Impacts of policy reforms on the livestock industry in Kenya: The case of the dairy sector

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Abstract

This article analyses the impact of liberalization on the dairy industry in Kenya. Much debate rages over the effects of this policy. This debate is, however, not well informed; it lacks recent studies to show events and processes taking place from the farmer to the consumer, that inform whether the policy changes have had the intended effects.

The results indicate that milk production and dairy herd productivity have reduced or remained low, on average. Food security with respect to milk has reduced from a position of sufficiency to that of insufficiency. Prices have improved slightly because of increased competition, leading to a stabilization of milk supply from year to year. Dairy capital stock in the form of processing plants has increased but is underutilized because of reduced milk deliveries as a result of an upsurge of small traders that offer more competitive prices. The negative impacts of liberalization policies are mainly attributed to the unsynchronized manner in which they were introduced.

Keywords: Dairy sector liberalization, food security, herd productivity, milk value chain

Introduction

In many countries in sub-Saharan Africa, including Kenya, there has been increasing desire to institute policy and institutional reforms to raise sectoral productivity and income growth. These concerns include the need to encourage private sector participation in providing farm inputs, financial and marketing services, and technical support (Nyariki and Thirtle 2000). The reforms in the dairy sector in Kenya, for example, were aimed at meeting the dairy production requirements through the use of improved technologies, increased input use and creation of an enabling economic and institutional environment, with favourable dairy development policies. In addition, the reforms were expected to improve the availability of and access to inputs and products in the dairy sector. They were also meant to allow the forces of supply and demand to guide the production, distribution and marketing of various goods and services and therefore promote efficiency and economic growth (World Bank 1998). Overall, these reforms have aimed at improving the macroeconomic environment, the incentives structure and the regulatory framework within which economic activity takes place

(Kimuyu and Moyi 1998). Some of the reforms made in the livestock sector that continue to influence the dairy sector include the liberalization and decontrol of animal feeds (1989), liberalization of milk prices and marketing (1992), and privatization of veterinary clinical, and tick control and artificial insemination (AI) services (1991) (ROK 1997a,b).

This paper assesses the effects of the outlined reforms on the dairy industry in Kenya with respect to herd productivity, food security, milk marketing structure and performance, and supply and demand situations.

Material and methods

Data collection and analysis

Data were collected through a review of both published and unpublished material and reports on the dairy sector. Herd productivity and food security with respect to milk were computed. Productivity is a general term frequently associated with ratios of output to input. Changes in productivity ratios at the farm level are usually thought of as indicators of technical change, and these figures have considerable significance in the policy-making arena. To measure productivity, inputs and outputs must be defined and determined. A simple approach to measuring herd productivity is by regarding the size of the dairy herd in milk each year as input and the quantity of milk produced by the herd as output. The milk marketing structure was analysed by reviewing literature on the main intermediaries in the chain that link the dairy producers to local and urban consumers and market centres. The performance of market intermediaries was investigated by using profit margins. The supply and demand in the milk market were estimated by considering price elasticity of supply and price and income elasticity of demand. Calculated also were market projections. These give an impression of the future expansion (or contraction) of the market for the country, and surpluses or deficits that are likely to occur.

Estimating the elasticity of milk supply

Both price and non-price elasticity estimates are important in understanding the relative importance of the factors affecting both individual commodity and aggregate agricultural supply behaviour. In the present study, price elasticity of supply was calculated by estimating a linear model, through OLS regression, using a 1980–2004 data set. A linear function was chosen to estimate elasticity because of the use of a dummy variable representing weather, which is an important factor influencing production and, therefore, supply. The estimated equation, which includes another important variable—the size of the dairy herd—affecting supply, can be written as:

(1)

Where:

Q_t is the quantity of milk produced and available for human consumption at time t;
b_0 is a constant;
P_{t-1} is the price of milk offered to producers in real terms, lagged once because price response of supply is not expected to be instantaneous;
D_t is the number of dairy animals at time t;
W_t is a dummy variable for weather at time t (1 standing for a wet year and 0 for a dry year);
b_1–b_3 are coefficients of the variables; and
m_t is a random error term. t stands for years.

The coefficients derived from the linear function (equation 1) were used to derive price elasticity of supply at the mean values as follows:

(2)

Where:
E_p is the price elasticity at the mean values of price and quantity;
P is the mean producer price;
Q is the mean quantity of fresh milk; and
b_1 is the fresh milk price coefficient in the linear function.

Estimating the elasticity of milk demand

A semi-logarithmic (semi-log) function, estimated using OLS, was hypothesized to explain the relationship between the consumption of fresh milk and the variables described. A number of studies of demand have used a similar functional form (Jones 1982; Burney and Akmal 1991; Mdoe and Wiggins 1996). The estimated equation can be written as:

(3)

Where:
Q_t is the quantity of milk consumed per capita at time t;
b_0 is a constant;
P_t is the average retail price of milk in real terms at time t;
Y_t is income per capita in real terms at time t;
H_t is human population at time t;
b_1–b_3 are coefficients of the variables; and
e_t is a random error term. t stands for years.

The coefficients derived from the semi-log function are used to calculate price and income elasticities of demand at mean values as follows:

; (4)

(5)

Where:

E_p is the price elasticity at mean price and quantity;
E_y is the income elasticity at the mean price and quantity;
Q is the mean quantity of fresh milk;
b_1 is the fresh milk price coefficient and
b_2 the fresh milk income coefficient in the semi-log function.

Computing supply and demand projections

The price elasticity of milk supply and herd productivity, and a base year milk supply level are appropriate in calculating milk supply projections. These are the main factors that work together to influence supply. The equation used to calculate milk supply projections can be written as follows:

(6)

Where:

Q_n is the projected supply of milk at the relevant point in time, *n;*
Q_0 is the base year supply;
D_r is the average annual productivity of dairy animals;
P_r is the real rate of growth of milk prices; and
E_p is price elasticity of supply.

On the other hand, the future expansion of the dairy market in Kenya has been explored using the demand projection model based on the growth of income and population, as shown in equation 7.

(7)

Where:

Q_n is milk consumption in year *n*,
Q_0 is milk consumption in the base year,
H_r is the population growth rate per annum,
Y_r is the rate of growth in per capita income per annum,
E_y is income elasticity of demand for milk, and
n is the number of years.

Results and discussion

Herd productivity

Between 1980 and when the milk market was liberalized in 1992, milk production increased more than two-fold, from about 1,000 million litres to close to 2,400 million litres. Subsequently, production stagnated until 1997 before it started to drop up to the year 2001, after which it started a consistent upward trend, as shown in Table 1.

Table 1. Milk production and dairy herd productivity 1992–2004

Year	Total milk production, mil. lit./year	Milk production from total dairy cattle, mil. lit./year*	Number of dairy cattle in milk, mil. head**	Productivity (yield), lit./head/year	Year-on-year productivity growth
1992	2365†	1419	1.15	1233.9	—
1993	2360	1416	1.17	1210.3	–0.02
1994	2368	1420	1.12	1268.4	0.05
1995	2448	1469	1.15	1277.2	0.01
1996	2396†	1438	1.12	1283.6	0.01
1997	2415	1449	1.12	1293.8	0.01
1998	2362	1417	1.12	1265.4	–0.02
1999	2342	1405	1.09	1289.2	0.02
2000	2224	1334	1.05	1270.9	0.01
2001	2150†	1290	1.05	1228.6	–0.03
2002	2200	1320	1.03	1281.6	0.04
2003	2340	1404	1.12	1253.6	–0.02
2004	2450	1470	1.16	1267.2	0.01
Average	2340	1404	1.11	1264.9	0.006

**Using 60% of total milk contribution by dairy cattle (ROK 2001); **Considering 50% of total numbers as mature cattle, 70% of which are milked; †Drought year*
Source of data: ROK (2001) Draft Report; Ministry of Agriculture Annual Reports (1993-2005).

Table 1 also gives productivity (yield) values. The table shows that between the year of liberalization (1992) and 2004, the average annual milk production was 2,340 million litres, a figure slightly less than that of the initial years of liberalization. This indicates that there has been no gain in the levels of milk produced, and instead a decline has been experienced. There has been no gain either in the size of the dairy herd (implied by the number of dairy cattle in milk) or productivity. It should be noted that in 2001 milk production reached its lowest point since liberalization followed by a crescendo which seems to taper off, indicating that it may be getting to a crest. However, the year 2001 experienced a drought, suggesting that the low milk production was influenced by poor weather, leading to a slow recovery of productivity afterwards. But, observing the general trend, it can also be conjectured that the sudden liberalization of the milk market initially had a harmful impact on production. The market 'shock' has now been absorbed, however; milk prices have started to improve.

The data show stagnating productivity, at an annual average of around 1,265 litres per dairy cow a year, translating into 0.6% year-on-year productivity growth. However, one positive aspect that

may be associated with liberalization can be noticed; that there have been no violent swings in milk supply (production) between rainy and drought years. This may be attributed to stabilized prices in both good and bad years which support increased use of preserved or conserved feed during drought.

Milk consumption and food security

Milk makes a contribution to food security; food security being access by all people at all times to adequate food for an active life (World Bank 1991; Nyariki et al 2002). At the time of liberalization, milk supply in Kenya was estimated at 45 litres per capita. The recommended minimum per capita consumption for sustenance of human physiological needs from nutrients derived from milk is 90 litres (Lelei 1993). Calculations for the 1992–2004 milk supply (Table 2) show that the country has moved from a position of per capita self-sufficiency (90.1 litres) to that of insufficiency (67.8), indicating a worsening food security situation with respect to milk supply. So from the point of view of milk availability and access, most Kenyans are food insecure.

Table 2. Per capita milk availability from domestic supplies 1992–2004

Year	Total milk supply, million litres	Milk for human, consumption, million litres*	Total human population, millions	Per capita milk availability, litres
1992	2365	2199	24.4	90.1
1993	2360	2195	25.0	87.8
1994	2368	2202	25.6	86.0
1995	2448	2277	26.2	86.9
1996	2396	2228	26.8	83.1
1997	2415	2246	27.4	82.0
1998	2362	2197	28.0	78.5
1999	2342	2178	28.6	76.2
2000	2224	2068	30.2	68.5
2001	2150	2000	30.9	64.7
2002	2200	2046	31.8	64.3
2003	2340	2176	32.7	66.5
2004	2450	2279	33.6	67.8

**Assumes 7% calf consumption (ROK 2001)*
Source of data: Ministry of Agriculture Annual Reports (1993-2005); Economic Surveys (1993-2005); Statistical Abstracts (1993-2005).

The decrease in per capita milk availability is due to human population growth and stagnating milk production. The situation has worsened because the liberalization policy has not brought about increased herd productivity. Whatever, it may be difficult to link the decline in milk-related food security to the advent of liberalization; but what the figures in Table 2 portend is that liberalization has not helped reverse the situation.

The structure of milk marketing

Table 3 indicates the quantities of milk sold through the formal and informal markets and on-farm consumption from 1992 to 2004.

Table 3. Milk entering the formal and informal markets 1992–2004

Year	Recorded deliveries to formal markets, mil. lit.[a]	Home consumption, mil. lit.	Calf consumption, mil. lit.	Milk entering informal markets, mil. lit.	Total milk sold, mil. lit	% milk entering formal markets[b]	% milk entering informal markets[b]
1992	361.7	875.1	65.9	1128.2	1490	24.3	75.7
1993	364.6	873.2	65.7	1122.2	1487	24.4	75.6
1994	258.0	876.2	66.0	1233.8	1493	17.3	82.7
1995	350.0	905.8	68.2	1192.2	1542	22.7	77.3
1996	257.0	886.5	66.7	1252.5	1509	17.0	83.0
1997	197.0	893.6	67.3	1324.4	1521	13.0	87.0
1998	126.0	873.9	65.8	1362.1	1488	8.4	91.5
1999	180.0	866.5	65.2	1295.5	1475	12.2	87.8
2000	137.0	822.8	62.0	1264.2	1401	9.8	90.2
2001	148.0	795.5	59.9	1207.0	1355	10.9	89.1
2002	178.0	814.0	61.3	1208.0	1386	12.8	87.2
2003	203.0	865.8	65.2	1271.0	1474	13.8	86.2
2004	274.0	906.5	68.2	1270.0	1544	17.7	82.3

[a]Data revised since 1995 to include KCC and other processors—till 1995 quantities delivered to other processors were negligible; [b]% of total marketed milk
Source of data: Statistical Abstracts (1993-2005).

Intake by the formal sector dwindled from the year of liberalization to 2000, and then started to improve slowly. The opposite can be said about intake by the informal sector. The volume of milk going through the Kenya Cooperative Creameries (KCC) and private processors declined rapidly after the market was liberalized, mainly because of drastic reduction in deliveries to KCC (Chesire 2001), precipitated by poor prices offered to farmers and because of a number of new milk outlets that sprung up. However, the volume has now begun to increase especially because of the revitalization of KCC in 2003. The decline caused the total milk flow to KCC and private processors to go down from 15.3% to 6.2% of the total production between 1992 and 2000, translating into a decline of 24.3% to 9.8% of the marketed milk. In contrast, milk flowing through the informal markets grew fairly steadily from about 76% to 90% during the same period (Table 3).

Figure 1 shows the pattern of milk marketing channels and the roles played by the various intermediaries.

Figure 1. Milk marketing channels in Kenya

Direct sales from producers to consumers constitute about 55% of marketed milk (TechnoServe 2001). These sales usually take place at the farm gate or at local markets in the milk producing areas. This marketing channel is common in areas of low production relative to the number of consumers. Thus, the opportunity to sell directly to consumers in the milk producing areas declines as the number of farmers or households keeping dairy cattle increases.

Raw and sour milk, mainly from smallholders owning zebu cattle, pass directly from producers to consumers. This mode of sale has increased since liberalization. Most of the small dairy producers dispose of their milk through intermediaries (small traders, cooperatives, processors, wholesalers, and retailers) for distribution to ultimate

consumers in markets outside the dairy producing areas (e.g., urban areas). A large volume of milk (about 63% of the total production) is marketed through the various channels (ROK 2004a). Milk outlets for dairy cooperatives include milk processors, hotels, retail shops, milk kiosks/bars, and direct sales to ultimate consumers in urban markets. Small milk vendors also sell their milk to hotels, retail kiosks, and individual consumers in urban centres.

The milk going through informal channels (about 82%) is sold as raw or non-processed milk. These channels include direct producer sales to consumers, to milk vendors (hawkers), to self-help groups, to dairy cooperative societies, and to processors. Apart from the KCC and other relatively large processors that produce pasteurized milk, butter, ghee, cheese, yoghurt and *mala*, most of the milk passing through small traders and dairy cooperatives is disposed of as raw milk. Milk changes hands from producers to market intermediaries or consumers at producers' homesteads, rural markets, collection points in dairy producing areas, KCC and private processors' milk collection and cooling centres, and processors' plants.

The performance of milk market intermediaries

Market performance is usually based on the analysis of price margins and operating expenses (Mugarura 2001). Table 4 presents average prices received by producers and paid by consumers through three main intermediaries: private processors, cooperatives and small traders (or hawkers). These are averages of dry and flush wet seasons since prices vary seasonally.

Table 4. Milk marketing margins by market intermediaries (average 2004 prices in Kshs/litre)

Description	Private processors	Cooperatives and self-help groups	Small traders (hawkers)
Costs			
Labour[a]	1.80	0.50	0.50
Transport to market[b]	6.25	5.60	4.00
Processing and packaging[c]	3.75	0.00	0.00
Administration[c]	3.75	3.00	0.00
Total cost (*a*)	15.6	9.10	4.50
Mean buying price (*b*)	25.0	22.5	26.5
Mean selling price (*c*)	48.0	34.0	35.0
Margin ($d = c - b$)	23.0	11.5	8.50
Net margin ($e = d - a$)	7.45	2.40	4.00
Net margin/working capital, % ($f = e/(a+b)$)	24.4	7.6	12.9
Farmer proportion of final price ($g = b/c$)	52.1	66.2	75.7

[a]Only the cost of hired labour is included for small traders; [b]Assumed to be 25% of buying price of milk for processors and cooperatives—mean buying and selling prices not weighted for volumes; [c]Assumed to be 15% of buying price of milk for processors.
Source of data: Ministry of Agriculture Annual Reports (1993-2005); Economic Surveys (1993-2005); Author's Field Surveys.

The table shows that (in 2004) the highest price was received by producers who sold their milk through hawkers, whilst the lowest price was received by producers who sold milk to cooperatives and self-help groups. Between private processors and cooperatives, there was a 10% difference in prices; between the processors and the hawkers a 6% difference; and between the cooperatives and the hawkers 15%. These differences were much higher for prices to consumers, except those between cooperatives and hawkers. The table indicates that consumers who purchased processed (packaged) milk from private processors at their selling points paid significantly more (by 37–41%) than those who purchased milk directly from dairy cooperatives and small milk traders. Prices charged by the small traders and the cooperatives differed only slightly (by 3%), suggesting a fairly competitive retail market in raw milk at this level.

Table 4 also summarizes the marketing costs incurred by milk market intermediaries in 2004 and their marketing (profit) margins. Private processors incurred the highest costs, owing to the cost of transporting, refrigeration, processing (pasteurization) and packaging. Most of the costs for the intermediaries arose in transport. Small traders saved on this cost. The hawkers were quite effective; they had low costs, returned most (76%) of the final price to the producer, and enjoyed returns to their working capital of 13%, although much of this could be regarded as a return to their labour. (Note that the labour costs for hawkers are estimates of farm labour hire in rural areas.) The cooperatives worked with almost similar costs to those for hawkers, with low overheads, accepted lower net margin, had the lowest returns to working capital, and returned to their members a fairly high final price (66%). But it is doubtful if a net margin of about 8% for the cooperatives can allow them to accumulate and invest. Private processors had higher costs and only gave producers just half (52%) of the final price, yet they had high margins with 24% return on working capital. However, if the depreciation of processing plants and high wear and tear of transport vehicles due to bad roads were to be considered, the apparently high return to processors would disappear. It may be useful to point out that even though private processors passed on a markedly smaller proportion of the final price to producers compared to the other marketers, their 52% is similar to that obtained by dairy producers in industrialised countries like Switzerland selling to processors (Smallfood 2000)—where vast quantities of milk are pasteurized and packed.

Price elasticity of milk supply

The estimated coefficients of equation 1 are shown in Table 5.

Table 5. The supply response of milk, estimated coefficients for a linear model

Variable	Coefficient	*t*-value
Constant	–66.24	–1.18
Milk buy price, lagged once (*P*)	81.54	2.43[a]
Dairy animal population (*D*)	0.48	3.67[a]
Weather (*W*)	55.87	1.28
Adjusted R^2	0.82	
$F_{3,20}$	36.0[a]	
Number of observations	24	

[a]*Significant at 5%*

Price and the dairy animal population variables show significance at 5%. Even though the time series sample points are few, the estimates can be used for prediction purposes (cf. Gujarati 1995; Pindyck and Rubinfeld 1998).

The mean price and quantity of milk is Kshs 2.85 (1980 prices) and 1071.18 litres per year respectively. Using equation 2, the price elasticity of supply is 81.54(2.85/1071.18), which is 0.17. This compares well with the elasticities reported by Nyangito (1998) of between 0.06 and 0.19. These are less than unity values, indicating that price response of milk supply is inelastic, and the restructuring of the milk marketing has not changed this situation.

Price and income elasticities of milk demand

Table 6 presents the results of the regression analysis, based on equation 3. The signs on the coefficients of the explanatory variables are as expected but demand shows low response to price, while the response to income and human population is high.

Table 6. The demand for fresh milk, estimated coefficients for a semi-log model

Variable	Coefficient	*t*-value
Constant	–76.29	–2.35[a]
Milk sale price (*P*)	–6.15	–1.59
Per capita income (*Y*)	23.45	2.62[a]
Human population (*H*)	42.48	2.30[a]
Adjusted R^2	0.51	
$F_{3,21}$	7.68[a]	
Number of observations	25	

[a]*Significant at 5%*

Using equations 4 and 5, price elasticity of demand is –6.15/56.12, which is –0.11; while income elasticity of demand is 23.45/56.12, which is 0.42. Earlier studies have reported a price elasticity and an income elasticity of milk demand for Kenya of 0.1

and 0.8, respectively (see, for example, Omore et al 1999). The findings of the present and earlier studies imply that there exists an inelastic demand (less than unity) with respect to both price and income in Kenya, probably because milk is a necessity and there are few substitutes for it. These findings show that variations in prices have less influence on consumption than income.

Milk supply and demand projections

The milk supply projections are calculated using equation 6 and a price elasticity of supply of 0.17, an average annual dairy animal productivity of 0.015, a real rate of growth of milk prices of 0.02 and a base year milk supply (2005 production) estimated at 2,500 million litres. In the case of demand projections, income and population have been estimated to grow at an average rate of 3% a year for the 1980s and most of the 1990s. However, the growth rate of the population has slowed down due to HIV/AIDS related deaths and now stands at about 2.56% per annum (ROK 2004b). It is assumed that these rates will be maintained for the next 20 years. The projected consumption levels are calculated using equation (7) and the year 2005 estimated quantity of milk demanded of 2305 million litres (ROK 2004a) as base.

Table 7 provides both supply and demand projections. It shows that supply will grow by 2.2% per year over a period of 20 years.

Table 7. Projected milk supply and demand 2005–2025

Description	2005	2010	2015	2020	2025
Milk supply projections, mil. lit.	2500	2739	3002	3289	3604
Milk demand projections, mil. lit.	2305	2785	3364	4064	4909

These figures are roughly supported by those estimated by the Ministry of Agriculture (ROK 2001), and depict fairly fast growth, considering the low animal productivity because of poor AI services after privatization, collapse of the infrastructure, poor performance of the major public milk outlet (KCC) after liberalization, and the low price elasticity of supply.

The demand projections depict a demand growth of 5.6% per year over a period of 20 years, and are almost similar to those estimated by the Ministry of Agriculture. As shown in the table, the demand for milk is likely to outstrip supply in a short period of 5 years. So milk market liberalization has not helped to close the gap between supply and demand, and is unlikely to do so in future. But instead milk deficits are likely to increase, unless measures are taken to improve dairy animal productivity, increase price incentives and improve infrastructure and other factors that play a major role in milk production and marketing.

Conclusions

- The process of liberalization of the dairy industry in Kenya has had both positive and negative effects. The positive effects include:

    - Unrestricted choice of markets by the farmers, so farmers can sell to those offering the best prices.
    - Creation of more market outlets, thus improving distribution and availability of milk products, a major source of proteins, to consumers in many parts of the country.
    - Increased capital stock in the dairy sector through increased processing capacity.
    - Creation of conditions for fair competition in marketing through increased market participants, thus resulting in improved income distribution. Increased participation means creating employment and livelihoods for a wide citizenry, thereby contributing to the alleviation of poverty.
    - Increased possibilities for prompt and better payments to farmers for their milk, which should act as an incentive for increased production, other things being equal.
    - Encouraging conditions for improved quality of products caused by increased numbers of processors competing in the market.
- The negative aspects of liberalization can be summarized as follows
    - Liberalization was done piecemeal within the dairy industry and across related sub-sectors. Reforms were, therefore, not adequately synchronized across sub-sectors and thus some sub-sectors have not kept pace with the changes.
    - Liberalization is seen as one of the reasons why KCC has faced operational difficulties. This coupled with the inadequate capacity of the private outlets and cooperatives to handle or purchase all the milk during flush periods have meant that farmers cannot deliver all their milk to the market.
    - The increase in milk hawking, while could be seen as a positive aspect from the point of view of job creation, has increased the sale of raw milk and the chances of contamination, thereby exposing consumers to health risks

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This article analyses the impact of liberalization on the dairy industry in Kenya. Much debate rages over the effects of this policy. This debate is, however, not well informed; it lacks recent studies to show events and processes taking place from the farmer to the consumer, that inform whether the policy changes have had the intended effects.

The results indicate that milk production and dairy herd productivity have reduced or remained low, on average. Food security with respect to milk has reduced from a position of sufficiency to that of insufficiency. Prices have improved slightly because of increased competition, leading to a stabilization of milk supply from year to year. Dairy capital stock in the form of processing plants has increased but is underutilized because of reduced milk deliveries as a result of an upsurge of small traders that offer more competitive prices. The negative impacts of liberalization policies are mainly attributed to the unsynchronized manner in which they were introduced.

Keywords: Dairy sector liberalization, food security, herd productivity, milk value chain

Introduction

In many countries in sub-Saharan Africa, including Kenya, there has been increasing desire to institute policy and institutional reforms to raise sectoral productivity and income growth. These concerns include the need to encourage private sector participation in providing farm inputs, financial and marketing services, and technical support (Nyariki and Thirtle 2000). The reforms in the dairy sector in Kenya, for example, were aimed at meeting the dairy production requirements through the use of improved technologies, increased input use and creation of an enabling economic and institutional environment, with favourable dairy development policies. In addition, the reforms were expected to improve the availability of and access to inputs and products in the dairy sector. They were also meant to allow the forces of supply and demand to guide the production, distribution and marketing of various goods and services and therefore promote efficiency and economic growth (World Bank 1998). Overall, these

reforms have aimed at improving the macroeconomic environment, the incentives structure and the regulatory framework within which economic activity takes place (Kimuyu and Moyi 1998). Some of the reforms made in the livestock sector that continue to influence the dairy sector include the liberalization and decontrol of animal feeds (1989), liberalization of milk prices and marketing (1992), and privatization of veterinary clinical, and tick control and artificial insemination (AI) services (1991) (ROK 1997a,b).

This paper assesses the effects of the outlined reforms on the dairy industry in Kenya with respect to herd productivity, food security, milk marketing structure and performance, and supply and demand situations.

Material and methods

Data collection and analysis

Data were collected through a review of both published and unpublished material and reports on the dairy sector. Herd productivity and food security with respect to milk were computed. Productivity is a general term frequently associated with ratios of output to input. Changes in productivity ratios at the farm level are usually thought of as indicators of technical change, and these figures have considerable significance in the policy-making arena. To measure productivity, inputs and outputs must be defined and determined. A simple approach to measuring herd productivity is by regarding the size of the dairy herd in milk each year as input and the quantity of milk produced by the herd as output. The milk marketing structure was analysed by reviewing literature on the main intermediaries in the chain that link the dairy producers to local and urban consumers and market centres. The performance of market intermediaries was investigated by using profit margins. The supply and demand in the milk market were estimated by considering price elasticity of supply and price and income elasticity of demand. Calculated also were market projections. These give an impression of the future expansion (or contraction) of the market for the country, and surpluses or deficits that are likely to occur.

Estimating the elasticity of milk supply

Both price and non-price elasticity estimates are important in understanding the relative importance of the factors affecting both individual commodity and aggregate agricultural supply behaviour. In the present study, price elasticity of supply was calculated by estimating a linear model, through OLS regression, using a 1980–2004 data set. A linear function was chosen to estimate elasticity because of the use of a dummy variable representing weather, which is an important factor influencing production and, therefore, supply. The estimated equation, which includes another important variable—the size of the dairy herd—affecting supply, can be written as:

(1)

Where:

Q_t is the quantity of milk produced and available for human consumption at time t;
b_0 is a constant;
P_{t-1} is the price of milk offered to producers in real terms, lagged once because price response of supply is not expected to be instantaneous;
D_t is the number of dairy animals at time t;
W_t is a dummy variable for weather at time t (1 standing for a wet year and 0 for a dry year);
b_1–b_3 are coefficients of the variables; and
m_t is a random error term. t stands for years.

The coefficients derived from the linear function (equation 1) were used to derive price elasticity of supply at the mean values as follows:

(2)

Where:

E_p is the price elasticity at the mean values of price and quantity;
P is the mean producer price;
Q is the mean quantity of fresh milk; and
b_1 is the fresh milk price coefficient in the linear function.

Estimating the elasticity of milk demand

A semi-logarithmic (semi-log) function, estimated using OLS, was hypothesized to explain the relationship between the consumption of fresh milk and the variables described. A number of studies of demand have used a similar functional form (Jones 1982; Burney and Akmal 1991; Mdoe and Wiggins 1996). The estimated equation can be written as:

(3)

Where:

Q_t is the quantity of milk consumed per capita at time t;
b_0 is a constant;
P_t is the average retail price of milk in real terms at time t;
Y_t is income per capita in real terms at time t;
H_t is human population at time t;

b_1–b_3 are coefficients of the variables; and
e_t is a random error term. *t* stands for years.

The coefficients derived from the semi-log function are used to calculate price and income elasticities of demand at mean values as follows:

; (4)

(5)

Where:
E_p is the price elasticity at mean price and quantity;
E_y is the income elasticity at the mean price and quantity;
Q is the mean quantity of fresh milk;
b_1 is the fresh milk price coefficient and
b_2 the fresh milk income coefficient in the semi-log function.

Computing supply and demand projections

The price elasticity of milk supply and herd productivity, and a base year milk supply level are appropriate in calculating milk supply projections. These are the main factors that work together to influence supply. The equation used to calculate milk supply projections can be written as follows:

(6)

Where:
Q_n is the projected supply of milk at the relevant point in time, *n;*
Q_0 is the base year supply;
D_r is the average annual productivity of dairy animals;
P_r is the real rate of growth of milk prices; and
E_p is price elasticity of supply.

On the other hand, the future expansion of the dairy market in Kenya has been explored using the demand projection model based on the growth of income and population, as shown in equation 7.

(7)

Where:
Q_n is milk consumption in year *n*,
Q_0 is milk consumption in the base year,
H_r is the population growth rate per annum,
Y_r is the rate of growth in per capita income per annum,

E_y is income elasticity of demand for milk, and
n is the number of years.

Results and discussion

Herd productivity

Between 1980 and when the milk market was liberalized in 1992, milk production increased more than two-fold, from about 1,000 million litres to close to 2,400 million litres. Subsequently, production stagnated until 1997 before it started to drop up to the year 2001, after which it started a consistent upward trend, as shown in Table 1.

Table 1. Milk production and dairy herd productivity 1992–2004

Year	Total milk production, mil. lit./year	Milk production from total dairy cattle, mil. lit./year*	Number of dairy cattle in milk, mil. head**	Productivity (yield), lit./head/year	Year-on-year productivity growth
1992	2365†	1419	1.15	1233.9	—
1993	2360	1416	1.17	1210.3	–0.02
1994	2368	1420	1.12	1268.4	0.05
1995	2448	1469	1.15	1277.2	0.01
1996	2396†	1438	1.12	1283.6	0.01
1997	2415	1449	1.12	1293.8	0.01
1998	2362	1417	1.12	1265.4	–0.02
1999	2342	1405	1.09	1289.2	0.02
2000	2224	1334	1.05	1270.9	0.01
2001	2150†	1290	1.05	1228.6	–0.03
2002	2200	1320	1.03	1281.6	0.04
2003	2340	1404	1.12	1253.6	–0.02
2004	2450	1470	1.16	1267.2	0.01
Average	2340	1404	1.11	1264.9	0.006

**Using 60% of total milk contribution by dairy cattle (ROK 2001); **Considering 50% of total numbers as mature cattle, 70% of which are milked; †Drought year*
Source of data: ROK (2001) Draft Report; Ministry of Agriculture Annual Reports (1993-2005).

Table 1 also gives productivity (yield) values. The table shows that between the year of liberalization (1992) and 2004, the average annual milk production was 2,340 million litres, a figure slightly less than that of the initial years of liberalization. This indicates that there has been no gain in the levels of milk produced, and instead a decline has been experienced. There has been no gain either in the size of the dairy herd (implied by the number of dairy cattle in milk) or productivity. It should be noted that in 2001 milk production reached its lowest point since liberalization followed by a crescendo which seems to taper off, indicating that it may be getting to a crest. However, the year 2001 experienced a drought, suggesting that the low milk production was influenced by poor weather, leading to a slow recovery of productivity afterwards. But, observing the general trend, it can also be conjectured that the sudden

liberalization of the milk market initially had a harmful impact on production. The market 'shock' has now been absorbed, however; milk prices have started to improve.

The data show stagnating productivity, at an annual average of around 1,265 litres per dairy cow a year, translating into 0.6% year-on-year productivity growth. However, one positive aspect that may be associated with liberalization can be noticed; that there have been no violent swings in milk supply (production) between rainy and drought years. This may be attributed to stabilized prices in both good and bad years which support increased use of preserved or conserved feed during drought.

Milk consumption and food security

Milk makes a contribution to food security; food security being access by all people at all times to adequate food for an active life (World Bank 1991; Nyariki et al 2002). At the time of liberalization, milk supply in Kenya was estimated at 45 litres per capita. The recommended minimum per capita consumption for sustenance of human physiological needs from nutrients derived from milk is 90 litres (Lelei 1993). Calculations for the 1992–2004 milk supply (Table 2) show that the country has moved from a position of per capita self-sufficiency (90.1 litres) to that of insufficiency (67.8), indicating a worsening food security situation with respect to milk supply. So from the point of view of milk availability and access, most Kenyans are food insecure.

Table 2. Per capita milk availability from domestic supplies 1992–2004

Year	Total milk supply, million litres	Milk for human, consumption, million litres*	Total human population, millions	Per capita milk availability, litres
1992	2365	2199	24.4	90.1
1993	2360	2195	25.0	87.8
1994	2368	2202	25.6	86.0
1995	2448	2277	26.2	86.9
1996	2396	2228	26.8	83.1
1997	2415	2246	27.4	82.0
1998	2362	2197	28.0	78.5
1999	2342	2178	28.6	76.2
2000	2224	2068	30.2	68.5
2001	2150	2000	30.9	64.7
2002	2200	2046	31.8	64.3
2003	2340	2176	32.7	66.5
2004	2450	2279	33.6	67.8

**Assumes 7% calf consumption (ROK 2001)*
Source of data: Ministry of Agriculture Annual Reports (1993-2005); Economic Surveys (1993-2005); Statistical Abstracts (1993-2005).

The decrease in per capita milk availability is due to human population growth and stagnating milk production. The situation has worsened because the liberalization policy has not brought about increased herd productivity. Whatever, it may be difficult to link the decline in milk-

related food security to the advent of liberalization; but what the figures in Table 2 portend is that liberalization has not helped reverse the situation.

The structure of milk marketing

Table 3 indicates the quantities of milk sold through the formal and informal markets and on-farm consumption from 1992 to 2004.

Table 3. Milk entering the formal and informal markets 1992–2004

Year	Recorded deliveries to formal markets, mil. lit.[a]	Home consumption, mil. lit.	Calf consumption, mil. lit.	Milk entering informal markets, mil. lit.	Total milk sold, mil. lit	% milk entering formal markets[b]	% milk entering informal markets[b]
1992	361.7	875.1	65.9	1128.2	1490	24.3	75.7
1993	364.6	873.2	65.7	1122.2	1487	24.4	75.6
1994	258.0	876.2	66.0	1233.8	1493	17.3	82.7
1995	350.0	905.8	68.2	1192.2	1542	22.7	77.3
1996	257.0	886.5	66.7	1252.5	1509	17.0	83.0
1997	197.0	893.6	67.3	1324.4	1521	13.0	87.0
1998	126.0	873.9	65.8	1362.1	1488	8.4	91.5
1999	180.0	866.5	65.2	1295.5	1475	12.2	87.8
2000	137.0	822.8	62.0	1264.2	1401	9.8	90.2
2001	148.0	795.5	59.9	1207.0	1355	10.9	89.1
2002	178.0	814.0	61.3	1208.0	1386	12.8	87.2
2003	203.0	865.8	65.2	1271.0	1474	13.8	86.2
2004	274.0	906.5	68.2	1270.0	1544	17.7	82.3

[a]Data revised since 1995 to include KCC and other processors—till 1995 quantities delivered to other processors were negligible; [b]% of total marketed milk
Source of data: Statistical Abstracts (1993-2005).

Intake by the formal sector dwindled from the year of liberalization to 2000, and then started to improve slowly. The opposite can be said about intake by the informal sector. The volume of milk going through the Kenya Cooperative Creameries (KCC) and private processors declined rapidly after the market was liberalized, mainly because of drastic reduction in deliveries to KCC (Chesire 2001), precipitated by poor prices offered to farmers and because of a number of new milk outlets that sprung up. However, the volume has now begun to increase especially because of the revitalization of KCC in 2003. The decline caused the total milk flow to KCC and private processors to go down from 15.3% to 6.2% of the total production between 1992 and 2000, translating into a decline of 24.3% to 9.8% of the marketed milk. In contrast, milk flowing through the informal markets grew fairly steadily from about 76% to 90% during the same period (Table 3).

Figure 1 shows the pattern of milk marketing channels and the roles played by the various intermediaries.

Figure 1. Milk marketing channels in Kenya

Direct sales from producers to consumers constitute about 55% of marketed milk (TechnoServe 2001). These sales usually take place at the farm gate or at local markets in the milk producing areas. This marketing channel is common in areas of low production relative to the number of consumers. Thus, the opportunity to sell directly to consumers in the milk producing areas declines as the number of farmers or households keeping dairy cattle increases.

Raw and sour milk, mainly from smallholders owning zebu cattle, pass directly from producers to consumers. This mode of sale has increased since liberalization. Most of the small dairy producers dispose of their milk through intermediaries (small traders, cooperatives, processors, wholesalers, and retailers) for distribution to ultimate consumers in markets outside the dairy producing areas (e.g., urban areas). A large volume of milk (about 63% of the total production) is marketed through the various channels (ROK 2004a). Milk outlets for dairy cooperatives include milk processors, hotels, retail shops, milk kiosks/bars, and direct sales to ultimate consumers in urban markets. Small milk vendors also sell their milk to hotels, retail kiosks, and individual consumers in urban centres.

The milk going through informal channels (about 82%) is sold as raw or non-processed milk. These channels include direct producer sales to consumers, to milk vendors (hawkers), to self-help groups, to dairy cooperative societies, and to processors. Apart from the KCC and other relatively large processors that produce pasteurized milk, butter, ghee, cheese, yoghurt and *mala*, most of the milk passing through small traders and dairy cooperatives is disposed of as raw milk. Milk changes hands from producers to market intermediaries or consumers at producers' homesteads, rural markets, collection points in dairy producing areas, KCC and private processors' milk collection and cooling centres, and processors' plants.

The performance of milk market intermediaries

Market performance is usually based on the analysis of price margins and operating expenses (Mugarura 2001). Table 4 presents average prices received by producers and paid by consumers through three main intermediaries: private processors, cooperatives and small traders (or hawkers). These are averages of dry and flush wet seasons since prices vary seasonally.

Table 4. Milk marketing margins by market intermediaries (average 2004 prices in Kshs/litre)

Description	Private processors	Cooperatives and self-help groups	Small traders (hawkers)
Costs			
Labour[a]	1.80	0.50	0.50
Transport to market[b]	6.25	5.60	4.00
Processing and packaging[c]	3.75	0.00	0.00
Administration[c]	3.75	3.00	0.00
Total cost (*a*)	15.6	9.10	4.50
Mean buying price (*b*)	25.0	22.5	26.5
Mean selling price (*c*)	48.0	34.0	35.0
Margin ($d = c - b$)	23.0	11.5	8.50
Net margin ($e = d - a$)	7.45	2.40	4.00
Net margin/working capital, % ($f = e/(a+b)$)	24.4	7.6	12.9
Farmer proportion of final price ($g = b/c$)	52.1	66.2	75.7

[a]Only the cost of hired labour is included for small traders; [b]Assumed to be 25% of buying price of milk for

processors and cooperatives—mean buying and selling prices not weighted for volumes; [c]Assumed to be 15% of buying price of milk for processors.
Source of data: Ministry of Agriculture Annual Reports (1993-2005); Economic Surveys (1993-2005); Author's Field Surveys.

The table shows that (in 2004) the highest price was received by producers who sold their milk through hawkers, whilst the lowest price was received by producers who sold milk to cooperatives and self-help groups. Between private processors and cooperatives, there was a 10% difference in prices; between the processors and the hawkers a 6% difference; and between the cooperatives and the hawkers 15%. These differences were much higher for prices to consumers, except those between cooperatives and hawkers. The table indicates that consumers who purchased processed (packaged) milk from private processors at their selling points paid significantly more (by 37–41%) than those who purchased milk directly from dairy cooperatives and small milk traders. Prices charged by the small traders and the cooperatives differed only slightly (by 3%), suggesting a fairly competitive retail market in raw milk at this level.

Table 4 also summarizes the marketing costs incurred by milk market intermediaries in 2004 and their marketing (profit) margins. Private processors incurred the highest costs, owing to the cost of transporting, refrigeration, processing (pasteurization) and packaging. Most of the costs for the intermediaries arose in transport. Small traders saved on this cost. The hawkers were quite effective; they had low costs, returned most (76%) of the final price to the producer, and enjoyed returns to their working capital of 13%, although much of this could be regarded as a return to their labour. (Note that the labour costs for hawkers are estimates of farm labour hire in rural areas.) The cooperatives worked with almost similar costs to those for hawkers, with low overheads, accepted lower net margin, had the lowest returns to working capital, and returned to their members a fairly high final price (66%). But it is doubtful if a net margin of about 8% for the cooperatives can allow them to accumulate and invest. Private processors had higher costs and only gave producers just half (52%) of the final price, yet they had high margins with 24% return on working capital. However, if the depreciation of processing plants and high wear and tear of transport vehicles due to bad roads were to be considered, the apparently high return to processors would disappear. It may be useful to point out that even though private processors passed on a markedly smaller proportion of the final price to producers compared to the other marketers, their 52% is similar to that obtained by dairy producers in industrialised countries like Switzerland selling to processors (Smallfood 2000)—where vast quantities of milk are pasteurized and packed.

Price elasticity of milk supply

The estimated coefficients of equation 1 are shown in Table 5.

Table 5. The supply response of milk, estimated coefficients for a linear model

Variable	Coefficient	*t*-value
Constant	–66.24	–1.18
Milk buy price, lagged once (*P*)	81.54	2.43[a]
Dairy animal population (*D*)	0.48	3.67[a]
Weather (*W*)	55.87	1.28
Adjusted R^2	0.82	
$F_{3,20}$	36.0[a]	
Number of observations	24	

[a]*Significant at 5%*

Price and the dairy animal population variables show significance at 5%. Even though the time series sample points are few, the estimates can be used for prediction purposes (cf. Gujarati 1995; Pindyck and Rubinfeld 1998).

The mean price and quantity of milk is Kshs 2.85 (1980 prices) and 1071.18 litres per year respectively. Using equation 2, the price elasticity of supply is 81.54(2.85/1071.18), which is 0.17. This compares well with the elasticities reported by Nyangito (1998) of between 0.06 and 0.19. These are less than unity values, indicating that price response of milk supply is inelastic, and the restructuring of the milk marketing has not changed this situation.

Price and income elasticities of milk demand

Table 6 presents the results of the regression analysis, based on equation 3. The signs on the coefficients of the explanatory variables are as expected but demand shows low response to price, while the response to income and human population is high.

Table 6. The demand for fresh milk, estimated coefficients for a semi-log model

Variable	Coefficient	*t*-value
Constant	–76.29	–2.35[a]
Milk sale price (*P*)	–6.15	–1.59
Per capita income (*Y*)	23.45	2.62[a]
Human population (*H*)	42.48	2.30[a]
Adjusted R^2	0.51	
$F_{3,21}$	7.68[a]	
Number of observations	25	

[a]*Significant at 5%*

Using equations 4 and 5, price elasticity of demand is –6.15/56.12, which is –0.11; while income elasticity of demand is 23.45/56.12, which is 0.42. Earlier studies have reported a price elasticity and an income elasticity of milk demand for Kenya of 0.1 and 0.8, respectively (see, for example, Omore et al 1999). The findings of the present and earlier studies imply that there exists an inelastic demand (less than unity) with respect to both price and income in Kenya, probably because milk is a necessity and there are few substitutes for it. These findings show that variations in prices have less influence on consumption than income.

Milk supply and demand projections

The milk supply projections are calculated using equation 6 and a price elasticity of supply of 0.17, an average annual dairy animal productivity of 0.015, a real rate of growth of milk prices of 0.02 and a base year milk supply (2005 production) estimated at 2,500 million litres. In the case of demand projections, income and population have been estimated to grow at an average rate of 3% a year for the 1980s and most of the 1990s. However, the growth rate of the population has slowed down due to HIV/AIDS related deaths and now stands at about 2.56% per annum (ROK 2004b). It is assumed that these rates will be maintained for the next 20 years. The projected consumption levels are calculated using equation (7) and the year 2005 estimated quantity of milk demanded of 2305 million litres (ROK 2004a) as base.

Table 7 provides both supply and demand projections. It shows that supply will grow by 2.2% per year over a period of 20 years.

Table 7. Projected milk supply and demand 2005–2025

Description	2005	2010	2015	2020	2025
Milk supply projections, mil. lit.	2500	2739	3002	3289	3604
Milk demand projections, mil. lit.	2305	2785	3364	4064	4909

These figures are roughly supported by those estimated by the Ministry of Agriculture (ROK 2001), and depict fairly fast growth, considering the low animal productivity because of poor AI services after privatization, collapse of the infrastructure, poor performance of the major public milk outlet (KCC) after liberalization, and the low price elasticity of supply.

The demand projections depict a demand growth of 5.6% per year over a period of 20 years, and are almost similar to those estimated by the Ministry of Agriculture. As shown in the table, the demand for milk is likely to outstrip supply in a short period of 5 years. So milk market liberalization has not helped to close the gap between supply and demand, and is unlikely to do so in future. But instead milk deficits are likely to increase, unless measures are taken to improve dairy animal productivity, increase price incentives and improve infrastructure and other factors that play a major role in milk production and marketing.

Conclusions

- The process of liberalization of the dairy industry in Kenya has had both positive and negative effects. The positive effects include:
    - Unrestricted choice of markets by the farmers, so farmers can sell to those offering the best prices.
    - Creation of more market outlets, thus improving distribution and availability of milk products, a major source of proteins, to consumers in many parts of the country.
    - Increased capital stock in the dairy sector through increased processing capacity.
    - Creation of conditions for fair competition in marketing through increased market participants, thus resulting in improved income distribution. Increased participation means creating employment and livelihoods for a wide citizenry, thereby contributing to the alleviation of poverty.
    - Increased possibilities for prompt and better payments to farmers for their milk, which should act as an incentive for increased production, other things being equal.
    - Encouraging conditions for improved quality of products caused by increased numbers of processors competing in the market.
- The negative aspects of liberalization can be summarized as follows
    - Liberalization was done piecemeal within the dairy industry and across related sub-sectors. Reforms were, therefore, not adequately synchronized across sub-sectors and thus some sub-sectors have not kept pace with the changes.
    - Liberalization is seen as one of the reasons why KCC has faced operational difficulties. This coupled with the inadequate capacity of the private outlets and cooperatives to handle or purchase all the milk during flush periods have meant that farmers cannot deliver all their milk to the market.
    - The increase in milk hawking, while could be seen as a positive aspect from the point of view of job creation, has increased the sale of raw milk and the chances of contamination, thereby exposing consumers to health risks

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