and cross price elasticities of demand in two separate regressions: first, when the response of consumption of groups of commodities are estimated under the assumption that dairy profits are constant; and second, when the response of consumption to changes in prices and wages incorporate changes in dairy profits.

The compensated elasticities with respect to prices are thus computed on the assumption that dairy profits are variable. Dairy profits are part of total profits earned by the households. In order to assess the effect of the technology on consumption, it is only the profit from dairying that is considered to vary in the analysis. Profit earned from crop production is considered to be constant across CBC and LBC households. A regression of diary profit on prices and crop production profit has shown that the variation in dairy profit is not explained by variation in crop production profit. There is no contribution of the profit from crop production (the other main source of income) to dairy profit or dairy income[3] . Therefore, dairy profit can stand on its own to assess the impact of the technology on the consumption of the various groups of commodities.

The estimated regression coefficients are found to have theoretically expected signs and statistically significant for about 28 percent of the coefficients estimated (Table 4.1). In most of the cases the calculated value of the F-ratio is found to be larger than its tabulated value at the 1 percent level, indicating the overall significance of the regression equation. However, in most cases, low values for the adjusted coefficient of multiple determination (R^2) were observed, indicating that much of the variation in consumption is not explained by the regressors used.

The own price consumption elasticities are negative for all commodity subgroups except that of butter (not significant statistically, however), assuming dairy profits constant (Table 4.1). Demand theory suggests that own consumption of normal goods decrease when their prices increase. The results of the computed elasticities for all items, except for butter, are consistent with the theory when farm households are treated only as consumers. In the case of butter the own price elasticity is positive. This implies that butter is an inferior good to these households. However, in the case of butter, since all that which is consumed in the house is produced in the house, an increase in the price of butter through a positive income effect, may result in less butter to be sold and more to be consumed by the household.

The sign of the computed cross price elasticities (Table 4.1) show that cheese is the only complement item to major staples while butter and cheese are complements to other crops.

Non-dairy items and milk are substitutes for crops. The three dairy products (milk, butter and cheese) are complementary with each other but are substitutes for other items. Of all the cross price elasticities computed, the cross price elasticity values of non-farm goods and services are the highest. These elasticity values predict that, compared to a change in prices of other items, the price of manufactured goods would increase the consumption of commodities.

In traditional demand theory, an increase in the wage rate implies an increase in farm income and, therefore, consumption of non-leisure goods but a decrease in leisure (an increase in labour supply). Except one negative coefficient value, the computed elasticities are mostly positive although all are not significant at 10 percent level.

The integrated household model that includes both production and consumption shows somewhat different results. An increase in wage in this case is an increase in costs to the household. Therefore, households profit would decrease and thereby consumption. A change in sign to negative coefficients is observed in some cases, while there is a decrease in the magnitude of positive wage coefficients and they become close to zero in other cases.

The own price effects are not offset by the income effect in the integrated household models (Table 4.2). Own consumption effects of prices do not change sign when dairy profits are added to the models. This implies that the price (substitution) effect is stronger than the profit effect. However, in most cases the net effect of profit and substitution effects are lower in the integrated models than the traditional models (where only price effects are taken into consideration). Nevertheless, in two cases, for major staples and non farm goods and services, higher negative own-price effects are observed after profit effects are added. The computed own price elasticities for major staples and non-farm goods and services are -0.94 and -0.28, respectively. These results indicate that an increase in dairy profits tend to improve household consumption of these important items.

The strength of dairy profit effect to outweigh the substitution (price) effect is thus low at the existing level of dairying of these households. However, the coefficients for dairy profits are higher for milk and butter than any other consumption items in the regression equations. CBC owners, as can be seen in Table IV of the Appendix 1, consumed more of each group of these items than LBC owners. Higher dairy profits of CBC owners than LBC owners can be considered to improve dairy products consumption of CBC households.

Table 4.1 Uncompensated Elasticities of Consumption of Various Groups of Items, Assuming Dairy Profits Constant

With respect to	Elasticity of consumption of							
	Major staple crops	Other crops	Non-dairy livestock and livestock products	Non-farm goods and services	Milk	Butter	Cheese	Leisure
price of major staple crops	-0.88 (-3.47)***	0.11 (0.39)	2.3 (2.97)***	0.38 (1.53)	0.84 (0.91)	1.7 (1.92)*	0.47 (0.6)	0.32 (0.34)
price of other crops	0.21 (1.2)	-1.02 (-4.94)***	1.36 (2.46)**	0.19 (1.05)	0.42 (0.63)	1.46 (2.31)**	-0.2 (-0.36)	-0.12 (-0.18)
price of non-dairy livestock and livestock products	0.43 (2.79)***	0.05 (0.28)	-1.03 (-2.19)**	0.21 (1.42)	0.58 (1.03)	1.21 (2.25)**	1.02 (2.15)**	0.60 (1.03)
price of non-farm goods and services	1.18 (5.17)***	0.91 (3.51)***	1.03 (1.49)	-0.11 (-0.5)	1.39 (1.69)*	2.78 (3.50)***	0.83 (1.2)	1.40 (1.62)
price of milk	0.22 (1.88)*	0.1 (0.72)	0.43 (1.2)	0.04 (0.32)	-1.17 (-2.8)***	-0.07 (0.16)	-0.31 (-0.87)	-0.38 (-0.86)
price of butter	0.11 (0.58)	-0.15 (-0.68)	0.74 (1.26)	0.03 (0.17)	-0.01 (-0.02)	0.02 (0.03)	-0.56 (-0.96)	0.48 (0.67)
price of cheese	-0.08 (-0.86)	-0.01 (-0.14)	0.43 (1.57)	0.09 (0.99)	-0.3 (-0.93)	-0.61 (-1.96)*	-1.15 (-4.18)***	-0.33 (-0.99)
wage	0.05 (0.67)	-0.07 (-0.77)	0.18 (0.75)	0.01 (-0.18)	0.12 (0.42)	0.26 (0.93)	0	-0.01 (-0.02)
F	16.08***	9.16***	2.59**	1.06	2.37**	4.02***	6.57***	0.93
R^2	0.67	0.53	0.18	0	0.15	0.29	0.43	0

T - values are shown in parenthesis.

***, **, * denote significant coefficients at 1, 5 and 10 percent levels, respectively.

Table 4.2 Compensated Elasticities of Consumption of Various Groups of Items, With Dairy Profits Assumed Variable

With respect to	Elasticity of Consumption							
	Major staple crops	Other crops	Non-dairy livestock and livestock products	Non farm goods and services	Milk	Butter	Cheese	Leisure
Price of major staple crops	-0.94 (-3.81)***	0.05 (0.16)	2.31 (2.94)***	0.32 (1.35)	0.38 (0.58)	1.24 (2.07)**	0.1 (0.18)	-0.01 (-0.02)
Price of other crops	0.22 (1.24)	-1.02 (-5.21)***	1.36 (2.44)**	0.18 (1.10)	0.40 (0.86)	1.44 (3.4)***	-0.21 (-0.52)	-0.14 (-0.23)
Price of non-dairy livestock and livestock products	0.28 (1.74)*	-0.14 (-0.76)	-1.0 (-1.92)*	0.05 (0.30)	-0.67 (-1.55)	-0.06 (-0.15)	0	-0.32 (-0.58)
Price of non-farm goods and services	1.03 (4.51)***	0.72 (2.82)***	1.07 (1.46)	-0.28 (-1.25)	0.16 (0.27)	1.53 (2.75)***	-0.16 (-0.31)	0.48 (0.62)
Price of milk	0.26 (2.26)**	0.14 (1.13)	0.42 (1.16)	0.08 (0.72)	-0.86 (-2.85)***	0.25 (0.92)	-0.05 (-0.2)	-0.14 (-0.37)
Price of butter	0.16 (0.85)	-0.09 (-0.42)	0.72 (1.22)	0.09 (0.48)	0.39 (0.78)	0.43 (0.94)	-0.24 (-0.55)	0.77 (1.22)
Price of cheese	-0.05 (-0.55)	0.02 (0.23)	0.42 (1.51)	0.12 (1.43)	-0.06 (-0.24)	-0.36 (-1.7)*	-0.95 (-4.62)***	-0.15 (-0.52)
Wage	0.05 (0.62)	-0.08 (-0.91)	0.18 (0.74)	-0.02 (-0.28)	0.07 (0.32)	0.21 (1.10)	-0.04 (-0.23)	-0.05 (-0.17)
Y*	0.07 (2.25)**	0.09 (2.56)**	-0.12 (-0.16)	0.08 (2.64)***	0.62 (7.11)***	0.63 (7.93)***	0.5 (6.55)***	0.46 (4.1)***
F	15.99***	9.76***	2.26**	1.83*	9.77***	14.89***	15.39***	3.0***
R^2	0.70	0.57	0.16	0.11	0.57	0.68	0.69	0.23

T - values are shown in parenthesis. ***, **, * denote significant coefficients at 1, 5 and 10 percent levels, respectively.

4.2 Household Labour Allocation Response

Farm household members allocate their time for farm work, wage employment, off-farm work and leisure. Changes in prices, wage and dairy profits (through a change in technology) cause household members to restructure labour allocation (family labour supply and demand for different farm activities).

4.2.1 Household Labour Demand

Household labour demand for crop and livestock production is the total quantity of labour the household demands for these farming activities. This study attempted to assess the demand for labour by incorporating only prices of outputs and the marginal physical product of labour (assumed to be captured by a dummy variable, 1 = if the household owns CBC, 0 = other wise) into the labour demand functions. The demand functions for crop, livestock and total production, thus, have the form:

$$L^* = L^* (P_{a1}, P_{a2}, P_l, P_k, P_b, W, D, F/L) \qquad [16]$$

$$L^*_a = L^*_a (P_{a1}, P_{a2}, P_l, P_k, P_b, W, D, F/L) \qquad [17]$$

$$L^*_d = L^*_d (P_{a1}, P_{a2}, P_l, P_k, P_b, W, D, F/L) \qquad [18]$$

Where L^* *total household labour demand for crop and livestock production,*
L^*_a *household labour demand for crop production,*
L^*_d *household labour demand for livestock production,*
P_j *sales price of good j, where j = a1, a2, l, k or b,*
a_1 *major staple crops (barley, teff and wheat),*
a_2 *other crops,*
l *non-dairy livestock and livestock products,*
k *milk,* b - butter, W - wage
D dummy variable (1 = if the household owns CBC, 0 = otherwise),
F/L Land/labour ratio.

As is the case for the purchase prices of consumption items, households face the same sales prices of outputs P_j and wage rate (W). Again, in order for wage and prices to vary across households, the following weighing method is employed.

$$P_j = \frac{\text{Average sales price for good j}}{(q_j \times p_j)/\left(\sum q_j \times p_j\right)}$$

Where j $= a1, a2, l, k,$ *and* b.
q_j = *quantity of item j sold.*

Wage rate is weighed using the same procedure.

For the purpose of assessing labour demand response, the specified demand functions were transformed into linear logarithmic forms and were then estimated. The estimated labour demand functions for crop, livestock and both crop and livestock productions are shown in Table 4.3.

The coefficients for wage are negative in conformity with economic theory and are also inelastic (but only significant in the case of total labour demand). The estimated coefficients imply that a 10 % increase in wage would decrease labour demand for crop, livestock and total farming by 1.4 %, 1.1 % and 1.2 %, respectively. Thus, a change in wage rate does not affect labour demand much. This is because hired labour participation is very low in farming and labour exchange arrangements are a more typical means of overcoming labour shortages (basically with little cost). Table 4.8 shows hired labour participation in relation to hired labour cost.

The estimated value of the intercept shifter variable, the dummy, shows that a shift from LBC to CBC dairying increases the labour demand for crop and livestock production significantly. This is plausible since CBC owners have larger size plots than LBC owners and dairying with CBC requires labour for additional feed production, other dairy activities and marketing of the outputs. The coefficient for the dummy variable in case IA (crop production) is elastic while in case IB (livestock production) is inelastic. The value of 1.29 for the intercept shifter variable (the dummy) in case IA implies that as a result of CBC introduction the intercept of the crop labour demand curve shifts upwards with the same slope of the curve. The same explanation holds for the coefficients 0.44 and 0.57 in cases IB and IC, respectively.

Table 4.3 Elasticities of Farm Labour Demand for Crop, Livestock and Both Crop and Livestock Productions.

With respect to	Elasticity of Farm Labour Demand for		
	Crop production (IA)	Livestock production (IB)	Both crop and livestock production (IC)
price of major staples (Barley, *teff* and wheat)	-0.06 (-0.83)	-0.07 (-1.5)	-0.07 (-1.57)
price of other crops	-0.01 (-0.09)	0.02 (0.27)	0.02 (0.28)
price of non-dairy livestock and livestock products	0.15 (1.09)	-0.05 (-0.53)	-0.02 (-0.19)
price of milk	-0.05 (-1.09)	0.02 (0.5)	0
price of butter	0.08 (0.98)	-0.05 (-0.82)	-0.01 (-0.24)
wage	-0.14 (-1.25)	-0.11 (-1.4)	-0.12 (-1.67)*
dummy variable	1.29 (8.07)***	0.44 (3.94)***	0.57 (5.29)***
land labour ratio	0.17 (1.25)	-0.15 (-1.58)	-0.12 (-1.34)
F	14.90***	2.55**	4.78***
R^2	0.65	0.17	0.33

t - values are shown in parenthesis

***, **, * denote significant coefficients at 1 percent, 5 percent and 10 percent levels respectively.

The estimated output price elasticities of labour demand are inelastic and not significant. An increase in price of a particular output does not increase labour demand. Theoretically, labour demand is responsive to price especially when the activity corresponding to the price change is important. Nonetheless, the coefficients for the output prices show that labour demand is not price responsive and only a few coefficients were found to have signs that confirm the theory. This does not, however, mean that all the activities considered are not important to the household but that labour demand is influenced more by the type of technology than the prices of outputs and wage.

4.2.2 Household Labour Supply

Technology also affects family labour supply. Labour supply response to changes in technology is considered to be more relevant from a policy standpoint than the demand for leisure. The labour supply functions used for the analysis are derived from leisure demand functions directly by means of the formula:

$$\frac{\partial S}{\partial Y^*} = - \frac{\partial C_v}{\partial Y^*}$$

To express this as an elasticity

$$\frac{\partial S}{\partial Y^*}\frac{Y^*}{S} = - \frac{\partial C_v}{\partial Y^*}\frac{Y^*}{S}$$

$$= - \frac{\partial C_v}{\partial Y^*}\frac{Y^*}{S}\frac{C_v}{S} \qquad [19]$$

Where S *stands for household labour supply,*
C_V *stands for household demand for leisure,*
Y^* *stands for household profit from dairying.*

The total family labour supply for both crop and livestock production is the summation of labour supplies of men, women and children. Theoretically, the labour supply of the household and its members (men, women, and children) for a particular activity is a function of household income, wage rate of labour in farming, wages that can be earned from other occupations, and the condition of the job (non pecuniary aspects of the job)[4]. Changes in factors other than the wage rate of labour in farming can shift the supply of labour curve.

Two of the factors that shift the labour supply curves, wages that can be earned from other occupations and the condition of the jobs, are less likely to affect households labour supply in the study area. This is because in the rural areas there are no other activities than farming that require hired labour. The conditions of the jobs available are not important either due to limited opportunities. Therefore, these two factors are not included as variables in the specified labour supply functions. The specified labour functions, thus, have the form:

$$S_{ij} = S_{ij}(P_a1 , P_a2 , P_l , P_k , P_b , W , Y^* , \frac{F}{L} \qquad [20]$$

where i = labour supply of men, women, children or the household as a unit,

j = crop, livestock, or both crop and livestock production activities.
P_{a1} = price of major staple crops (Barley, *teff* and wheat),
P_{a2} = price of other crops,
P_l = price of non-dairy livestock and livestock products,
P_k = price of milk,
P_b = price of butter,
W = agricultural wage rate,
y^* = profit from dairying,
F/L = Land/labour ratio.

The labour supplied of men, women and children (S_j) to crop and livestock production are obtained by dividing the hours allocated to crop and livestock production (all converted into man equivalent hours) by the number of economically active members of the household (number of standardized household labour units between age 8 and 75)[5] .

The values for the price of crops, livestock products, and labour (wage) for each household is based on the same procedure used in computing prices and wage values in the labour demand functions. The labour supply functions are also transformed to linear logarithmic form for estimation. The estimated labour supply functions for crop, livestock and the combined crop and livestock production is given in Table 4.4.

The computed values of F are significant at the 10 percent level, showing the joint significance of the explanatory variables. However, in these three cases the observed adjusted coefficients of multiple determination (R^2) are low. The estimated regression coefficients are all inelastic, have statistical significance for some of the variables and expected signs for most coefficients in the integrated models. Nevertheless, the estimated labour supply function for livestock production, assuming dairy profits constant, shows that the regression equation is not significant.

For comparison, two regressions of the same labour supply functions are run, assuming dairy profits constant in one case and variable in another. In all the three cases, the estimated elasticities of the integrated model are different from the traditional ones (which do not incorporate dairy profits into the model).

Table 4.4 Elasticities of Household Labour Supply to Crop, Livestock and Both Crop and Livestock Productions

With respect to	Elasticity of Household Labour Supply to					
	Crop (IIA)		Livestock (IIB)		Both (IIC)	
	a	b	a	b	a	b
price of major staples	0.02 (0.24)	-0.05 (-0.68)	-0.15 (-1.8)*	-0.05 (-0.54)	-0.11 (-1.86)*	-0.04 (-0.68)
price of other crops	0.05 (0.55)	-0.01 (-0.06)	-0.03 (-0.32)	0.05 (0.5)	-0.01 (-0.12)	0.05 (0.64)
price of non-dairy livestock and livestock products	0.19 (1.31)	0.03 (0.16)	-0.28 (-1.7)*	-0.03 (-0.19)	-0.19 (-1.53)	-0.02 (-0.14)
price of milk	-0.08 (-1.72)*	-0.04 (-0.82)	0.08 (1.47)	0.02 (0.34)	0.05 (1.29)	0.01 (0.24)
price of butter	0.01 (0.09)	0.03 (0.35)	-0.1 (-1.02)	-0.13 (-1.44)	-0.08 (-1.05)	-0.1 (-1.43)
wage	0.05 (0.44)	0.06 (0.56)	-0.04 (-0.32)	-0.06 (-0.48)	-0.04 (-0.38)	-0.05 (-0.53)
dairy profits (y^*)	-	0.09 (2.17)**	-	-0.13 (-2.94)***	-	-0.09 (-2.7)
land labour ratio	0.59 (3.97)***	0.59 (4.12)***	0.15 (0.89)	0.15 (0.94)	0.23 (1.84)*	0.23 (1.95)*
F	4.08***	4.41***	1.72	2.8**	2.06*	2.94***
R^2	0.27	0.32	0.08	0.20	0.11	0.21

t - values are shown in parenthesis
a)- dairy profits assumed constant
b) - dairy profits assumed variable
***, **, * *denote significant coefficients at 1, 5 and 10 percent levels, respectively.*

In the case of household labour supply to crop production, the regression coefficients are significant at 1 percent level under the assumptions of both constant and variable diary profits. Of the nine elasticities reported for comparison (under a and b of Table 4.4) two of them have different signs while the other four differ in magnitude but with the same sign. It is the joint effects of prices, wage and income (dairy profit) that account for these differences.

Traditional labour supply theory suggests that an increase in the price of an output that uses labour in production would increase household supply of labour. The estimated elasticities with respect to prices of major staples and other crops are 0.02 and 0.05, respectively. This result consistent with the theory. An increase in wage should also increase household supply of labour by decreasing hiring in of labour. The estimated elasticity is 0.05, which although not significant, is consistent with the theory.

The integrated models predict a decrease in family labour supply due to an increase in price, labour supply and wage. The estimated elasticities of family labour supply to crop production with respect to prices of major staples and other crops are -0.05 and -0.01 respectively, although these coefficients are not significant at 10 percent level.

In the traditional model, a unit increase in the prices of milk and butter change the family labour supply to crop production by -0.18 and 0.01 respectively (the response of household labour supply to butter price is not significantly different from zero, however). The profit effect in the integrated model could not offset the effect of milk price, but the magnitude is reduced (although it still maintains a negative sign). This result suggests that in the short run an increase in price of non-crops is less strong in affecting family labour supply to crop production than an increase in crop prices.

Table 4.5 Elasticities of Total Labour Supply of Men, Women and Children

With Respect to	Elasticity of Total Labour Supply of					
	Men (IIIA)		Women (IIIB)		Children (IIIC)	
	a	b	a	b	a	b
price of major staples	-0.14 (-1.46)	-0.19 (-1.75)*	0.02 (0.24)	0	-0.12 (-0.64)	0.15 (0.8)
price of other crops	(0.06) (0.49)	0.02 (0.19)	0.1 (0.93)	0.08 (0.75)	-0.08 (-0.32)	0.15 (0.64)
price of non-dairy livestock and livestock products	0.05 (0.26)	-0.06 (-0.25)	0.27 (1.64)	0.23 (1.2)	-0.61 (-1.6)	0.05 (0.12)
price of milk	0	0.02 (0.34)	-0.08 (-1.39)	-0.06 (-1.09)	0.1 (0.77)	-0.07 (-0.54)
price of butter	0.02 (0.21)	0.04 (0.33)	-0.15 (-1.47)	-0.14 (-1.39)	-0.32 (-1.39)	-0.4 (-1.94)*
wage	-0.16 (-0.95)	-0.15 (-0.9)	0.17 (1.25)	0.18 (1.27)	0.33 (1.04)	0.28 (0.97)
dairy profits (y^*)	–	0.06 (1.02)	–	0.02 (0.49)	–	-0.35 (-3.5)***
land labour ratio	0.21 (1.05)	0.21 (1.05)	0.02 (0.11)	0.02 (0.11)	-0.11 (-0.28)	-0.11 (-0.32)
F	0.95	0.96	1.78	1.56	1.02	2.62**
R^2	0.00	0.00	0.08	0.07	0.00	0.18

t - values are shown in parenthesis
a) dairy profits assumed constant
b) dairy profits assumed variable
***, **, * *denote significant coefficients at 1, 5 and 10 percent levels, respectively.*

The effect of technology is captured again here by the dummy variable dairy profit[6]. The integrated model shows that household labour supply to crop production (IIA in Table 4.4) increases with an increase in dairy profits. Family labour supply to livestock production (IIB) and in general to farming (IIC), however, decreases with an increase in dairy profits. These are indicated by elasticities 0.09,-0.13 and -0.09 in IIA, IIB, and IIC, respectively. All are significant at the 5 percent level.

These three elasticities indicate that a 1% increase in dairy profit decrease total family's labour supply to livestock production by 0.13% and increase total family's labour supply to crop production by 0.09%. The net household labour supply response is, however, a decrease in labour supply (the elasticity is -0.09). This means a 10 percent increase in dairy profit would decrease total family labour supply by 0.9 percent. The household labour supply response does not reveal the change in labour force participation of men, women and children to crop and livestock production. Men, women and children labour supply responses with respect to prices, wage, and dairy profits are shown in Table 4.5.

The estimated coefficients in cases IIIA and IIIB, as indicated by the F-ratios, are not significant at the 10 percent level and the regression lacks information (as R^2 shows value around 0). For children labour supply (case IIIC), however, the calculated value of F-ratio was found to be higher than its tabulated value at the 10 percent level. The estimated regression coefficients in the integrated models show that children decrease their supply of labour with an increase in household profits from dairying.

The above general predictions for total labour supply responses to a change in dairy profit is the net effect of each member's supply responses to livestock and crop productions. The regression equations for men (VA), women (VB) and children (VC) labour supply to livestock production is shown in Table 4.6.

Table 4.6. Elasticities of Labour Supply for Men, Women and Children to Livestock Production

With Respect to	Elasticity of Labour Supply of					
	Men (VA)		Women (VB)		Children (VC)	
	a	b	a	b	a	b
price of major staples	-0.52 (-2.23)**	-0.46 (-1.8)*	0.06 (0.65)	0.03 (0.35)	-0.12 (-0.62)	0.16 (0.82)
price of other crops	0.02 (0.08)	0.07 (0.23)	0.08 (0.67)	0.06 (0.47)	-0.11 (-0.44)	0.12 (0.52)
price of non-dairy livestock and livestock products	0.16 (0.34)	0.3 (0.55)	0.31 (1.7)*	0.25 (1.21)	-0.66 (-1.66)	0.02 (0.05)
price of milk	-0.06 (-0.42)	-0.1 (-0.59)	-0.09 (-1.5)	-0.07 (-1.16)	0.1 (0.8)	-0.06 (-0.51)
price of butter	0.16 (0.59)	0.15 (0.52)	-0.15 (-1.36)	-0.14 (-1.27)	-0.33 (-1.41)	-0.42 (-1.96)*
wage	-0.16 (-0.42)	-0.17 (-0.44)	0.18 (1.19)	0.19 (1.21)	0.3 (0.92)	0.25 (0.84)
dairy profits (y^*)	-	-0.07 (-0.54)	-	0.03 (0.58)	-	-0.36 (-3.49)***
land labour ratio	-0.28 (-0.58)	-0.28 (-0.58)	-0.02 (-0.1)	-0.12 (-0.1)	-0.15 (-0.37)	-0.15 (-0.41)
F	1.01	0.91	1.75	1.55	1.09	2.67***
R^2	0.00	0.00	0.08	0.07	0.01	0.19

t - values are shown in parenthesis,

a) dairy profits assumed constant,

b) dairy profits assumed variable,

****, **, * denote significant coefficients at 1, 5 and 10 percent levels, respectively.*

The estimated regression coefficient when dairy profit is included is found to be inelastic and statistically significant for the case VC (children labour supply to livestock production). The regression for men and women livestock labour supply is not significant at the 10 percent level. The estimated elasticity when dairy profit is included in case of VC is -0.36. This elasticity suggests that a 10% increase in dairy profit decreases the labour supply of children by 0.36%. This result implies that it is mainly children's labour supply to livestock production that is reduced as the household shifts from LBC to CBC dairying.

Table 4.7 Elasticities of Labour Supply for Men, Women and Children to Crop Production

With Respect to	Elasticity of Labour of					
	Men (IVA)		Women (IVB)		Children (IVC)	
	a	b	a	b	a	b
price of major staples	0.05 (0.43)	-0.11 (-0.96)	-0.43 (-2.15)**	-0.45 (-2.03)**	0.06 (0.28)	-0.04 (-0.19)
price of other crops	-0.04 (-0.25)	-0.17 (-1.19)	0.42 (1.6)	0.4 (1.47)	0.22 (0.84)	0.14 (0.5)
price of non-dairy livestock and livestock products	0.3 (1.24)	-0.09 (-0.35)	-0.3 (-0.74)	-0.35 (-0.75)	0.1 (0.24)	-0.14 (-0.29)
price of milk	-0.09 (-1.12)	0.01 (0.13)	-0.14 (-1.09)	-0.13 (-0.92)	-0.14 (-1.02)	-0.08 (-0.53)
price of butter	-0.05 (-0.32)	0.01 (0.06)	-0.21 (-0.88)	-0.21 (-0.84)	-0.01 (-0.04)	0.02 (0.09)
wage	-0.04 (-0.63)	-0.04 (-0.56)	0.05 (0.38)	0.05 (0.39)	-0.22 (-1.8)*	-0.21 (-1.76)*
dairy profits (y^*)	-	0.21 (3.34)***	-	0.03 (0.22)	-	0.13 (1.08)
land labour ratio	0.61 (2.51)***	0.62 (2.75)***	0.06 (0.14)	0.06 (0.14)	-0.17 (-0.4)	-0.17 (-0.39)
F	1.88*	3.36***	1.21	1.04	0.9	0.94
R^2	0.09	0.24	0.02	0.01	0.00	0.00

t - values are shown in parenthesis,
a) dairy profits assumed constant,
b) dairy profits assumed variable,
***, **, * *denote significant coefficients at 1, 5 and 10 percent levels respectively.*

Similarly a separate regression of total (men, women and children) labour supply response to crop production, given changes in dairy profits, in the integrated models predicts that total supply to crop production will increase. The regressions for IVB (women supply) and IVC (children supply) are not significant and lack information (R^2=0) (Table 4.7)..

However, the sign and value of coefficient of men labour supply, 0.21, predict that total labour supply is increased to crop production (slightly) with an increase in dairy profits. The regression equation IVA (men labour supply) as can be observed from the F-ratio, is significant at the 1 percent level.

The result that CBC family members increase their labour supply to crop production is not surprising since CBC owning households have more cultivated land area than LBC owners. Moreover, the results of the demand equations show that CBC owners demand more labour for both crop and livestock production. The family labour supply response of CBC households to livestock production is negative while to crop production is positive but inelastic. This implies that such households get labour from external sources (outside of the family). Nevertheless, as Table 4.8 shows, hired labour participation is low and households meet most of the additional labour needs by exchanging labour (which is the most observed practice of overcoming labour shortages).

Table 4.8. The Mean Cost (in Birr), Family Labour Supply (in hours) and the Share of Labour Cost From the Total Cost for Crop and Livestock Production of CBC and LBC Households

Owners of	Crop production				Livestock production			
	Hired cost (Birr)	Total cost (Birr)	Family labour supply (hours)	Total labour demand (hours)	Hired labour cost (Birr)	Total cost (Birr)	Family labour supply (hours)	Total labour demand (hours)
CBC	57.30	355.60	119.30	1014.45	30.40	474.9	299.35	3444.55
LBC	79.30	149.30	50.00	226.40	34.50	150.3	628.50	2292.20

Therefore, although CBC is labour demanding and households are benefiting from the technology, the spill over effect to the rural poor (who do not adopt the technology) through employment expansion is very low.

5. POLICY IMPLICATIONS AND CONCLUSION

5.1 Policy Implications

The empirical results of this study have implications for price policy and technological change. The estimated models provide three types of information: first, responses in terms of consumption of various commodity groups; second, labour supply responses of farm families to crop and livestock production; and third, farm labour demand responses of farm households.

The results from the integrated models estimated in this study suggest that an increase in output prices, not accounting for differences in profits from dairying, decrease the consumption of both non-food and food items. However, an increase in the wage rate is unlikely to change consumption of consumable items in the study area. There is, thus, some scope for government output price policy (labour input price policy) to affect farm household consumption, a result consistent with other studies of the consumption responses of low income rural populations to changes in price and wage policies. Household labour supply response to an increase in wage rates and output prices, meanwhile, is likely to decrease labour supply marginally. The estimated labour demand equation also suggests that labour demand is unlikely to be price responsive as long as price changes take place along with technological change.

In general, changes in output prices are likely to have negative impact on consumption of food and non-food commodities of rural households whereas allocation of labour does not seem to be affected by output price changes. Price of labour (wage) is also unlikely to affect household labour allocation and consumption.

With regard to the policy implications of technological change on consumption and labour allocation, the results of farm household response provide considerable insight. An increase in profit resulting from introduction of dairy production technology has significant and positive consumption effects particularly on dairy products; the impact on labour allocation is also significant.

The estimated equations show that the elasticities of labour demand are higher than the supply of household labour. The demand for labour both for crop and livestock production increases, but the supply of household labour, in general, decreases marginally. The response to crop production is slightly positive. The slack is not, however, taken up by increasing the hiring in of labour. It is usually obtained through labour exchange arrangements. Households who get labour from external sources might give their oxen to external labour suppliers to use it in return for their labour. Nevertheless, this study can not adequately predict the likely effects of the technology on wage farm employment since the study does not fully cover how rural factor markets operate. Moreover, implication of the technology on labour supply of men and women to livestock production as well as labour supply of children and women to crop production are not predicted explicitly.

5.2 Conclusions

This study extends the theory of agricultural household models to a multi-crop and mixed farming (crop and livestock production) environment of the North-western Zone of Shoa. The study has attempted to indicate the impacts of changes in dairy production technology, output prices and wage rate on consumption and household labour allocation.

The results of this study complement the implications of research on irrigation technology change in Gambia in improving dairy profit and household consumption, as well as in increasing labour demand. In contrast with the results in Gambia, labour supply of men also increases, but hiring in of wage labour (paid in cash) is not expected to occur. Moreover, unlike results from Korea, Nigeria and Malaysia, the positive dairy profit effects is not strong enough to offset the negative own-price effects on consumption. Nevertheless, the results of this study showed those with higher dairy profits (CBC households) consumed more of most consumption items.

With regard to labour allocation, like the results in Malaysia, labour demand was found to be highly responsive to technology, and less responsive to wage rate. Household labour supply to farming was found to decrease, but marginally. Unlike results from Malaysia, labour supply was found not to be responsive to output price.

The methodological procedure used to model agricultural households has some limitations. The assumption of risk free production, homogenous market products and single food prices, and single market wage rate for labour were made to simplify the analysis using the household framework. The assumption of risk free production is particularly strong where farm households practice inter-cropping as a risk averting strategy.

Data on LBC owners for values of most of the variables is based on extrapolations from a short survey period and a relatively small sample size. Data on prices of outputs were also from one particular region (where variability could not be observed). The limitation of data reliability could be improved by collecting data for one year in different regions (or market areas) from larger sample sizes.

In spite of all these limitations of the study, the predictions of household consumption and labour allocation responses made using the framework were insightful. Further research would help to resolve the questions of what household response would be to different kinds of risk, wage rates for various categories of labour (by sex and age), differences in farm gate and retail prices of food, and examine the assumption of profit maximization under the condition of inter-linked factor markets.

NOTES

[1] Leisure consumption of the family as well as total family and hired labour input in to crop and livestock production are valued at the market wage (see Singh and Janakiram, 1986).

[2] Barnum and Squire (1979) noted that the results of the estimated leisure functions are quite sensitive to the length of working day (see Barnum and Squire, 1979).

[3] The correlation between dairy profit and profit from crop production is 0.03. The square of this correlation value can serve as a rough estimation to indicate the proportion of the variation in dairy profit explained by variation in profit from crop production.

[4] For the details of the basic factors that affect the supply of labour (see Raffin and Gregory, 1983).

[5] It is believed that amount of labour each member of the household contributes to crop production varies by age, sex and working condition of each member in the household. Working condition of members refer to the fact that family members working greater (less) than the annual average working hours required in the farm are referred to as 'full-time workers' (part-time workers). Members can be part-time workers because of many reasons: farmers with other social and administrative responsibilities; housewives; students; traders; house maids; etc. The coefficients for converting household labour into man equivalents (standard labour units) by age and sex categories are shown in Appendix 1.

[6] The correlation of dairy profits with the technology dummy variable was found to be high and significant at the 1 percent level. Therefore to avoid multi- collinearity in the estimated equations, dairy profit is assumed to capture the effect of dairy technology.

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APPENDIX 1

Table 1.1 FAO/WHO coefficients for converting family size into standardized household size.

Age Category (Years)	Sex		
	Male	Both	Female
< 1		0.4	
1-3		0.6	
4-6		0.8	
7-9		0.9	
10-12	1.1		1.0
13-15	1.0		0.9
16-19	1.0		0.8
20-39	1.0		0.8
40-49	1.0		0.7
50-59	0.9		0.7
60-69	0.8		0.6
≥ 70	0.7		0.5

Source: Michael (1985)

Table 1.2 Coefficients for converting household labour into a standard labour unit.

Sex/age category	Condition	Labour unit
< 8 or >75		
Children (8-14)		
Children (8-14)		
Adult male (15-65)	1	
Adult male (15-65)	2	
Old men (66-75)		
Old men (66-75)		
House wives (15-65)	2	
House wives (66-75)	2	
Adult females (15-65)	1	
Adult females (15-65)	2	
Old women (66-75)	1	
Old women (66-75)	2	

Condition 1 refers to 'full-time worker' and condition 2 refers to 'part-time worker'.
Source: Bekele (1991).

Table 1.3 Definition of commodity groups.

Commodity sub-group	Components
1. Major staple crops	Barley, *teff* and wheat
2. Other crops	Horse beans, temenze, sorghum, haricot beans, oats, maize, lentils, sunflower, nough, linseed, chickpea, rough peas, fenugreek, field peas, millet, hopes, vegetables, fruits, spices and coffee.
3. non-dairy livestock and L.S.P: and livestock products	Meat, egg, hides and skin
4. non farm goods and services	Cooking oil, sugar, salt, Household goods, kerosene, soap, clothing, services (health, education, transport, milling), social commitments (wedding, baptism, etc.)
5. Milk	
6. Butter	
7. Cheese	
8. Leisure	All non own farming and marketing activities

Table 1.4: Mean values and coefficients of variation (cv) of consumption of various groups of commodities (in Birr) for LBC owners, CBC owners and both groups of households.

Consumption items	Consumption (in Birr)*		
	LBC owners	CBC owners	Both LBC and CBC owners
Major staple crops (Barley, teff & wheat)	108.25 (0.64)	313.040 (0.67)	2107.80 (0.88)
Other crops	614.55 (0.55)	1514.15 (0.78)	1064.35 (0.91)
Non-dairy livestock and livestock products	262.50 (0.91)	269.25 (1.04)	265.90 (0.97)
Non farm goods and services	670.95 (0.42)	885.55 (0.47)	778.25 (0.48)
Milk	64.10 (1.28)	126.45 (1.01)	95.25 (1.17)
Butter	148.05 (1.31)	355.35 (0.66)	251.70 (0.95)
Cheese	48.85 (2.13)	107.90 (1.02.)	78.35 (1.41)
Leisure	113.75 (0.60)	88.00 (0.83)	100.85 (1.0)
Total consumption	3000.80 (0.36)	6600.05 (0.41)	4800.45 (0.57)
Number of observation	30	30	60

* The values in parenthesis are coefficients of variation