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ESSP II Working Paper 38

Consumption Patterns of Livestock Products in Ethiopia: Elasticity Estimates Using HICES (2004/05) Data

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Abstract

Ethiopia is known to have one of the largest livestock populations in the world. Yet the overall contribution of livestock products to households' daily consumption is very limited. The average per capita annual consumption of meat and dairy products are just 4.6 kg and 16.7 kg, respectively. Given recent growth in income, there is potential for growth in the demand for livestock products.

This study attempts to estimate elasticities of livestock products. We use the Household Income, Consumption, and Expenditure Survey (HICES), the Welfare Monitoring Survey (WMS), and Retail Prices of Goods and Services of 2004/05 data sets of the Ethiopian Central Statistical Agency (CSA). Descriptive analysis of budget shares from livestock products shows that such products account for a very small share of total household expenditure and food expenditure, even by African standards. There is also a remarkable difference in the composition of livestock products between rural and urban areas. When viewed across income categories, the study also reveals that richer households tend to have higher consumption of livestock products. For the econometric analysis, we chose the Quadratic Almost Ideal Demand System (QUAIDS) model for its efficiency and reliability of results. The estimated figures reveal that there is a considerable expenditure and price response for livestock products in Ethiopia. It also appears that rural areas have higher expenditure elasticities than urban areas. Furthermore, price responses are higher in rural areas than urban areas. Similarly, own-price responses exhibit wide variation across commodities. We also found a strong substitution relationship among most livestock products.

Limited market access, high dependence on subsistence agriculture, poor marketing infrastructure for perishable products (such as a lack of cold chains), low level of urbanization, indivisible nature of the product (specifically for beef and mutton), and lack of rural retail markets for such products all constrain rural households, resulting in a low demand for livestock products. Our results also suggest that there is an opportunity to take advantage of the country's huge livestock resources and to increase the consumption of livestock products through policies aiming at raising household income. The findings also suggest that improving the country's marketing infrastructure for livestock products could also improve opportunities for substitution among livestock products in response to preferences and market signals.

Keywords: Ethiopia; consumption patterns; demand elasticities; livestock products; QUAIDS

1. Introduction

Ethiopia is known to have one of the largest livestock populations in the world. The livestock sector accounts for over 26 percent of agricultural GDP (2009/10)¹ and 8 percent of export earnings (2010) (CSA 2010 National Statistics). Yet, the domestic consumption of livestock products remains low compared with other African countries (FAO 2010).

It has been established that composition of food depends on the level and distribution of income and the degree of urbanization in a country, among other factors. As income grows, there is a tendency to consume more livestock products. Likewise, urbanization and the consequent improvements in infrastructure encourage diversity of diets, with shifts toward livestock products and nutritious foods (Delgado et al. 1999). Given recent income growth in Ethiopia and the government's focus on developing the industrial sector, which is likely to lead to expansion of urban centers, there is potential for growth in the demand for livestock products. Channeling this demand growth so that the potential gains will thoroughly improve the welfare of producers and consumers requires an understanding of the consumption patterns of livestock products. To that end, this study discusses the consumption patterns and expenditure and price elasticities of livestock products in Ethiopia.

Kedir (2005), Ulimwengu et al. (2009), and Tafere, Taffesse, and Tamiru (2010) estimated price elasticities for livestock products. These studies are not specifically focused on estimating demand elasticities of various livestock products. Rather, those estimates are for aggregate livestock products. So, this study attempts to fill this gap by estimating price elasticities of livestock products of four commodity disaggregation levels of Beef, Mutton and goat meat, Other animal and animal products, and Dairy products. Conducting the analysis at these disaggregation levels enables us to better understand the different price dynamics of different livestock products and the domestic demand incentives across their respective categories.

¹ These calculations do not include the value of livestock plowing services. According to IGAD (2010), in case the value of plowing services is included, the share of livestock in agricultural GDP for 2008/09 GDP would be 45 percent.

Box 1.1—Definitions

The reaction of households to price and income changes can be predicted and quantified through economic parameters that are called '**demand elasticities**'.

Income elasticities (or **expenditure elasticities**) help to predict the impact of income changes on consumption levels. Income elasticity is the percentage change in consumption is when there is a 1 percent change in income, with all other factors being constant.

A positive income elasticity between 0 and 1 means that an increase in income will result in an increase in demand of that good (called 'normal good'). However, an increase of the income by 100 percent would only increase the demand by less than 100 percent.

A negative income elasticity means that an increase in income will result in a decrease in demand of that good (called 'inferior good').

Income-inelastic goods means that changes in income have a relatively small effect on the demand of these goods.

Very high income elastic demand (>1) shows that the proportional consumption increase exceeds the proportional income increase, which eventually leads to a higher expenditure share of that good (called 'superior good').

Price elasticities help to predict the impact of price changes on consumption levels. Price elasticity is the percentage change in consumption when there is a 1 percent change in price, with all other factors being constant.

Own-price elasticity is the elasticity of demand with respect to the good's own price.

Cross-price elasticity is the elasticity of demand with respect to the price of another good. It refers to the effect a change in a price of one good can have on the demand for another good.

A complementary good is a good with a negative cross-price elasticity of demand. It is a good which demand increases (or decreases) when the price of another good decreases (or increases).

A substitute good is a good with a positive cross-price elasticity of demand. It is a good which demand increases (or decreases) when the price of another good increases (or decreases).

Source: Authors' compilation

2. The data

The analysis in this paper is primarily based on the Household Income, Consumption, and Expenditure Survey (HICES) 2004/05 of the Ethiopian Central Statistical Agency (CSA) (CSA 2007a, 2007b). We extracted additional information on household demographics and asset variables from the Welfare Monitoring Survey (WMS) 2004 (CSA 2004a, 2004b, 2004c). Moreover, because HICES does not have information on prices, we relied on the Retail Prices of Goods and Services 2004/05 of the CSA (CSA 2005) for the prices of livestock products that we used in this study. We made a special effort to ensure that the prices taken from the external price survey coincide with the months during which the HICES survey was conducted.

HICES 2004/05 covers all rural and urban areas of Ethiopia except all zones of the Gambella region, three predominantly non-sedentary zones of the Afar region and six such zones of the Somali region. It is important to note that—the Afar and Somali regions being largely pastoral—a lack of sufficient data from these regions may somewhat inhibit the extent to which this study is able to capture the whole picture. Thus, the results of this study should be taken with caution.

For the purpose of HICES 2004/05, CSA divided the country into three broad categories: 'rural', 'major urban centers', and 'other urban centers'. The 'rural' category consists of all rural areas in all regions of Ethiopia except those noted earlier. 'Major urban centers' consists mainly of regional capitals and four other urban centers with relatively sizable populations, while 'other urban centers' includes all urban areas that do not fall under the 'major urban centers' category.² A total of 21,595 households make up the HICES sample. This nationally representative sample contains 12,101 urban households and 9,494 rural households selected from 1554 enumeration areas (EAs) in 444 woredas.

3. Consumption patterns of livestock products

As per the descriptive statistics from the HICES (2004/05) data, the national expenditure on livestock products is computed to be about 4.7 billion ETB (Ethiopian Birr) with a mean annual per capita expenditure of 90.07 ETB. Table 3.1 shows the total expenditure and the per capita expenditure on livestock products for the different Ethiopian regions. Oromia takes the lion's share in the total national expenditure on livestock products, i.e. 44.5 percent, while the Southern Nations, Nationalities, and Peoples (SNNP) region and Amhara take the second and the third place, with 20 percent and 17 percent of the total national expenditure share of livestock consumption, respectively. This is not surprising, as these regions have the highest population numbers. All the remaining regions together take a share of about 15 percent of the total national expenditure. Even though Afar takes the smallest expenditure share, about 1 percent, the regional per capita expenditure is the highest. This could be due to the fact that the region is well known for its pastoral lifestyle.

Table 3.1—Regional expenditure on livestock products

Region	Expenditure (ETB)	Average per capita expenditure (ETB)	Share of national expenditure (percentage)
Tigray	326,952,243	95.15	7.01
Afar	45,997,621	223.14	0.99
Amhara	810,122,501	65.55	17.36
Oromia	2,077,789,094	98.86	44.53
Somali	101,670,004	171.51	2.18
Benishangul/Gumuz	59,848,656	95.96	1.28
SNNP	933,975,062	85.63	20.01
Harari	19,710,358	132.27	0.42
Addis Ababa	267,750,069	125.77	5.74
Dire Dawa	22,729,948	98.35	0.49
Total	4,666,545,556	90.07	100.00

Source: Authors calculation using HICES 2004/05

Note: ETB = Ethiopian Birr, the exchange rate was roughly 8.71 ETB per US Dollar in 2004/05 (NBE 2005); SNNP = Southern Nations, Nationalities, and Peoples region

² According to CSA, an urban area is generally defined as a locality with 2000 inhabitants or more. However, in the HICES (2004/05) survey urban areas are:

- i) All administrative capitals (Regional capitals, Zonal capitals and Woreda capitals);
- ii) Localities with Urban Dwellers' Association (UDAs) not included in (i); and
- iii) All localities that are not included either in (i) or (ii) above, having a population of 1000 or more persons, and whose inhabitants are primarily engaged in nonagricultural activities.

When we look at the expenditure share across income categories, classified based on their overall expenditures, we see that households in the richest quintile group tend to spend nearly twice as much on livestock products as the poorest quintile group. Households in the second to the fourth quintile group take a comparable expenditure share, ranging from 18.50 to 22.85 percent. In addition, the average per capita expenditure on livestock products consistently increases from the poorest to the richest quintile groups. The average per capita expenditure of the richest quintile is more than threefold to that of the poorest quintile group. The details on expenditure share across expenditure quintile groups are presented in Table 3.2.

Table 3.2—Expenditure on livestock products across the five quintile groups of households

Expenditure quintile groups	Expenditure (ETB)	Average per capita expenditure (ETB)	Share of national expenditure (percentage)
Q1 (poorest)	625,850,839	45.30	13.41
Q2	863,525,198	66.45	18.50
Q3	912,277,633	78.00	19.55
Q4	1,066,145,111	102.00	22.85
Q5 (richest)	1,198,746,776	149.37	25.69

Source: Authors calculation using HICES 2004/05

3.1. Budget shares

As of 2004/05, livestock products accounted for 4.4 percent of total household expenditure and 8.7 percent of food expenditure. There is an important location dimension to this—there exists a significant difference in expenditure shares between rural and urban areas. Urban households spend a higher share of their expenditure on livestock products—they spend 5.2 percent of their total expenditure and 12.7 percent of their food expenditure on livestock products. Rural households spend 4.3 percent and 8 percent, respectively. Delisle (1990) found that in developing countries urban diets are generally more diversified, contain more animal products and vegetables, and are more nutritionally adequate than rural diets.³ Guo et al. (2000) show, using 1989–1993 Chinese data, that urban populations consume significantly more high-fat food than rural ones. There is also evidence that the process of urbanization affects patterns of food consumption. Using 1960–1988 data, Huang and David (1993) report a reduction in urban demand for cereals (rice and coarse grains) in high income Asian countries.

Expenditure on meat (beef and mutton & goat meat) represents the largest expenditure group among livestock products, followed by dairy products (see Table 3.3). Meat accounts for half of the total expenditure on livestock products while the dairy products' share for the period stands at over 39 percent. Chicken and eggs are the other livestock products with relatively significant expenditure shares, averaging 7.3 percent and 2.6 percent, respectively. The expenditure shares of fish and the 'other meat' group (which includes camel meat, pork⁴, and crocodile meat, among others), however, are negligible.

³ Using 1770–1850 data from Great Britain, Clark, Huberman, and Lindert (1995) show urbanization doesn't necessarily lead to improved nutrition. They point out that rural people consumed more calories and proteins from grains and were consistently taller.

⁴ Pork is barely eaten in Ethiopia because of religious reasons.

Table 3.3—Expenditure share of livestock products (percent)

	Beef	Mutton & goat meat	Chicken	Other meat (camel, pork, crocodile...)	Fish & fish products	Dairy products	Eggs	Honey
National	40.9	8.3	7.3	0.5	0.4	39.5	2.6	0.8
Urban	55.8	11.7	9.3	0.5	0.3	17.4	4.7	0.7
Rural	37.9	7.6	6.9	0.5	0.5	44.1	2.2	0.9
Expenditure quintiles								
Q1 (poorest)	43.0	7.4	7.8	0.5	0.5	38.5	2.0	0.7
Q2	39.9	7.5	7.1	0.5	0.4	42.1	2.0	0.8
Q3	41.0	7.2	7.4	0.5	0.4	41.0	2.2	0.7
Q4	40.5	8.8	7.4	0.4	0.5	39.2	2.7	0.9
Q5 (richest)	40.4	10.3	6.8	0.4	0.4	37.1	4.0	1.0

Source: Authors' calculation using HICES 2004/05

There is also considerable variation in the composition of expenditure shares across location and expenditure quintiles. The shares of meat, chicken, and eggs are higher in urban areas. Urban populations of Ethiopia spend, on average, 67.5 percent, 9.3 percent, and 4.7 percent of their livestock expenditure on meat, chicken, and eggs respectively, whereas the corresponding average for rural populations is 45.5 percent, 6.9 percent, and 2.2 percent. On the other hand, rural populations appear to spend a higher proportion of their livestock products' expenditure on dairy products (44.1 percent) compared with their urban counterparts (17.4 percent). Rural households spend as much on dairy products as they do on beef and mutton and goat meat (Table 3.3).

It appears, on average, the livestock products' expenditure shares of beef, dairy products, and chicken fall with income (expenditure) (Table 3.3). While the change in shares is smooth and marginal for the top four quintiles (Q2-Q5), transition from the first to the second quintile seems less smooth. For example, the expenditure on beef declines from 43 percent in the first quintile to 40 percent in the second quintile, and the share of dairy products, on the other hand, initially rises from 38.5 percent in the first quintile to 42.1 percent in the second quintile, and then consistently declines. The share of chicken declines from 7.8 percent in the first quintile to 6.8 percent in the fifth quintile, though it slightly recovers in the third quintile. In contrast, the expenditure share of mutton & goat meat and eggs appear, on average, to rise with income. The average shares of mutton & goat meat and eggs for the poorest quintile are 7.4 percent and 2 percent, respectively, which are considerably less than the 10.3 percent and 4 percent, respectively, for the richest quintile. Bopape and Myers (2007) have reported consistent results for South Africa. They found that high-income groups have higher expenditure shares for meat, fish, and dairy products, whereas low-income groups have a higher expenditure share for grains. There is also evidence from cross-country studies that food demands change with income growth, with people showing a greater preference for fruit, meat, dairy products, and other 'high value' food (Drewnowski and Popkin 1997; Cranfield et al. 1998; Guo et al. 2000; Regmi et al. 2001).

3.2. Quantity consumption

The per capita consumption of livestock products, especially meat, is extremely low in Ethiopia, even by African standards⁵. The national average of annual meat consumption stands at just 5.3 kg per person, of which 3.1 kg is beef, 1.4 kg mutton & goat meat, and 0.7 kg chicken. This very low meat consumption is mainly driven by low rural consumption. In urban areas, the average annual meat consumption stands at 11.5 kg per person, while the corresponding number for rural areas is 4.0 kg per person. Consumption of eggs also follows the same trend: urban areas have a higher consumption than rural areas. The national level of egg consumption is very low, at just 0.2 kg per person per year; but urban people consume five times as many eggs as their rural counterparts (Table 3.4).

Dairy products form the largest consumption group among the livestock products. In 2004/05, the national average of annual consumption per person was 16.7 kg⁶. There is a substantive difference between urban and rural areas, however. Unlike meat consumption, the annual per capita consumption of dairy products in rural areas is more than twice that of urban areas. At 18.4 kg, the rural annual consumption of dairy products overwhelms the meat consumption, which is only 4.0 kg. The picture is different in urban areas: per capita annual dairy product consumption is 8.5 kg and is less than the average meat consumption of 11.5 kg (Table 3.4).

The reason for this marked difference between rural and urban areas could be food availability and individuals' ability to buy food. These factors differ in urban and rural areas (Regmi and Dyck 2001). The Ethiopian rural economy is mainly based on subsistence agriculture, so the composition of food in rural areas is likely to be influenced by residents' market access (for selling their own produce and buying other foods). On average, 76 percent of rural households get their food from their own production, whereas the number for urban households is just 7 percent. Moreover, the poor marketing infrastructure for perishable products, such as the lack of cold chains—which, to an extent, could be associated with the low level of urbanization in Ethiopia—limits the extent to which rural households can sell their produce. It is also likely that rural households are discouraged from meat consumption as much by the nature of the product—it is produced in bulk and is largely indivisible⁷—as by the lack of retail markets for such products in rural areas.

⁵ FAO (2010) reports that in 2004 the African and East African average was about 15 kg and 10 kg respectively, whereas the Ethiopian average for the same period was 8 kg. The Ethiopian average reported by FAO is substantially higher than what we found in this study using a nationally representative dataset.

⁶ Like per capita meat consumption, the amount of dairy product consumption lags behind other African countries. According to FAO (2010), the average annual per capita consumption of dairy products for Africa and East Africa in 2004 are 36.4 kg and 26.7 kg respectively, which are considerably higher than the Ethiopian average of 17.2 kg.

⁷ If a farm household slaughters an animal for the meat, it has to consume all in a short time; this discourages the households. Exceptions are holidays, during which the traditional 'kircha' system presents an opportunity for sharing the meat of slaughtered animals and easing the restrictions imposed due to the indivisibility of livestock.

Table 3.4—Per capita consumption (Adult Equivalent) of livestock products (kg)

	Beef	Mutton & goat meat	Chicken	Other meat (camel, pork, crocodile...)	Fish & fish products	Dairy products	Eggs	Honey	Total meat *
National	3.1	1.4	0.7	0.1	0.1	16.7	0.2	0.1	4.6
Urban	6.8	3.1	1.6	0.1	0.0	8.5	0.5	0.1	9.9
Rural	2.4	1.1	0.5	0.1	0.1	18.4	0.1	0.1	3.5
Expenditure quintiles									
Q1	1.6	0.7	0.3	0.0	0.0	10.2	0.0	0.0	2.3
Q2	2.1	1.0	0.4	0.1	0.1	15.2	0.1	0.1	3.1
Q3	2.7	1.2	0.6	0.1	0.0	16.9	0.1	0.1	3.9
Q4	3.5	1.6	0.7	0.1	0.1	19.9	0.2	0.1	5.0
Q5 (richest)	5.3	2.7	1.3	0.1	0.1	20.6	0.5	0.1	8.0

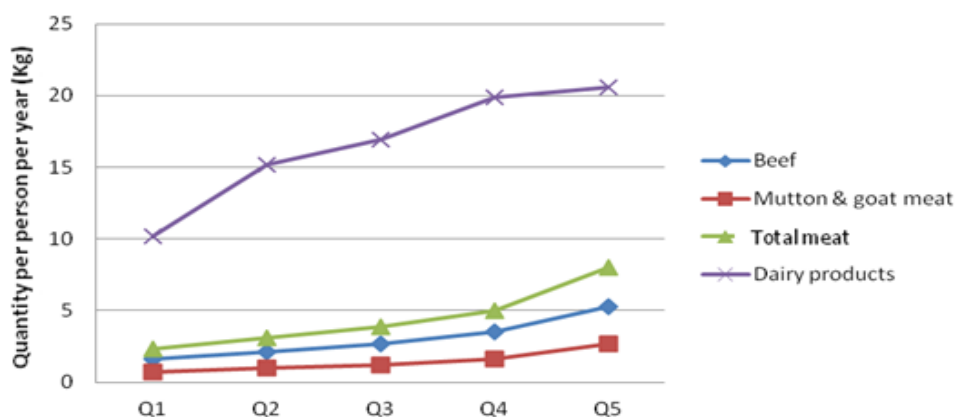
Source: Authors calculation using HICES 2004/05

Note: * Total meat = Beef + Mutton & goat meat

A glimpse across income (expenditure) groups suggests that richer households tend to consume more livestock products than poorer ones do. This is true for all major consumption groups including beef, mutton & goat meat, chicken, dairy products, and eggs (Table 3.4). The average individual in the poorest quintile consumes 2.3 kg meat (1.6 kg beef, and 0.7 kg mutton & goat meat), and 10.2 kg dairy products, whereas his or her counterpart in the richest quintile consumes 8.0 kg meat (5.3 kg beef, and 2.7 kg mutton & goat meat), and 20.6 kg dairy products. The richest quintile consumes thus 250 percent more meat and 100 percent more dairy products than the poorest quintile (Table 3.4).

For all income groups, beef is the most commonly eaten meat. It accounts for roughly two-thirds of total meat consumption nationally and it doesn't seem to vary much across location (urban versus rural) or across income groups (expenditure quintiles). It can also be seen from Figure 3.1 that across income groups, the per capita consumption of meat (beef and mutton & goat meat) appears to rise at an increasing rate. These results seem to be consistent with findings of other cross-country studies of developing countries. For example, Regmi et al. (2001) show that in low-per-capita-income countries, consumers will eat (or drink) more higher-value livestock products and fewer lower-value cereals to higher value livestock products when per capita income rises.

Figure 3.1—Quantity of meat consumption (kg/capita/year) across income groups



Source: Authors calculation using HICES 2004/05

Note: Total meat = Beef + Mutton & goat meat

3.3. Calorie consumption

Livestock products account for a very small share of daily per capita calorie intake. At the national level, in 2004/05 the share of livestock products in daily calorie intake amounted to just 2.9 percent. Urban Ethiopians get 4.8 percent of their daily calories from livestock products, while rural Ethiopians get 2.6 percent of their daily calories from such products.

Table 3.5—Per capita calorie intake per day (Adult Equivalent) from livestock products

	Beef	Mutton & goat meat	Chicken	Other meat (camel, pork, crocodile...)	Fish & fish products	Dairy products	Egg	Honey	Total
National	17.5	8.8	3.6	0.5	0.4	34.6	1.1	0.7	67.3
Urban	39.2	19.3	8.6	0.7	0.3	23.1	3.5	1.2	95.8
Rural	13.1	6.7	2.6	0.5	0.4	36.9	0.6	0.7	61.4
Expenditure quintiles									
Q1	9.0	4.0	1.6	0.4	0.1	18.9	0.3	0.3	34.7
Q2	11.4	6.0	2.2	0.5	0.6	32.3	0.4	0.7	53.9
Q3	14.8	7.2	2.9	0.5	0.1	31.7	0.6	0.5	58.3
Q4	19.2	9.3	3.8	0.5	0.7	41.4	1.0	0.7	76.7
Q5 (richest)	31.3	16.6	7.1	0.6	0.4	46.1	3.0	1.4	106.6

Source: Authors calculation using HICES 2004/05

Nationally, the daily amount of calories obtained from livestock products stands at 67 calories. There is, however, considerable variation across location and income groups. The average per capita calorie intake per day from livestock products in urban areas is about 96 calories, which is 42 percent higher than the rural average of just over 61 calories. The amount of calories sourced from livestock products consistently rises with income. Ethiopians in the poorest quintile get only 35 calories per day per person from livestock products, whereas those in the richest quintile get about 107 calories, which is 207 percent more than the average of the first quintile (Table 3.5). Similar results have been found in other studies. Guo et al. (2000) show that in 1993, only 17.3 percent of low-income Chinese adults between the ages of 20 and 45 obtained more than 30 percent of their energy from fat, whereas 52.7 percent of high-income adults drew more than 30 percent of their energy from fat. The researchers also found considerable variation among low- and high-income adults by where they lived. A larger fraction of urban residents received more than 30 percent of their energy from fat compared with rural ones. This is consistent with the view that urbanization leads to diversification of diets and improved nutrition (Drewnowski and Popkin 1997; Guo et al. 2000). Urbanization can lead to changes in food consumption patterns for several reasons. The urban-rural difference in calorie consumption in earlier times is largely attributed to difference in lifestyle and the resulting difference in calorie needs (Clark, Huberman, and Lindert 1995). In recent times, however, urbanization appears to affect composition of food rather than the level of per capita calorie consumption (Regmi and Dyck 2001).

The major sources of calories from livestock products are dairy, beef, mutton & goat meat, and chicken, in descending order. Nationally, they provide 35, 18, 9, and 4 calories per day per person, respectively, which amount to 51 percent, 26 percent, 13 percent, and 5 percent of the daily calorie intake from livestock products. The composition varies between urban and rural areas. In urban areas, beef is the most important source of calories from livestock products. Beef and dairy products account for 41 percent and 24 percent, respectively, of the daily calorie intake from livestock products in urban areas. In rural areas, on the other hand,

dairy products are the primary source of calories from livestock products and account for 60 percent of daily calorie intake from livestock products, while beef is second with a share of 21 percent. The amount of calories obtained from the major livestock products also appears to rise with income. People in the poorest quintile, on average, get 19, 9, and 4 calories from dairy products, beef, and mutton and goat meat, respectively, representing 55 percent, 26 percent and 12 percent of their daily calorie intake from livestock products. The average for the richest quintile, on the other hand, is 46 calories from dairy products, 31 calories from beef, and 17 calories from mutton & goat meat. These represent 43 percent, 29 percent, and 17 percent of daily calorie intake from livestock products per person. Though the calories obtained from all major livestock products rises with income, there is a hint of change in their composition—the share of meat (beef, mutton & goat meat, and chicken) rises while that of dairy products falls (Table 3.5).

4. Demand elasticities

4.1. Model specification⁸

One of the most widely used specifications in applied demand analysis is the Almost Ideal Demand System (AIDS) model proposed by Deaton and Muellbauer (1980b). Its popularity is in part due to the fact that it satisfies a number of desirable properties⁹ and allows linear approximation at the estimation stage. The model has budget shares as dependent variables and logarithm of prices and real expenditure/income as regressors.

However, various empirical Engel curve studies (for example Lewbel (1991), Hildenbrand (1994), Hausman, Newey, and Powell (1995), Villarreal (2003), etc.) suggest that further terms in income may be required to achieve reliable estimations. Rank two models, such as AIDS, do not adequately describe the relationship between demands and total expenditure. Banks, Blundell, and Lewbel (1997) show that a rank three generalization of the AIDS model leads to different conclusions relative to the standard rank two AIDS model.

The original AIDS model was subsequently extended to permit non-linear Engel curves. The resulting model, proposed by Banks, Blundell, and Lewbel (1997), is the Quadratic Almost Ideal Demand System (QUAIDS). Under QUAIDS, the i^{th} budget share (w_i) equation for household h is given by:¹⁰

$$w_{ih} = \alpha_i + \sum_{j=1}^n \gamma_{ij} \ln p_j + \beta_i \ln \left[\frac{x_h}{a(p)} \right] + \frac{\lambda_i}{b(p)} \left\{ \ln \left[\frac{x_h}{a(p)} \right] \right\}^2 \quad (1)$$

⁸ This section borrows a large part of its text from Tafere, Taffesse, and Tamiru (2010).

⁹ AIDM satisfies axioms of choice exactly; it allows exact aggregation over consumers; is simple to estimate; and it can be used to test the restriction of homogeneity and symmetry through linear restrictions on fixed parameters (see Deaton and Muellbauer 1980b; and Moschini 1995).

¹⁰ Note that with $\lambda=0$ the QUAIDS reduces to the original AIDS.

with:

$$\ln a(p) = \alpha_0 + \sum_{k=1}^n \alpha_k \ln p_k + \frac{1}{2} \sum_{k=1}^n \sum_{j=1}^n \gamma_{kj} \ln p_k \ln p_j \quad (2)$$

$$b(p) = \prod_{k=1}^n p_k^{\beta_k} \quad (3)$$

In equations (1) to (3), p_j and x stand for the price of commodity j and total consumption expenditure, respectively, while $\ln(\cdot)$ indicates logarithmic transformation. The α s, β s, γ s, and λ s are parameters to be estimated.

Three main properties of demands derived from utility maximization under a budget constraint can be stated and tested as restrictions on the parameters of the QUAIDS equation system (1).¹¹

These are:

$$\sum_{i=1}^n \alpha_i = 1; \quad \sum_{i=1, j=1}^n \gamma_{ij} = 0; \quad \sum_{i=1}^n \beta_i = 0; \quad \sum_i \lambda_i = 0 \quad (4)$$

$$\sum_j \gamma_{ij} = 0 \quad (5)$$

$$\gamma_{ij} = \gamma_{ji} \quad (6)$$

The equalities in (4) are the adding-up restrictions. They express the property that the sum of the budget shares equals 1 (i.e. $\sum w_{ih} = 1$). The restriction in (5) expresses the prediction that the demand functions are homogenous of degree zero in prices and income. Satisfaction of the restriction in (6) ensures that Slutsky symmetry would hold true.

A number of additional features are introduced below to accommodate various data and estimation issues. These adjustments will modify the form in which these restrictions apply.

Zero-expenditures

Zero expenditure on individual commodities is a common feature of survey data, and HICE surveys are no exception. The statistical problems that may be thus created depend on the causes underlying the phenomena. Similarly, the treatment of zero-expenditures has to reflect these causes.¹² Apart from imperfect recall, three main reasons for zero-expenditure on a good can be identified: permanent zero consumption, zero consumption during the survey period, and optimal zero consumption.¹³

Unfortunately, it is not possible to identify which of these reasons is responsible for each of the reported zero-expenditures from the HICES data. However, aggregation over commodities helps reduce the problem. Accordingly, livestock products have been aggregated into four groups. Commodity aggregation went some way toward reducing the

¹¹ Note that negativity of own-price responses cannot be imposed in the form of restrictions on the parameters of the model. See Deaton and Muellbauer (1980b).

¹² Pudney (1989, Chapter 4) deals with the problem of zero-expenditures in some length. See also Deaton (1987, 1990 and 1997), and, for the more recent developments, Heien and Wessells (1990), Yen and Lin (2006).

¹³ Consumption rather than purchase is used as the criterion because we are dealing with the food consumption of farming households. They generally produce food so that purchases do not necessarily coincide with expenditures due to the consumption of their own output.

incidence of zero expenditure. The problem, however, doesn't go away—at least 23 percent of households have zero-expenditure for one of the livestock products groups. Thus, it is necessary to deploy a technique for alleviating the sample selection problem that may arise with the presence of zero-expenditure (or a censored dependent variable). Maddala (1983, Chapter 9) shows that econometric estimates that neglect censoring will be biased and inconsistent.

The study adopts the two-step approach initially proposed by Heien and Wessells (1990) and further modified by Shonkwiler and Yen (1999). Following Shonkwiler and Yen (1999), the problem can be stated as estimating the system of equations:

$$w_{ih}^* = f(x_{ih}, \mu) + \mu_{ih}, \quad d_{ih}^* = z_{ih}' \theta_i + v_{ih} \quad (7)$$

$$d_{ih} = \begin{cases} 1 & \dots \text{if } \dots d_{ih}^* > 0 \\ 0 & \dots \text{if } \dots d_{ih}^* \leq 0 \end{cases}$$

$$w_{ih} = d_{ih} w_{ih}^*$$

where i and h respectively index commodity sub-groups and households, w_{ih} and d_{ih} are the observed expenditure shares and the indicator of whether household h consumed the i^{th} commodity sub-group; w_{ih}^* and d_{ih}^* , the corresponding latent variables; \mathbf{x}_{ih} and \mathbf{z}_{ih} , vectors of explanatory variables; μ_i and θ_i , vectors of parameters and u_{ih} and v_{ih} , random disturbances. Shonkwiler and Yen (1999) identify two main difficulties in estimating the system of equations in (7):

- i. If a considerable fraction of w_i are zero, then representing it by a continuous distribution is likely to be inappropriate; and
- ii. The presence of cross-equation correlation of error terms means that the likelihood function will involve multiple integrals, thereby making direct maximum likelihood estimation of equation (7) very difficult.

As an alternative, Shonkwiler and Yen (1999) developed a two-step procedure that also solves the inconsistency of the Heien and Wessells (1990) approach. Shonkwiler and Yen (1999) assume that for each i , the disturbance terms $\{u_i, v_i\}$ are distributed as bivariate normal with $\text{cov}(u_i, v_i) = d_i^2$, and show the unconditional expectation of w_{ih} to be:

$$E(w_{ih} | x_{ih}, z_{ih}) = \Phi(z_{ih}' \theta_i) f(x_{ih}, \mu_i) + \delta_i \phi(z_{ih}' \theta_i) \quad (8)$$

With this it is possible to restate the equation for each i in (7) as:

$$w_{ih} = \Phi(z_{ih}' \theta_i) f(x_{ih}, \mu_i) + \delta_i \phi(z_{ih}' \theta_i) + e_{ih} \quad (9)$$

where $e_{ih} = w_{ih} - E(w_{ih} | \mathbf{x}_{ih}, \mathbf{z}_{ih})$, $\Phi(\cdot)$ and $\phi(\cdot)$ are the univariate standard normal cumulative distribution function and the probability density function, respectively.

Consequently, a two-step procedure using all observations becomes possible (Shonkwiler and Yen 1999):

Step 1: obtain ML probit estimates $\hat{\theta}_i$ of θ_i using the binary outcome $d_i = 1$ and $d_i = 0$ for each i ;¹⁴

Step 2: calculate $\Phi(z'_{ih}\hat{\theta}_i)$ and $\phi(z'_{ih}\hat{\theta}_i)$ and estimate μ_1 , μ_2 , and δ_1 , δ_2 in the system

$$w_{ik} = \Phi(z'_{ih}\theta_i)f(x_{ih}, \mu_i) + \delta\phi(z'_{ih}\theta) + \xi_{ih} \quad (10)$$

by ML or SUR procedure, where:

$$\xi_{ih} = e_{ih} - [\Phi(z'_{ih}\theta_i) - \Phi(z'_{ih}\hat{\theta}_i)]f(x_{ih}, \mu_i) + \delta[\phi(z'_{ih}\theta_i) - \phi(z'_{ih}\hat{\theta}_i)] \quad (11)$$

The implications of this procedure should be noted:

- i. The parameter estimates of the second step are consistent (Shonkwiler and Yen 1999).
- ii. The disturbance terms in equation (10) are heteroscedastic. We did not attempt steps to systematically deal with this problem in line with ways suggested by Shonkwiler and Yen (1999) and Drichoutis et al. (2008). We did use robust standard errors, however.

Endogeneity of total expenditure

If total expenditure is jointly determined with the budget shares of the specific commodities in the demand model, total expenditure becomes endogenous in the budget share equations. This may induce inconsistent parameter estimates if not taken care of (Blundell and Robin 1999). Blundell and Robin (1999) recommend and illustrate an augmented regression technique to solve the problem. Two steps are involved. First, total expenditure is regressed on a set of exogenous variables including those which may directly influence budget shares. In the second step, the residual from this reduced-form regression is added, as an explanatory variable in the budget share equations together with total expenditure. The OLS estimator of the parameter of the total expenditure variable in this augmented regression is identical to the Two-Stage Least Squares (2SLS) estimator (Blundell and Robin 1999). Moreover, Blundell and Robin (1999) argue that in the augmented regression, testing for the significance of the coefficient of the 'residual' obtained in the first regression serves as a test of the exogeneity of total expenditure in the share equations. The paper adopts this approach.

Spatial variation

As important as it is to learn the national consumption responses to changes in prices and income, it is no less imperative to recognize that the responsiveness of households may differ across space. One important distinction of this type is between urban and rural areas. Major differences in household characteristics, asset holdings, and expenditure or income levels (or both) between urban and rural households point toward potential differences in their reactions to changes in economic variables (such as price and income). Accordingly, three sets of elasticities are estimated: country-level (national) elasticities and separate elasticities for urban and rural households.

¹⁴ Shonkwiler and Yen (1999) acknowledge that "estimation of the separate probit models implies the restriction $E(v_{ih}, v_{kh}) = 0$ for $i \neq k$, without which the multivariate probit model would have to be estimated. With some loss in efficiency (relative to multivariate probit) these separate probit estimates are nevertheless consistent."

4.2. Estimation procedure

The first step involves a probit regression to estimate the probability that a household will consume the commodity under consideration. It expresses the dichotomous choice problem as:

$$d_{ih} = \theta_0 + \sum_j \theta_{ij} \ln p_j + \theta_x \ln x_h + \sum_k \theta_{1k} N_{kh} + \sum_l \theta_{2l} a_{jh} + \sum_r^{R-1} \theta_{3r} D_r + \sum_z^{Z-1} \theta_{4z} D_z + \mu_i \quad (12)$$

where $d_{ih}=1$ if the h^{th} household consumes the i^{th} livestock product (i.e., if $w_{ih} > 0$) and 0 if the household does not consume the item in question; N_k s are household demographic variables (household size, age of household head, age of household age squared, gender of household head, and years of schooling completed by the household head), a_j s are household assets (household ownership of its dwelling unit, number of rooms in the dwelling unit, main construction material of the dwelling's roof, number of dwellings/other buildings owned by the household, number of pack animals owned, number of gas or electric stoves owned, number of radios owned, number of plow animals owned, and number of bicycles owned), D_r s are regional dummies (10 regions), D_z s are zonal dummies (74 zones).

Equation (12) is estimated for all commodities. The corresponding $\Phi(z'_{ih} \hat{\theta}_i)$ and $\phi(z'_{ih} \hat{\theta}_i)$ are computed from these regressions and subsequently entered in the second-stage estimation as instruments that correct for zero expenditures.

Prior to executing the second-stage, total expenditure was regressed on its determinants:

$$\ln x_h = \alpha_0 + \sum_j \alpha_{ij} \ln p_j + \sum_k \alpha_{1k} N_{kh} + \sum_l \alpha_{2l} a_{jh} + \sum_r^{R-1} \alpha_{3r} D_r + \sum_z^{Z-1} \alpha_{4z} D_z + e_h \quad (13)$$

where, x_h is total household consumption expenditure on non-durables, N_k s are household demographic variables (household size, age of household head, gender of household head, and years of schooling completed by the household head), a_j s are household assets (household ownership of its dwelling unit, number of rooms in the dwelling unit, main construction material of the dwelling's roof, type of toilet for the household, number of dwellings/other buildings owned by the household, number of pack animals owned, number of gas or electric stoves owned, number of radios owned, number of plow animals owned, number of sheep and goats owned, number of equine animals (horses, mules, or donkeys) owned, and number of bicycles owned), D_r s are regional dummies (10 regions), D_z s are zonal dummies (74 zones), and e is a normally distributed residual. The residuals \hat{e}_h are computed and subsequently entered in the budget share equations estimated in the second-stage.

Therefore, the demand system when finally estimated takes the form:¹⁵

$$w_{ih} = \Phi(\hat{z}_{ih} \hat{\theta}_i) \left\{ \alpha_i + \sum_{j=1}^n \gamma_{ij} \ln p_j + \beta_i \ln \left[\frac{x_h}{a(p)} \right] + \frac{\lambda_i}{b(p)} \left[\ln \left(\frac{x_h}{a(p)} \right) \right]^2 + \tau_i \hat{e}_h \right\} + \delta_i \phi(z'_{ih} \hat{\theta}_i) + \xi_{ih} \quad (14)$$

where \hat{e}_h is the residual from the total expenditure regression and $\Phi(z'_{ih} \hat{\theta}_i)$ and $\phi(z'_{ih} \hat{\theta}_i)$ are obtained from the first-stage probit regressions.

¹⁵ See Appendix A.1 for price and expenditure elasticity of demand formulas under QUAIDS model.

The parameters of the QUAIDS model are estimated using Poi's STATA routine (Poi 2008). Adjustments are made to the original routine to include additional control variables in order to capture endogeneity and selectivity problems as appropriate.

The specific estimation technique we chose reflects a number of requirements in part created by the specific features of the QUAIDS. First, adding-up, homogeneity, and symmetry have to be accommodated. The adding-up condition is accommodated by dropping one of the budget share equations and imposing an adding-up identity (see above). Symmetry and homogeneity, on the other hand, have to be explicitly imposed during estimation. The way this is achieved reflects the nature of these restrictions. Symmetry is a cross-equation restriction, whereas homogeneity is essentially a within-equation restriction. The joint application of the two is a major feature of the QUAIDS. Second, QUAIDS is non-linear because of the quadratic total expenditure term and the two expressions in log prices ($a(\mathbf{p})$ and $b(\mathbf{p})$). To handle these features the model was estimated as a non-linear system of seemingly unrelated regression equations (or NLSURE).¹⁶ Parameter estimates are thus obtained by estimating the respective system of SURE, with symmetry and homogeneity simultaneously imposed. In each case the 'Other non-food' budget-share equation is dropped to accommodate adding-up. The remaining 20 equations were estimated by iterated, feasible, generalized non-linear least squares (IFGNLS) which is equivalent to the maximum likelihood (ML) (Poi 2008).^{17,18} Estimates of the excluded (or dropped) budget-share equation are then recovered by exploiting the adding-up and homogeneity restrictions.

4.3. Results

There have been attempts to estimate demand elasticities for livestock products in Ethiopia. These attempts were made within a general demand system that includes all consumption goods including livestock and animal products. The estimated elasticities display considerable variation. Kedir (2005) estimated price elasticity of demand for meat and milk to be 1.9 and 2.1, respectively. Likewise, Ulimwengu et al. (2009) found the income elasticity for meat in Ethiopia to be 0.85 nationally and 0.74 and 0.43 in urban and rural areas, respectively. Tafere, Taffesse, and Tamiru (2010) estimated the expenditure and price elasticity for animal products. Expenditure elasticities were 1.31, 1.23, and 1.22 nationally and in urban and rural areas, respectively. And estimated price elasticities were -0.94, -0.95 and -0.93 nationally and in urban and rural areas, respectively. To our knowledge, there is no study specifically focused on estimating demand elasticities for various livestock products in Ethiopia.

For the purpose of estimating demand elasticities, the eight livestock products above have been reduced to four: beef, mutton & goat meat, other meat & animal products, and dairy products. Nationally, these items account for 47 percent, 11 percent, 13 percent, and 30 percent of expenditure on livestock products, in that order. The budget shares in urban areas are 55 percent, 13 percent, 15 percent, and 17 percent; and in rural areas are 35 percent, 8 percent, 10 percent, and 47 percent, respectively (Table 4.1).

¹⁶ The NLSURE framework also accommodates the possibility that the disturbances contain unobserved factors common to budget shares.

¹⁷ All estimation procedures were implemented using Stata/MP 11.1 for Windows.

¹⁸ Following the recommendation in Deaton and Muellbauer (1980a) a_0 in $\ln a(\mathbf{p})$ is chosen to be just below the lowest value of $\ln x$ in the data. This ensures positive real total expenditure throughout.

Table 4.1—Statistics for SURE estimates of QUAIDS

	Commodity	Budget share	Proportion of non-zero observations	Probit pseudo R-Squared	R-Squared	Significance of $\hat{\epsilon}_h$ ($p > z $)
National	Beef	0.47	0.70	0.21	0.68	0.00
	Mutton & goat meat	0.11	0.23	0.14	0.30	0.02
	Other meat & animal products	0.13	0.47	0.18	0.30	0.16
	Dairy products	0.30	0.60	0.23	-	0.00
Urban	Beef	0.55	0.82	0.21	0.75	0.00
	Mutton & goat meat	0.13	0.27	0.25	0.46	0.08
	Other meat & animal products	0.15	0.59	0.18	0.33	0.44
	Dairy products	0.17	0.53	0.17	-	0.12
Rural	Beef	0.35	0.54	0.22	0.60	0.00
	Mutton & goat meat	0.08	0.17	0.14	0.17	0.63
	Other meat & animal products	0.10	0.30	0.16	0.28	0.00
	Dairy products	0.47	0.70	0.25	-	0.00

Source: Authors' calculation based on CSA's HICES 2004/05 data.

The proportion of non-zero expenditure among the four livestock products ranges between 70 percent in the case of beef to 23 percent in the case of mutton & goat meat at the national level. Zero-expenditure is more prevalent in rural than in urban areas. In urban areas, beef has the highest proportion of non-zero-expenditure, with 82 percent, and mutton & goat meat has the lowest, with 27 percent. On the other hand, in rural areas the corresponding figures stand at 70 percent for dairy products and 17 percent for mutton & goat meat. The existence of substantial zero-expenditure is the reason why we chose the model discussed in the previous section. Moreover, the probability density term turned out to be significant in all equations except for mutton & goat meat in the country level model and other meat & animal products in the rural level model. This further corroborates the importance of adjusting for zero-expenditure. There is also strong evidence in support of the adjustments we made to control endogeneity of total expenditure. In all but four of the estimated budget share equations, the coefficients of the predicted residual term from first stage regression are statistically significant (Table 4.1).

The overall performance of the estimated demand models is also satisfactory with three out of nine equations having R-square values higher than 0.5, and four equations having R-Square of 0.3 or more. There is, however, considerable difference in the R-square values between urban and rural models. The urban model appears to produce higher R-square values for all unrestricted equations than does the rural model. The R-square values of beef, mutton & goat meat, and other meat & animal products equations for the urban model are 0.75, 0.46, and 0.33 respectively, whereas their corresponding values in the rural model are 0.6, 0.17, and 0.28 (Table 4.1). These results are manifestations of the differences in consumption patterns noted in preceding sections, which are also reflected in the estimated demand elasticities below.

Table 4.2—Expenditure elasticities

	Total	Urban	Rural
Beef	0.939*** [0.0178]	0.896*** [0.0198]	0.985*** [0.0423]
Mutton & goat meat	0.671*** [0.1268]	0.304*** [0.1138]	0.917*** [0.1361]
Other meat & animal products	0.538*** [0.0455]	0.519*** [0.0551]	1.045*** [0.0757]
Dairy products	0.420*** [0.0148]	0.389*** [0.0136]	0.479*** [0.0061]

Source: Authors' calculation based on CSA's HICES 2004/05 data.
Standard Errors in Brackets; ***, **, * are significance level at 1%, 5% & 10%

Table 4.2 shows that in Ethiopia, households make significant adjustments to their consumption of livestock products in response to changes in their income/expenditure. All livestock products have a positive and significant expenditure elasticity, suggesting that livestock products are normal goods, as one would expect in the Ethiopian context, where income and consumption levels are very low. Moreover, expenditure elasticities display substantive variation across commodities. At country level, beef and dairy products have the highest and lowest expenditure responses among livestock products with elasticity coefficients of 0.94 and 0.42, respectively. In other words, the amount of beef households consume changes more than twice as much in response to changes in their income or spending as it does for dairy products.

The general pattern of the country level estimates is also reflected in urban and rural areas, barring small variations. The mutton & goat meat group has the smallest expenditure elasticity in urban areas, the other meat & animal products group has the highest expenditure response in rural areas. Besides, it appears that expenditure elasticities are higher in rural than in urban areas. The gap between the two sets of elasticities (urban and rural) is highest for the mutton & goat meat group and for the other meat & animal products group.

Despite the considerably higher budget share of dairy products in rural areas, the corresponding expenditure elasticity appears to be higher than that in urban area. This could suggest the constraint imposed on the consumption choices of rural households by lack of markets. Due to the nature of the product, and the lack of required infrastructure for its marketing, the possibility of shifting consumption away from dairy products to other livestock products is very limited.¹⁹

¹⁹ Because expenditure, not income, is used to measure households' responses and because 76 percent of rural households' consumption is own production, the consumption responses could well be interpreted as constituting, mainly, own produce.

Table 4.3—Compensated price elasticities

		Beef	Mutton & goat meat	Other meat & animal products	Dairy products
Beef	Total	-0.733*** [0.0233]	0.391*** [0.0193]	0.083*** [0.0073]	0.259*** [0.0105]
	Urban	-0.665*** [0.0235]	0.382*** [0.0176]	0.136*** [0.0071]	0.147*** [0.0087]
	Rural	-0.793*** [0.0786]	0.378*** [0.0577]	0.031 [0.0266]	0.386*** [0.0331]
Mutton & goat meat	Total	1.554*** [0.1003]	-1.465*** [0.1144]	0.069 [0.0426]	-0.158* [0.0846]
	Urban	1.889*** [0.1103]	-1.882*** [0.1144]	0.184*** [0.0378]	-0.192*** [0.0613]
	Rural	2.822*** [0.6603]	-2.008*** [0.4221]	-0.292 [0.2907]	-0.523** [0.2565]
Other meat & animal products	Total	0.403*** [0.0285]	0.395*** [0.0337]	-0.996*** [0.0229]	0.194*** [0.0336]
	Urban	0.71*** [0.0476]	0.181*** [0.0386]	-0.988*** [0.0228]	0.071** [0.0289]
	Rural	-0.056 [0.233]	0.289 [0.1926]	-1.039*** [0.0698]	0.806*** [0.0989]
Dairy products	Total	0.405*** [0.0244]	-0.249*** [0.0344]	0.28*** [0.0152]	-0.669*** [0.0344]
	Urban	0.06 [0.098]	0.062 [0.0868]	0.304*** [0.0289]	-0.523** [0.2613]
	Rural	0.134 [0.1256]	-0.009 [0.0618]	0.247*** [0.0577]	-0.151** [0.0746]

Source: Authors' calculation based on CSA's HICES 2004/05 data.

Note: Standard Errors in Brackets; ***, **, * are significance level at 1%, 5% & 10%

Like expenditure elasticities, all price responses have theoretically expected signs—all own-price effects are negative and statistically significant. There is also substantive variation in the magnitude of the responses across livestock products and location (urban or rural). At the national level, the mutton & goat meat group has higher own-price elasticity, followed by the other meat & animal products group and then by beef. Likewise, these items have the largest own-price responses in urban and rural areas. However, it appears that households in rural areas have higher own-price elasticities for beef, mutton & goat meat, and for other meat & animal products and lower own-price responses for dairy products compared with their urban counterparts. These results are consistent with the urban versus rural budget shares of livestock products shown in Table 4.1.

There also appears to be a strong substitution relationship among most of the livestock products. The beef, mutton & goat meat group, and the other meat & animal group products have positive cross-price elasticities at the national as well as at the urban or rural level, suggesting they are substitutes for each other. The degree of substitution is particularly strong in rural areas and between beef and mutton & goat meat. Dairy products, on the other hand, appear to be substitutes for beef and other meat & animal products, but complementary goods with mutton & goat meat.

5. Conclusions and policy implications

Ethiopia is known to have one of the largest livestock populations in the world. Yet the overall contribution to Ethiopian households' daily consumption is very limited. At the national level, the average per capita annual consumption of meat and dairy products is just 5.3 kg and 16.7 kg, respectively. The consumption of livestock products, however, varies considerably between urban and rural areas. Urban areas have higher consumption of meat, whereas rural areas have higher consumption of dairy products. Likewise, the contribution of livestock products to the daily per capita calorie intake is low and stands at 2.9 percent nationally, 4.8 percent in urban areas, and 2.6 percent in rural areas. Moreover, the quantity of livestock products and the related calorie intake appear to rise with income. The richest 20 percent of households consume about three-and-a-half times more meat and twice as many dairy products as their poorest counterparts. Similarly, an average person in the richest quintile obtains three times more calories from livestock products than his counterpart in the first quintile. The reason for the urban-rural difference in the consumption of livestock products could be due to: limited market access for rural people; high dependence of rural households on subsistence agriculture (that is 76% get their food from their own production, whereas for urban households this is just 7%); a lack of marketing infrastructure—such as cold chains—for perishable products; low level of urbanization; the nature of the product itself constrains rural households (that is, it is produced in bulk—it is largely indivisible); and a lack of rural retail markets for such products.

There is considerable expenditure and price response for livestock products in Ethiopia. At the national level, expenditure elasticities range between 0.94 for beef, and 0.42 for dairy products. It also appears that rural areas have higher expenditure elasticities than urban areas. Similarly, own-price responses exhibit a wide variation across commodities ranging between -1.47 in the case of mutton & goat meat and -0.67 in the case of dairy products. Also, strong substitution relationships have been found among most livestock products, the only exception being dairy products. Furthermore, price responses are higher in rural areas than in urban areas. These results appear to suggest there is an opportunity to take advantage of the country's huge livestock resources and boost the consumption of nutritious food (protein, micronutrients, zinc, vitamin A, and the like) through policies aiming at raising household income. Direct fiscal interventions through taxes and subsidies are likely to have significant effects on household consumption of livestock products. For instance, introduction of programs (like school milk programs), making livestock products available at subsidized prices, and/or reducing the value added tax (VAT) rate for producers who serve the poor segment of consumers might play a role in enhancing consumption of livestock products.

The composition of livestock product consumption and estimated expenditure and price elasticities seem to indicate the existence of constraints imposed upon the consumption choices of rural households. For example, in rural areas the possibility of shifting consumption away from dairy products to other livestock products is very limited. Many households consume the dairy products they produce due to the perishable nature of the product and the lack of required infrastructure for its marketing. Thus, improving the country's livestock products' marketing infrastructure could improve opportunities for substitution among livestock products in response to preferences and market signals through increased access for food.

Appendix

Appendix A.1—Derivation of elasticity of demand for QUAIDS

Recall that the i^{th} budget share equation for the QUAIDS is given by:

$$w_{ih} = \alpha_i + \sum_{j=1}^n \gamma_{ij} \ln p_j + \beta_i \ln \left[\frac{x_h}{a(p)} \right] + \frac{\lambda_i}{b(p)} \left\{ \ln \left[\frac{x_h}{a(p)} \right] \right\}^2$$

where:

$$\ln a(p) = \alpha_0 + \sum_{k=1}^n \alpha_k \ln p_k + \frac{1}{2} \sum_{k=1}^n \sum_{j=1}^n \gamma_{kj} \ln p_k \ln p_j$$

$$b(p) = \prod_{k=1}^n p_k^{\beta_k}$$

and p and x stand for prices and total expenditure, respectively.

Since $w_i = \frac{p_i q_i}{m}$, the uncompensated own-price and the cross-price elasticities respectively are:

$$\varepsilon_{i,p} = \frac{1}{w_i} \left\{ \gamma_{ii} - \left\langle \left(\alpha_i + \sum_{k=1}^n \gamma_{kj} \ln p_k \right) \left[\beta_i + \frac{2\lambda_i}{b(p)} (\ln x - \ln a(p)) \right] + \frac{\beta_i}{b(p)} \lambda_i [\ln x - \ln a(p)]^2 \right\rangle \right\} - 1$$

$$\varepsilon_{i,p_j} = \frac{1}{w_i} \frac{p_i}{p_j} \left\{ \gamma_{ii} - \left\langle \left(\alpha_i + \sum_{k=1}^n \gamma_{kj} \ln p_k \right) \left[\beta_i + \frac{2\lambda_i}{b(p)} (\ln x - \ln a(p)) \right] + \frac{\beta_i}{b(p)} \lambda_i [\ln x - \ln a(p)]^2 \right\rangle \right\}$$

Corresponding compensated price elasticities are:

$$\tilde{\varepsilon}_{i,p_i} = \varepsilon_{i,p_i} + \varepsilon_{i,x} W_i \quad \text{and} \quad \tilde{\varepsilon}_{i,p_j} = \varepsilon_{i,p_j} + \varepsilon_{i,x} W_j$$

Similarly, the expenditure elasticity of demand for commodity i (q_i) is given by:

$$\varepsilon_{i,x} = \frac{x}{q_i} \frac{\partial q_i}{\partial x} = \frac{1}{w_i} \left\{ \beta_i + \frac{2\lambda_i}{b(p)} \ln x - \ln a(p) \right\} + 1$$

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