AN ECONOMIC ANALYSIS OF THE IMPACTS OF TRADE LIBERALIZATION ON KENYA'S MAIZE SECTOR

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JONATHAN MAKAU NZUMA

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Nzuma, Jonathan Makau

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i. Chair, Doctoral Examination Committee (G. Fox)

ii. External Examiner (T. Jayne)

iii. Graduate Faculty Member (K. Meilke)

iv. Advisory Committee (R. Sarker)

v. Advisory Committee (M. Hoy) Date: Oct. 5. 2007

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ABSTRACT

AN ECONOMIC ANALYSIS OF THE IMPACTS OF TRADE LIBERALIZATION ON KENYA'S MAIZE SECTOR

Jonathan Makau Nzuma | **Advisor:**
University of Guelph, 2007 | **Rakhal Sarker**

Kenya like most other developing countries has been reforming her staple grain markets since 1986. In these sectors, market reforms were initiated as a key component of the economy-wide structural adjustment programmes (SAPs). The SAPs were later strengthened and made irreversible by Kenya's commitments at the multilateral trade negotiations. The reforms were envisaged to improve the sectors terms of trade as a means of stimulating food production. However, the impacts of trade reforms on Kenya's maize sector remain controversial. Thus, there is need for empirical research to inform government interventions in this sector.

This study evaluates the impacts of trade liberalization and their distributional effects on stakeholders in Kenya's maize sector. Specifically, the objectives are threefold: to assess the price responsiveness of producers, wholesalers and consumers, to quantify the market and welfare impacts of trade liberalization and to draw policy recommendations. The study uses recent developments in time series econometrics based on cointegration techniques and error correction models (ECM) to estimate price responses. To quantify the impacts of trade liberalization, a partial equilibrium model (PEM), which accounts for market interrelationships at the farm, wholesale and retail levels is developed.

The elasticities of supply and demand were estimated using annual cereal production and consumption data for the period 1963-2005 from Kenya's statistical office. In all cases, the estimated models performed well on theoretical and statistical grounds. All own-price elasticities had the expected signs and were statistically significant. On the basis of the Marshallian elasticities, cereals can be considered as necessities in Kenya. All long-run own-price acreage elasticities were elastic. Similarly, the long-run own-price elasticities at the intermediate level were elastic. The elastic price responses imply that cereal producer responses in Kenya are quite high, suggesting a significant potential for the sector's response to trade liberalization.

The results from the trade policy simulations suggest that tariff reductions yield price decreases across the three market levels. The declining prices increase maize consumption but reduce domestic production. Consequently, consumer surplus increases while producer surplus decreases. However, the gain in consumer surplus is not sufficient to compensate the loss in producer surplus. Thus, Kenya's implementation of the Uruguay Round trade liberalization commitments leaves the maize sector worse off. Any further tariff reductions without compensating maize producers cannot be recommended based on the compensation principle.

DEDICATION

In loving memory of my late grandfather, ***Mfalme Mutiso wa Ngava*** who passed on a month into my PhD programme.

"***Kyamakongo no kiima***"

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Chapter 1

Introduction

1.1. Background Information

Over the past two decades, Kenya like most other developing countries has implemented two major economic reforms in her staple grain markets. In the mid 1980's, the reform of food markets was an important component of the economy-wide Structural Adjustment Programs (SAPs) adopted by developing countries (Minot and Goletti, 2000). The SAPs entailed the privatization[1] and liberalization[2] of staple grain marketing and pricing in over 20 countries in Africa (World Bank, 1994).

In the 1990's, the SAPs were deepened by Kenya's tariff reduction commitments at the multilateral trade negotiations that culminated in the creation of the World Trade Organization (WTO). The key multilateral rules affecting grain trade relate to the Uruguay Round's Agreement on Agriculture (URAA), whose main pillars are improved market access, reduced domestic support and the elimination of export subsidies. Among the WTO modalities, the market access commitments have had the most important impacts on grain marketing in Kenya.

The grain market reforms have been concentrated in the maize sector because of its strategic importance as Kenya's key staple food and a source of income for a vast majority of the population. Prior to the SAPs, maize markets in Kenya were strictly controlled by the government that enforced administratively determined uniform prices across regions and seasons. Maize marketing was monopolized by the National Cereals and Produce Board (NCPB), a state sponsored single-desk marketing board.

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[1] Withdrawal of state agencies from grain pricing and marketing activities.
[2] The relaxation of regulatory controls on private marketing.

Kenya's maize sector reforms began in the mid 1980's and intensified through the 1990's, resulting in a fully decontrolled market by the end of 1993. Thus, by the time of signing the URAA in 1995, the county was implementing the SAPs and had substantially liberalized its grain markets. Currently, the government intervenes in the maize sector via two main policy instruments: the operations of the National Cereals and Produce Board (NCPB) and the application of import tariffs. The NCPB remains active in a liberalized market, but its role[3] has been confined to the management of a national strategic grain reserve and a buyer of the last resort (Wangia *et al*, 2001).

However, the impacts of trade liberalization on Kenya's maize sector have proved to be controversial. On the one hand, farm lobby groups argue that increased market access lowers producer prices, which serves as a disincentive to production and thus a direct threat to food security (Mghenyi, 2006). Conversely, the elimination of food subsidies under the SAPs in Africa has been thought to exacerbate food insecurity for low income consumers (Jayne and Argwings-Kodhek, 1997). The controversy surrounding the impacts of trade liberalization in this sector has been compounded by the paucity of reliable information on producer and consumer price responsiveness.

Consequently, welfare evaluations are mired in controversy. While the potential gainers and losers have generally been identified, a review of the literature indicates that the magnitudes of these gains/losses and their distributional effects remain largely unexplored. Thus, there exists an empirical gap on these issues. This study employs an economic surplus framework to estimate the market and welfare impacts of reducing maize import tariffs levels in Kenya.

[3] However, the Boards activities still influence Kenya's maize markets since it sets its prices well above market price levels and absorbs product off the market to raise the market price levels

1.2. Economic Problem

The signing of the URAA and the subsequent liberalization of agricultural trade has forced governments throughout the world to put more emphasis on understanding the consequences of agricultural trade reforms. In the literature, there is a broad agreement that a general liberalization of trade improves welfare (Jayne and Jones, 1997; Karp and Perloff, 2002). However, as Karp and Perloff (2002) argue, beyond that limited and unremarkable agreement, controversy exists about the distribution of benefits and about the effects of piecemeal policy reforms.

On the one hand, neoclassical trade theory has been used to demonstrate that free trade benefits all countries owing to their comparative advantages. On the other hand, it is now widely acknowledged that free trade adversely affects the food security status of previously protected agricultural economies, at least, in the short-run (Carter, 1993). Moreover, the increased efficiency sought in agricultural trade reforms may have potentially devastating effects on other developmental goals pursued by low-income countries (Boussard *et al*, 2004).

In light of the emerging controversy about the consequences of trade liberalization on food markets, policy makers and market actors in developing economies continue to operate in poorly informed environments. This is especially true for countries in Sub-Saharan Africa (SSA) where economic policy makers designing government interventions in the staple grain sectors seek to strike a balance between the competing interests of farmer's and those of consumers. Thus, there is a need for rigorous research that can improve our understanding of the impacts of trade liberalization in these sectors.

1.3. Economic Research Problem

In the past two decades, developing countries have been liberalizing their agricultural markets in line with the SAPs that were made stronger and irreversible through their commitments at the UR multilateral trade agreements. The underlying philosophy has been that more liberal trade benefits all countries owing to differences in relative factor endowments. However, the notion that open international trade helps all poor countries is now in dispute (Dixit and Grossman, 2005). Thus, a growing concern about the welfare impacts of trade liberalization in many developing countries, especially on poverty, has arisen (Boussard *et al*, 2004).

In Kenya, the literature on the impacts of trade liberalization in the maize sector is at best mixed. While some authors argue that the reforms have improved maize availability and enhanced consumer welfare (Jayne and Argwings-Kodhek, 1997; Jayne *et al*, 2005), others report that the declining farm prices and hence domestic production pose a major threat to Kenya's food security (Karanja *et al*, 2003; Nyangito *et al*, 2004). Overall, the impacts of trade policy reforms in the maize sector remain controversial and poorly informed by the existing empirical evidence.

This empirical controversy is attributable to the paucity of a set of reliable demand and supply elasticities for policy analysis. Indeed, a thorough search of the literature reveals that the available estimates were either generated long before the reforms were initiated or have been derived from samples covering short periods that might not be valid for policy analysis. Thus, there is a dearth of theoretically consistent empirical estimates of producer and consumer responses that confounds the controversy in the literature on the welfare impacts of trade liberalization on Kenya's maize sector.

The economic research problem addressed in this study is the dearth of reliable empirical evidence on the market and welfare impacts of trade liberalization on Kenya's maize sector. Consequently, the impacts of trade liberalization on the sector are not well understood, partly because of the lack of rigorous empirical research to bridge the existing literature gaps and inform the divergent opinions. This study derives theoretically consistent elasticities and employs them in an economic surplus framework to generate welfare measures of the gains from trade liberalization on Kenya's maize sector. The information generated can aid policy makers in Kenya and other parts of SSA to design appropriate policies for the staple grain sectors.

1.4. Purpose and Objectives of the Study

The purpose of this study is to identify the sizes of the gains/losses from trade liberalization and their distribution effects on stakeholders in Kenya's maize sector.

The specific objectives of this study are:

(i) To assess the price responsiveness of cereal grain producers, wholesalers and consumer in Kenya.

This objective is achieved by estimating acreage responses, intermediate demands and consumer demand elasticities for the four major cereal grains (maize, wheat, rice and sorghum) produced and consumed in Kenya.

(ii) To quantify the market and welfare impacts of trade liberalization on maize producers, wholesalers and consumers in Kenya.

This objective is achieved by calibrating a partial equilibrium model (PEM) of trade from the elasticity estimates. The model is employed to simulate policy changes.

(iii) To discuss the implications of the results for future food policy and agricultural trade policies in Kenya.

1.5. Significance of the Study

This study evaluates the market and welfare impacts of trade liberalization and their distributional effects on key stakeholders in Kenya's maize sector. It addresses a major policy concern in Kenya and many other countries in SSA where maize is the key staple food. Maize is chosen for this study because it is Kenya's dominant staple food, which is produced and consumed by over 90 percent of the rural households. The sector is also a major determinant of Kenya's food security and a major contributor to national income and employment.

The study uses recent developments in time series estimation, based on cointegration techniques and error correction models (ECM) to estimate theoretically consistent elasticities of supply and demand for cereals in Kenya. These elasticity estimates are then used to calibrate a simulation model, which is employed to quqntify the welfare impacts of trade liberalization on Kenya's maize sector. The key results of the policy analysis are used to draw policy implications. While this study focuses on the maize in Kenya, its findings are applicable in many developing countries particularly those in Southern and Eastern Africa where maize is the major staple food.

Overall, this study makes four contributions to the existing stock of knowledge. First a theoretical framework is developed to analyze producer behaviour under price risk. Secondly, the study generates theoretically consistent and statistically reliable elasticity estimates of supply and demand. Third, a PEM of trade that can be applied for policy analysis is developed. Finally, the study recommends viable policy options. The study is of interest to maize producers, consumers, policy makers and researchers in the field of agricultural policy, international trade and development.

1.6. Organization of the Thesis

This thesis is presented in eight chapters. The next chapter reviews background information on the maize sector in Kenya and presents the existing policy framework. It reviews the structure of production, marketing and consumption after examining the economic significance of maize in Kenya. Overall, chapter two provides the key contextual information required for developing the analytical frameworks and the empirical models used to estimate supply and demand. In addition, it provides context for the policy analysis that follows in the reminder of the thesis

Chapter three provides a review of the approaches used to analyze the effects of agricultural trade agreements in both developed and developing countries. It guides the choice of an appropriate economic surplus framework to solve the problem at hand. The conceptual and theoretical basis for this study is presented in chapter four. Specifically, the chapter derives the analytical frameworks for understanding producer and consumer behavior, and develops a framework for quantifying welfare measures. Chapter five specifies the econometric models used in this study. It discusses the data sources and specifies the empirical models to be estimated.

The econometric results generated from the estimation supply and demand are presented in chapter six. These parameter estimates are used to construct a partial equilibrium simulation model in chapter seven. The model is used to simulate two policy scenarios and the simulation results are also reported in chapter seven. Finally, chapter eight summarizes the major findings of the study, discussed their policy implications and suggests potential areas for future research.

Chapter 2

Overview of the Maize Sector in Kenya

2.1. Introduction

This chapter presents background information on the maize sector in Kenya. It provides context for the analytical work that follows in the remainder of the thesis. The chapter is organized into four sections. First, the economic importance of maize in Kenya is described in the first two parts. This is followed by a discussion of the policy framework. Finally, the evolution of the maize marketing system is presented.

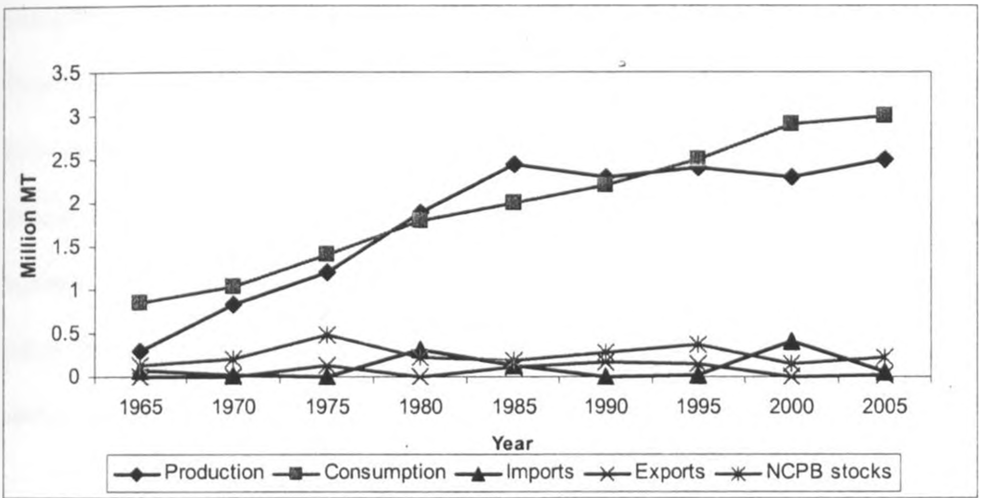
2.2. Economic Significance of Maize in Kenya

Maize is Kenya's main staple food. It is produced by over 90 percent of the rural households and is the most widely consumed foodstuff in Kenya (Nyangito, 1997). It constitutes three percent of Kenya's gross domestic product (GDP) and 12 percent of the agricultural GDP (Wangia *et al*, 2001). The agricultural sector accounts for a quarter of Kenya's GDP and employs a third of the labour force. It is estimated that the maize sector employs one quarter of the agricultural labour force and accounts for about 20 percent of the value of agricultural production in Kenya (GoK, 2004).

Maize consumption accounts for roughly two-thirds of the staple grain diet in Kenya (Jayne *et al*, 1997). The crop supplies 40 to 45 percent of the calories, and 35 to 40 percent of the protein consumed by an average Kenyan (Mghenyi, 2006). It is estimated that maize per capita consumption rates in Kenya have averaged 0.098 tonnes in the last two decades (FAOSTAT, 2006). About two-thirds of Kenya's maize producers are also net purchasers, spending roughly a third of their incomes in procuring the staple grain for consumption (Karanja *et al*, 2003).

Kenya's maize production peaked in the mid 1980's but has since stagnated (Figure 2.1). In the recent past, the country has become a deficit producer of maize. The area under maize cultivation has stabilized at around 1.5 million hectares, producing about 2.4 million tonnes per annum against an estimated consumption of three million tonnes (Figure 2.1). As Jayne *et al*, 2005 observe, production has not kept pace with demand, which is mainly driven by the expanding population and hence the widening gap between domestic production and consumption.

Figure 2.1. Maize Production and Consumption Trends (1965 – 2005)



Source: Economic Survey, Various Issues.

In an effort to bridge the supply deficit, Kenya has been importing maize formally and informally across the border from Uganda and Tanzania. Large offshore imports are also sourced from as far as South Africa, Malawi, USA and other South American countries such as Brazil and Argentina (Nyoro *et al*, 1999; Jayne *et al*, 2005). It is estimated that maize imports have averaged 15 percent of total consumption since 1996 (Figure 2.1). However, the share of maize imports is highly understated because of massive unreported cross border trade from Uganda and Tanzania (Kibaara, 2005).

Kenya does not normally produce any surplus maize for the export market. However, maize imports and exports can occur concurrently even as the country suffers from consumption deficits and when it enjoys production surpluses as witnessed in 1980, 1985 and 1995 (Figure 2.1). In the 1980's NCPB's exports amounted to less than 50,000 MT but have been negligible after 1996. The Board's purchases declined since 1976 but have exceeded exports in the last four decades. Notably, the decline in NCPB stocks coincides with the initiation of maize market reforms in Kenya.

2.2.1. Staple Grain Production and Consumption Trends in Kenya

Roughly three percent of Kenya's arable land is devoted to cereal grain production. However, cereal grain production trends have exhibited mixed trends over the past four decades as evidenced in the preceding analysis. Maize cultivation dominated cereal production and occupied over 81 percent (1.243 million ha) of total cereal acreage over the 1963 to 2005 period (Table 2.1). In contrast, the acreage devoted to other the cereal crops was less prominent with the combined area under wheat, rice and sorghum accounting for less than 20 percent of the total cereal area.

Table 2.1. Cereal Production and Consumption Patterns in Kenya (1963 – 2005)

	Entire Period		Government Controls		Liberalized Period	
Trend	**Mean**	**CV[a] (%)**	**Mean**	**CV[a] (%)**	**Mean**	**CV[a] (%)**
Cropped Acreage (Million Ha)						
Maize	1.243	*25.73*	1.043	*28.72*	1.473	*9.16*
Wheat	0.132	*14.87*	0.121	*16.19*	0.145	*6.95*
Rice	0.009	*47.03*	0.008	*39.17*	0.011	*44.81*
Sorghum	0.158	*25.33*	0.182	*21.62*	0.129	*8.45*
Budget Shares (w)						
Maize	0.540	*24.94*	0.477	*31.02*	0.613	*10.80*
Wheat	0.290	*26.00*	0.297	*29.34*	0.301	*21.37*
Rice	0.048	*63.47*	0.033	*29.04*	0.066	*54.98*
Sorghum	0.122	*78.83*	0.193	*38.97*	0.030	*51.99*

[a] The Coefficient of Variation (CV) is a ratio of the standard deviation to the mean.

Source: Author's computation from Economic Surveys

The acreages under all cereals except sorghum expanded substantially after the cereal sector reforms of 1986 (Table 2.1). The area under maize grew from an average of 1.043 million ha prior to the reforms to 1.473 million ha after reforms. In addition, the variability of cropped acreage as indicated by the CV declined for all cereals except rice in the liberalized period. The increased variability in the acreage for paddy rice can be explained by the collapse of rice irrigation schemes in Kenya following the withdrawal of public irrigation subsidies during the implementation of the SAPs.

Cereal consumption accounts for over a third of the total food expenditure in Kenya while food accounts for 46 percent of total household expenditure (Seale *et al*, 2003). The budget share devoted to maize consumption exceeded 54 percent of the total cereal consumption expenditure in Kenya over the 1963 to 2005 period (Table 2.1), making it the key staple grain. Over the same period, the budget shares of wheat and sorghum amounted to about 29 and 12 percent respectively while that of rice was below a tenth of total cereal consumption expenditure (Table 2.1). These trends and budget shares underscore the importance of maize as the staple food in Kenya.

The consumption of tradable cereals (maize, wheat and rice) expanded modestly after the cereal sector reforms of the mid 1980's. However, the share of sorghum in total cereal expenditure declined by about 163 percent between the controlled and the liberalized period (Table 2.1). The variability of the budget shares for maize and wheat fell after the reforms while those for rice and sorghum increased. These consumption patterns suggest a consumption shift away from the traditional non-tradables (sorghum) to the tradable cereals (maize, wheat and rice). Overall, the production trends and budget shares underscore the importance of maize in Kenya.

2.2.2. Trends in Domestic Cereal Prices

The level and variability of prices can be used to assess the impacts of policy changes on the performance of domestic markets and indicate the extent to which prices stimulate growth. Table 2.2 gives a summary of the evolution of real producer prices prior to and after the cereal sector reforms of the mid 1980's in Kenya. Real producer prices declined for all cereals grown in Kenya after the liberalization of the sector (Table 2.2). However, there was a marked increase in cereal producer price variability in the post liberalized period as indicated by the CV in Table 2.2. These producer price trends might explain decline in maize production shown in Figure 2.1.

Table 2.2. Domestic Producer Prices of Cereals in Kenya (1997 = 100)

Commodity	Period of Government Controls (1963 – 1985)		Post Liberalized Period (1986 – 2005)	
Producer Price	Mean Price (KES/MT)	CV[a] (%)	Mean Price (KES/MT)	CV[a] (%)
Maize	11916.36	13.62	11274.06	44.64
Wheat	18489.19	12.65	16021.78	34.60
Rice	17678.76	19.22	16614.05	66.68
Sorghum	46707.15	42.55	21026.74	48.13
Millet	70506.66	18.90	31728.14	49.04

[a] The Coefficient of Variation (CV) is a ratio of the standard deviation to the mean.

Source: Author's Computation from Economic surveys

In conformity with supply side price trends, cereal consumer prices in Kenya fell after the sector's liberalization but experienced significant increases in price variability (Table 2.3). Consumer prices declined more than the decline in producer prices largely because of the availability of cheap imports. It can, therefore, be concluded that the cereal sector reforms led to a general decline in producer and consumer prices. While declining prices benefit cereal consumers, they would be expected to hurt cereal producers whose net returns fall with the decreasing producer prices.

Table 2.3 Real Consumer Price Changes by Commodity (1963 – 2005)

Commodity Retail Price	Period of Government Controls (1963 – 1985)		Trade Policy Reform Period (1986 – 2005)	
	Mean Price (KES/MT)	CV[a] (%)	Mean Price (KES/MT)	CV[a] (%)
Maize	18269.05	13.01	13993.45	30.44
Wheat	61552.82	24.21	39505.41	27.53
Rice	42379.19	12.12	30855.19	17.56
Sorghum	43727.31	31.30	19958.19	45.92
Millet	73093.83	17.47	30921.90	49.09

[a] The Coefficient of Variation (CV) is a ratio of the standard deviation to the mean.

Source: Author's Computation from Economic surveys

2.2.3. Household Maize Production Patterns and Market Participation

Maize production in Kenya is characterized by the existence of heterogeneous small-scale farmers alongside large-scale commercial producers. There are about three million such small-scale farms operating about two hectares of land and producing about 70 percent[4] of the total maize output but contributing only 30 percent of the marketed surplus (Wangia *et al*, 2001). In contrast, commercial producers operate over 20 hectares of land and dominate the marketed share of maize.

These two groups differ considerably in terms of production technologies, cropping systems and maize consumption patterns. Smallholders plant maize mainly as a subsistence crop, either monocropped or intercropped with other annual crops such as beans. Their operations are labour intensive with limited use of purchased inputs. In contrast, the large-scale commercial producers practice monocropping and are highly mechanized. Most households produce, store, consume and purchase maize to meet their consumption needs. On the basis of their market participation, maize producing households in Kenya can be categorized into subsistent, net sellers and net buyers.

[4] Kenya's Ministry of Agriculture (MoA) reports aggregated cereal production data. However, the Central Bureau of Statistics (CBS) uses land size indices to map out the output produced by farm size.

2.3. Domestic Maize Production and Trade Policy in Kenya

The government's policy objective in the maize sector as spelled out in *Sessional Paper No. 2 of 1994 on National Food Policy* is to attain a broad self-sufficiency in maize production (GoK, 1994). To achieve this objective, a number of policy instruments have been used. These have included price controls, buffer stocks, trade licensing, and import restrictions. Given its strategic position in Kenya's agriculture, maize dominates national food security considerations. Consequently, self sufficiency and importation strategies have been used to attain national food security in Kenya.

Kenya's policy towards maize marketing and trade has gone through a series of distinct periods (Table 2.4). Broadly speaking, the state monopolized maize marketing through statutory marketing boards from the colonial era until the mid 1980's. The first attempt to control maize marketing was promulgated by the colonial government via the enactment of the native produce ordinance of 1935. This ordinance created the Maize Control Board (MCB) as the sole purchaser of maize and as a provider of guaranteed minimum return per acre to colonial farmers (Heyer, 1976).

The MCB was a statutory monopoly geared towards the protection of European maize farmers from the competition posed by African producers (Nyangito, 1997). In this period, maize imports were restricted through ad valorem tariffs that had been imposed in 1922 (Heyer, 1976). The entire colonial period was characterized by direct state controls of maize marketing, pricing and movement[5] via the activities of MCB. The Board strictly enforced movement and price controls that ensured stable prices and incomes for white settlers on the Kenyan highlands (Wangia *et al*, 2001).

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[5] Transit of maize across districts was restricted with transportation of more than two 90 kg bags requiring a permit from the NCPB (Nyangito, 1997)

Table 2.4. Milestones in the Reform of Maize Marketing in Kenya

Period	Role of State Agency in Marketing	Outcomes
1935 - 1963	Strict control of maize price, movement and storage under MCB	Stable producer prices and incomes for white settlers in the Kenyan highlands High food prices
1963 - 1979	Strict control of maize price, movement and storage under MMPB	Stable producer prices and incomes to all maize farmers in Kenya Subsidized maize meal prices Food security ensured
1979 - 1986	Strict control of maize price, movement and storage under NCPB	Stable pan-territorial and pan-seasonal prices in the entire country Stable producer incomes Self sufficiency in Maize production Subsidized sifted maize meal prices Food security ensured Financial losses to NCPB
1986 - 1990	Limited relaxation on the control of maize price, movement and storage under NCPB First serious market reform under CSRP conditional to EEC/WB aid	Stable incomes with uniform territorial and seasonal prices Self sufficiency in maize production Improved movement of maize across district borders Food security ensured Financial losses by NCPB EEC/WB aid to Kenya Gradual reduction of movement controls
1990 - 1995	Gradual elimination of maize price and movement controls by NCPB NCPB's marketing monopoly status abolished Market reforms conditional to aid	Unstable territorial and seasonal prices. Unstable producer incomes Easy flow of maize across regions Limited self sufficiency in maize production Limited maize imports Mixed results on food security. Financial losses to NCPB EEC/WB aid to Kenya
1995 - 1999	Full market liberalization NCPB's role reduced to maintaining strategic reserves and buyer/seller of last resort Tariff reductions and membership to WTO	Unstable producer prices and incomes. Low urban maize meal prices Increased private sector participation in maize marketing Mixed results on food security Limited loss of public funds Weak market institutions Increased maize imports
1999 - 2005	Further tariff reductions Duty free access for maize imports from COMESA & EAC	Unstable producer prices and incomes Increased consumer access to maize Low maize consumer prices Increased imports

Source: Nyangito, 1997; Wangia *et al*, 2001

After independence in 1963, the MCB was renamed the Maize Marketing and Produce Board (MMPB). The MMPB enforced tight controls over maize marketing for another 15 years. In 1978, the MMPB was renamed the National Cereals and Produce Board (NCPB). The NCPB was a statutory monopoly that procured and sold maize at administratively determined prices. The Board maintained a price band buffer stock scheme where domestic prices were permitted to fluctuate only between pre-set maximum and minimum prices (Pinckney *et al*, 1987). In addition, the Board enforced uniform prices and handled all foreign maize trade.

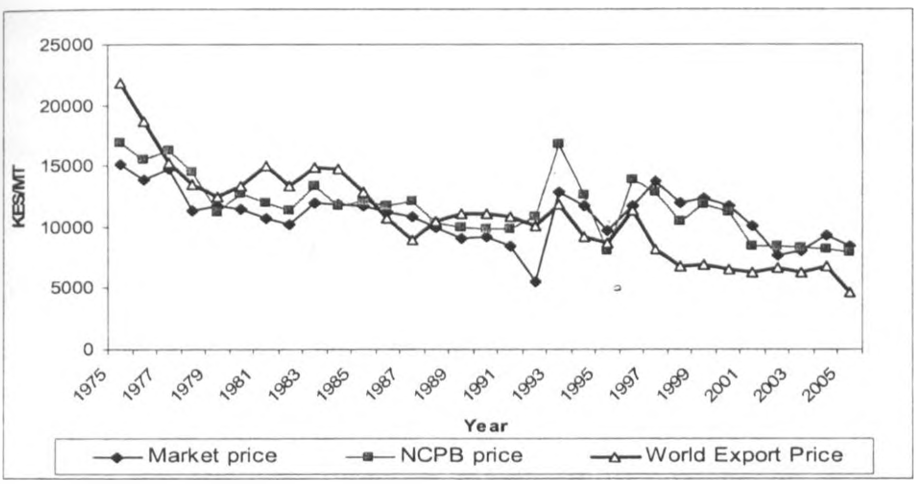
The Board's controls ensured an orderly marketing system with reasonable price stabilization. However, the controls led to the development of a parallel informal market for maize. The formal maize marketing system[6] was strictly regulated and managed by the NCPB[7]. In contrast, the informal system was unregulated and unofficial with many market participants operating parallel to the formal system (Schmidt, 1979). It evolved to fill the vacuum created by the NCPB controls and accounted for over 50 percent of the marketed maize share (Wangia *et al*, 2001).

Maize producer and consumer prices were controlled and strictly enforced on a standardized pan-seasonal and pan-territorial basis. Official prices were gazetted at all market levels and announced by the Minister in charge of Agriculture before the crop was planted each year. Prices were based on the cost of domestic production and a mark-up and subsequently, between 1981 and 1992, prices were based on world market parity prices. Decisions to import or export maize during this period were made by the Cabinet and enforced by the NCPB (Nyangito, 1997).

[6] The formal system only accounted for about 50% of the marketed output or about 25% of total output.
[7] The board operated through a network of Primary Marketing Centres (PMCs) purchasing (21%), cooperative societies (23%), agents (3%) and individual farmer's deliveries (53%).

The controlled maize marketing system artificially raised producer prices above the world export prices (Figure 2.2). Moreover, local market prices varied significantly from the official NCPB prices. Local market prices were lower than the officially announced NCPB price and the world export throughout the controlled period (Figure 2.2). Thus, the Boards marketing operations consistently generated financial losses leading to large claims that had not been budgeted for (Nyangito, 1997). The realization that price controls were fiscally unsustainable coupled with external pressure from international lenders paved the way for maize market reforms in Kenya.

Figure 2.2. Maize Producer Price Comparisons (1997=100)



Source: NCPB, FAOSTAT and MOA.

Kenya's maize market reforms date back to 1973 when the World Bank started advocating for the relaxation of transit rules and a reduction of the monopoly status of the MPMB. However, it was not until 1988 that serious reforms began under the auspices of the European Commission (EC) sponsored Cereal Sector Reform Programme (CSRP) (Lewa and Hubbard, 1995). The EC induced CSRP was part of Kenya's overarching SAPs. The general policy shift was not unique to Kenya but a general trend in many Eastern and Southern Africa countries.

The CSRP in Kenya focused on the decontrol of maize prices, the removal of movement restrictions and a reduction of the monopoly status enjoyed by the NCPB in maize markets. To encourage wider private sector participation, all administrative and licensing controls on maize marketing were removed. In 1992, price controls for all food items and farm inputs in Kenya were abolished while import bans were replaced with import tariffs. Subsequently, the government removed all restrictions on maize trade and the domestic market was fully liberalized in 1995 (Table 2.4).

Domestic maize policy shifted dramatically after 1995. The NCPB plays a reduced role in a liberalized market, but sets its prices well above market price levels to influence the market. The Board's direct maize procurement, sale and buffer stock holding have shrunk to marginal proportions while restrictive import bans have been replaced with import tariffs (Jayne and Jones, 1997). Kenya joined the WTO in 1995 and bound her agricultural tariffs at 100 percent. However, maize import tariffs have generally been below 25 percent and have never exceeded the bound rates even with the imposition of suspended duties in 1994 and 1998 (Nyangito *et al*, 2004).

In addition, Kenya has complied with its basic URAA commitments on the market access pillar, since all her agricultural tariffs are bound and their applied rates are below the ceiling (WTO, 2000). The country has no WTO commitments on domestic support measures since all such measures pertain to the exempt categories or are within the *de minimis*[8] levels. In the maize sector, quantitative import restrictions and price controls have been dismantled and the main trade policy instrument is a tariff. In addition, Kenya does not grant export subsidies on any of her agricultural products.

[8] Product specific support not greater than 10 percent of the total value of production of the agricultural commodity in questions (for developing countries) that is exempt from reduction commitments.

Currently, maize imports from the East African Community (EAC)[9] and the Common Market for East and Southern Africa (COMESA) states enter the market duty free as long as they are accompanied by a certificate of origin (Nyangito *et al*, 2004). However, maize imports from other parts of the world are subjected to an import tariff of about 25 percent. In addition all imports are subject to an Import Declaration Fee of 2.75 percent, pre-shipment inspection and phytosanitary certification (WTO, 2000).

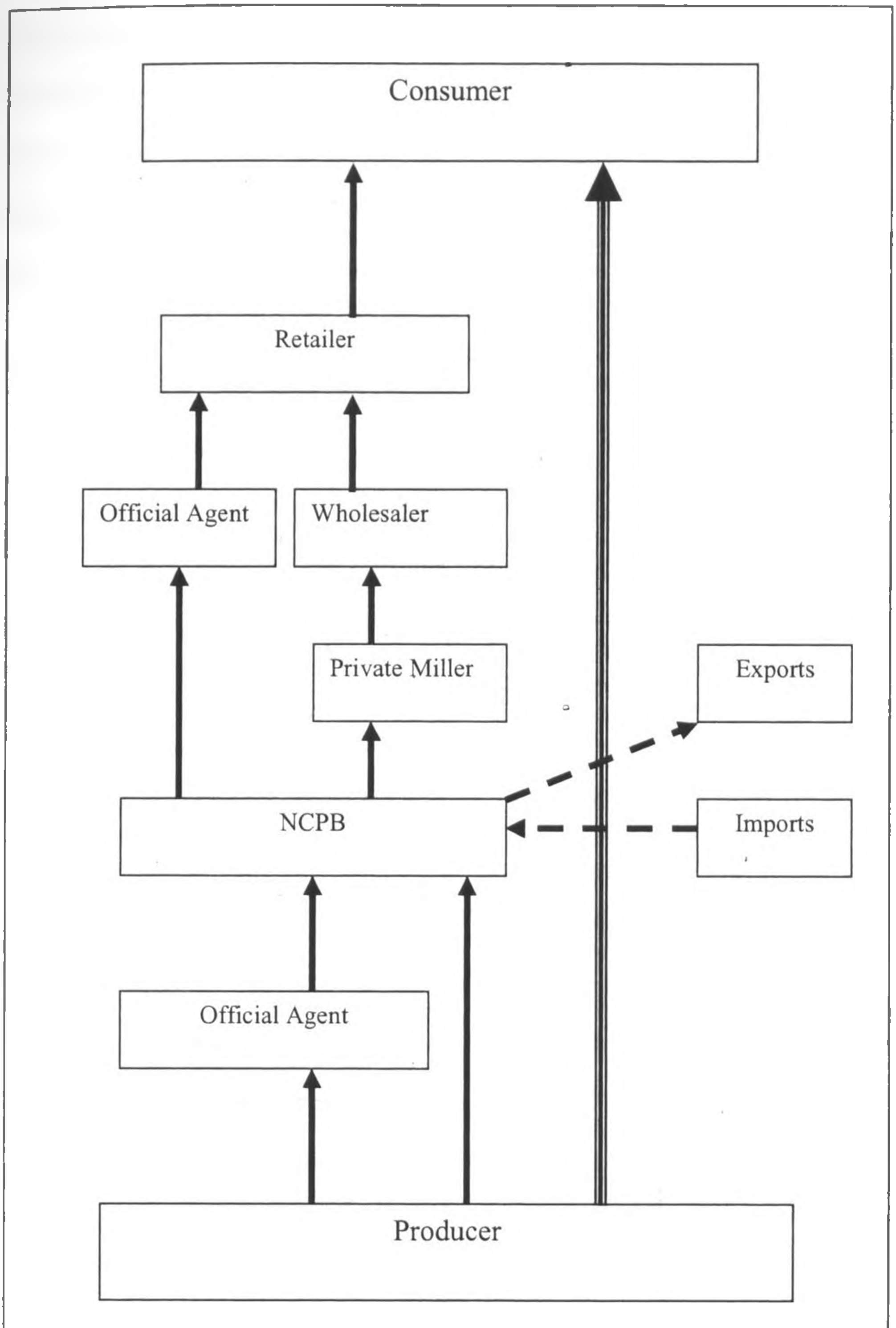
2.4. Evolution of Maize Marketing System in Kenya

In Kenya, the reform of grain marketing has been a central policy issue for decades with maize occupying the core position. Prior to the reforms, maize was extensively marketed through local markets (thick stripped arrow in Figure 2.3). Farmers delivered small quantities (usually not more than a few bags of maize) to the local retail market or store. The commodity was transported by head, bicycles, trucks, donkeys and carts to be exchanged in the market place (Argwings-Kodhek *et al*, 1993). Localized trade in small quantities over small distances was legal.

The official distribution channel (the unbroken arrows in Figure 2.3) was controlled by the NCPB. The Board operated through a system of storage depots spread over the country. Licensed agents bought maize from producers and delivered it to the nearest depot (Heyer, 1976). Large farmers, however, delivered their produce directly to NCPB. Uniform prices for every level of the marketing chain were established by an interministerial price review committee and announced by the Minister in charge of Agriculture before planting each year (Pinckney *et al*, 1987). In turn, the Board offloaded its stocks to millers and wholesalers or sold it in export markets.

[9] EAC is a customs union for Kenya, Uganda and Tanzania initially established in 1967 and later expanded to include Rwanda and Burundi in 2007 while COMESA is a free trade area for 20 countries in Eastern and Southern Africa established in 1994.

Figure 2.3. The Maize Marketing System in Kenya (1963 – 1994)



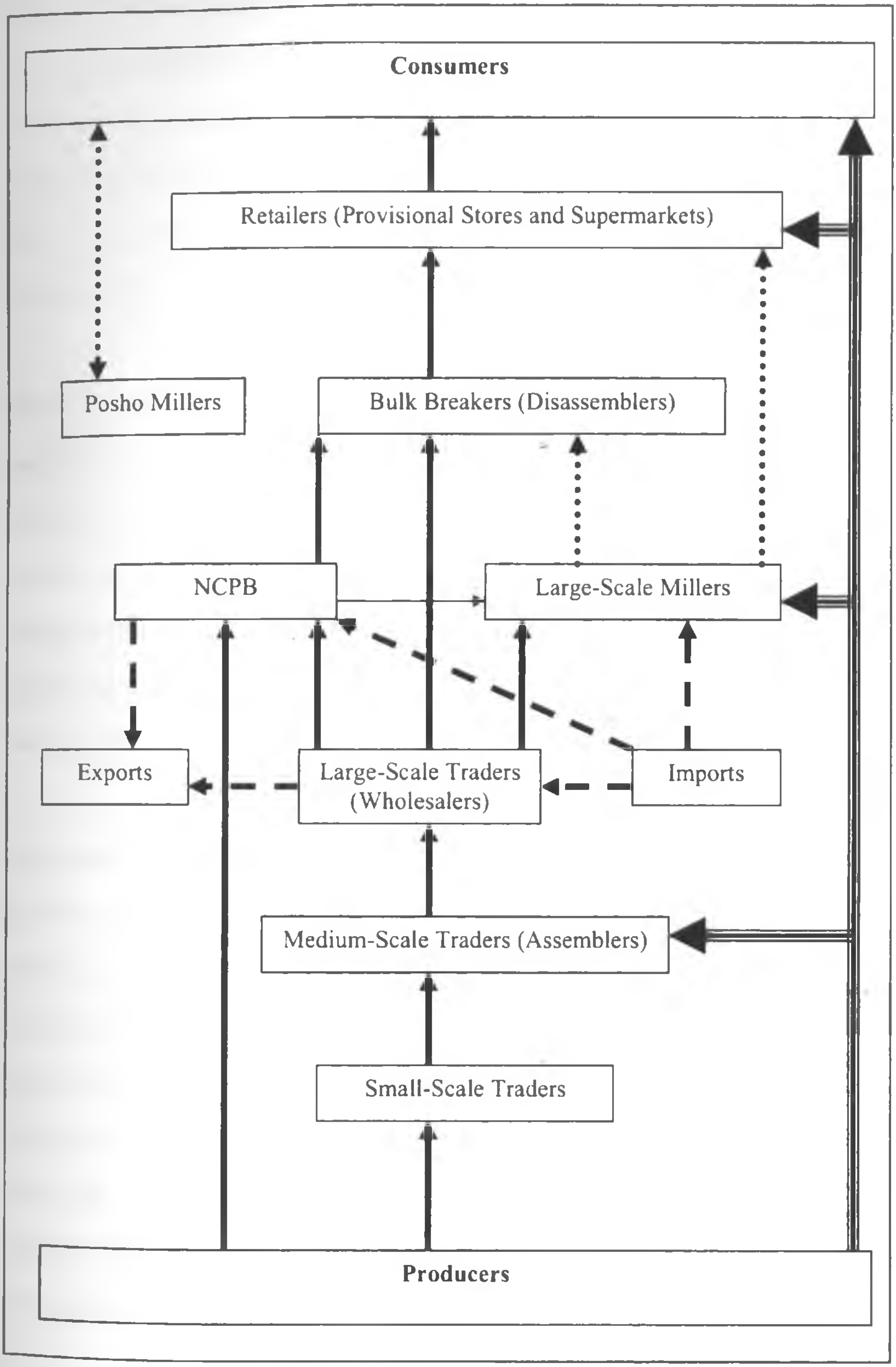
Adopted from Heyer, 1976.

Outside the officially controlled maize marketing system, a significant amount of smuggling and black marketing thrived (Heyer, 1976). A substantial amount of illegal movement of maize across district borders unquestionably occurred (Pinckney *et al*, 1987). The Board lacked the fiscal resources necessary to fulfil its regulatory mandate which created room for informal maize marketing in Kenya. These informal marketing arrangements were further fuelled by NCPB's inability to purchase all the maize offered for sale and to supply maize in all rural areas.

The liberalisation of the sector in 1995 allowed the private sector to play a greater role in maize marketing and reformed the role of the NCPB. Subsequently, two parallel marketing systems have evolved. These comprise the official marketing system under NCPB and an alternative private trading system (Figure 2.4). The post liberalized maize marketing system differs substantially from the controlled system and features a well developed supply chain involving a large number of intermediaries and comprising of many distinct marketing channels. Thus, maize is distributed freely by willing traders and imported with minimal trade restrictions.

A substantial amount of private maize trade still occurs in local markets (thick strived arrows in Figure 2.4). However, farmers sell their produce to an increased number of marketing agents as compared to the controlled system. These agents comprise of small and medium-scale traders who sale the grain to wholesalers. Producers can also sell maize to wholesalers and millers at the wholesale level. The official channel (unbroken arrows in Figure 2.4) under NCPB competes with private traders in the post liberalized period. Farmers can also sell their produce to the NCPB that offloads its purchases to relief food agencies and large-scale millers or to export markets.

Figure 2.4. The Maize Marketing System in Kenya (1995 - 2005)



The bulk of maize trade occurs at the wholesale level in the form of unprocessed grain. At this level, wholesalers, large-scale millers and the NCPB have been licensed to undertake foreign trade in the liberalized period (broken arrows in Figure 2.4). However, maize consumption occurs either in unprocessed form (whole or cracked grain) or as processed products (maize meal). Almost all maize in Kenya is processed before consumptions (Argwings-Kodhek *et al*, 1993). Two major types of maize meal products, each with its own milling technology are processed in Kenya.

Maize meal products comprise of a relatively unrefined (97 percent extraction) whole maize meal (*Posho*) that is hammer milled and sifted maize meal that is highly refined (80 percent extraction) using a roller milling technology. Large-scale millers located in urban centres handle large volumes of maize and produce sifted maize meal that is packaged and sold to retail chains. On the other hand, Posho millers have gained prominence in both rural and urban areas after 1995. Posho millers practice custom milling where the customer supplies their own grain to be milled at a fee.

2.5. Chapter Summary

In this chapter, an overview of the maize production and consumption patterns in Kenya is presented. The chapter further discusses the evolution of the marketing system along with the underlying policy framework, a discussion that is focussed on institutional changes and the policy instruments applied overtime. Specifically, the chapter serves two purposes. It offers a rationale for basing this study on the maize sector and provides context for the analytical work that follows in the remainder of the thesis. The next chapter reviews the relevant theoretical and empirical literature on the approaches used to analyze the impacts of agricultural trade reforms.

Chapter 3

Approaches for Analyzing Agricultural Trade Policies

3.1. Introduction

This chapter reviews the theoretical approaches used to analyze the effects of agricultural trade reforms. It is intended to guide the choice of an appropriate framework to address the problem at hand. The chapter begins by comparing the key modeling approaches and their empirical applications in the developed and in the developing world. Finally, it reviews the literature on Kenya's Maize market reforms.

3.2. Approaches used in Applied Trade Policy Analysis

The key approaches used to analyze the effects of agricultural reforms can be grouped into econometric and simulation models. Both approaches comprise of a system of mathematical equations that depict selected relationships in an economy. Econometric and simulation models differ in how values are assigned to the parameters (McKitrick, 1998). While econometric model parameters are estimated statistically, simulation parameters are drawn from a variety of other sources including prior econometric studies, other simulation models and the analyst's intuition or judgment.

Econometric models combine parameter estimation and model validation in the same analysis, but simulation models break these two steps apart. Simulation models are calibrated such that they exactly reproduce the base period data given base policies and market conditions. In between these two categories are hybrid approaches that combine features of both econometric and simulation models (Abler, 2006). These include econometric models in which some parameters are intuitively adjusted and simulation models in which some parameters are econometrically estimated.

Econometric models quantify the effects of past policies and other economic variables. They are categorized into models designed to predict trade flows between countries and those designed to predict the economic impacts of trade. Economic impacts of interest in the literature include employment and wages, productivity, competition, and firm survival and exit (Abler, 2006). Among models designed to predict trade flows between countries, the Gravity model is by far the most popular approach. It has been widely applied in analyzing bilateral trade flows.

On the other hand, simulation models simulate the future impact of alternative trade policies. Basically, simulation frameworks can be grouped into partial equilibrium (PE) and computable general equilibrium models (CGE) or applied general equilibrium (AGE). PE models treat international markets for a selected set of traded goods, such as agricultural commodities, as closed systems without linkages with the rest of the economy. In contrast, CGE models cover all goods and services simultaneously within an economy or a group of economies.

The chief advantage of econometric modelling is that it involves real data and assuming a study is methodologically sound provides real results. However, model results are historical in nature and may no longer be relevant due to structural changes that are subject to the Lucas critique. On the other hand simulation models are preferred to econometric models for their ability to capture the effects of other variables influencing trade agreements and accommodate structural changes. Policy analysts wishing to develop confidence in their estimated parameters and to ensure a perfect match between the parameter estimates and the calibrated models often move to hybrid models that combine simulation modelling with econometric estimation.

3.2.1. Simulation Models

Simulation models for measuring the effects of trade reforms fall into two broad classes, PE and CGE frameworks. PE models cover a limited set of goods and services within an economy. Conversely, CGE models encompass all sectors within an economy. Whereas CGE models are suitable for policy analysis when agriculture forms a large share of the economy, PE models are useful when analyzing detailed sectors. However, when the policy shock is sector specific, PE models perform very well in predicting changes in patterns of food production and trade (Hertel, 1993).

The basic structure of a PE model comprises of either linear or log-linear behavioural equations, which allows the representation of the supply and demand relationships prevailing in the market under study (Van Tongeren *et al*, 2001). PE models may be single or multi-product specifications that capture border policies via price transmission elasticities or price wedges. The bulk of PE models focus on trade in primary products, but neglect trade in processed products and intra-industry trade (Meilke *et al*, 1996). They are best used when the effects of the policy change are largely limited to the sector in question (Rude and Meilke, 2004).

A CGE model can be viewed as a consistent sum of all PE models, with the explicit structural representation of all goods and factor markets as well as the specification of macroeconomic equilibrium conditions (Gohin and Moschini, 2006). They consider the agricultural sector as an open system that can potentially have significant effects on the rest of the economy. In addition, CGE models capture the implications of international trade for the whole economy, covering the circular flow of income and inter-industry relationships (Van Tongeren *et al*, 2001).

CGE models compliment PE approaches by illustrating input resource flows, changes in factor returns, marketing margins and input adjustments (Duff, 1996). Consequently, they improve on PE models by explicitly incorporating resource constraints, static demand side effects, broader coverage of processing activities and generally handle intra-industry trade using the Armingtons approach (Meilke *et al*, 1996). Moreover, CGE models impose regularity conditions on supply and demand elasticities and hence allow for the modelling of interactions between agricultural products and other commodities in a consistent way.

3.2.2. Strengths and Weaknesses of PE and CGE Models.

Even though PE and CGE models compliment each other, there are some meaningful trade offs between the two approaches. The major advantage of using PE models is that they are simple, transparent and add realism to a specific sector. PE models are suitable if the focus is on finely detailed sectors or on complicated agricultural policy mechanisms that are difficult to represent accurately and tractably without sacrificing consistency with economic theory. They serve as a first step towards understanding major direct effects of various trade interventions. Moreover, it is easier to incorporate policy mechanisms in PE than CGE models since they are structurally more flexible.

The major weakness with PE models is that they ignore interactions between agricultural sectors and other sectors of the economy. Consequently, they short-circuit broad economy wide considerations of trade policy. These models often fail to capture the demand side effects resulting from agricultural and non-agricultural trade liberalization (Meilke *et al*, 1996). Thus, PE models do not explicitly consider the shifting of resources across different sectors in an economy.

The ultimate advantage of a CGE framework lies in its ability to trace everything back to the household and its explicit treatment of inter-industry linkages. *Ceteris Paribus*, a CGE approach is bound to be more general and the results are more appealing on theoretical grounds (Gohin and Moschini, 2006). Other attractive attributes of CGE models include accounting consistency, theoretical consistency with the powerful check offered by Walrus law, and the possibility of conducting household-based welfare analysis (Hertel, 2002). In addition, CGE modelling is appropriate if the analyst is interested in social welfare calculations.

However, the improvement over PE models is often achieved at the cost of much higher levels of commodity and country aggregation and typically even simpler policy structure. The high level of product aggregation obscures sectoral details and often yields higher magnitudes of parameter estimates. Moreover, CGE models sacrifice important commodity and policy detail in evaluating trade agreements and often rely on outdated policy and market information (Westhoff *et al*, 2004). In addition, CGE models typically lag on policy and market information.

While CGE modelling is appropriate for economy wide studies in countries where agriculture forms a large share of the economy or where agriculture accounts for a large percentage of the labour force, PE modelling is timely and suited for sector specific studies. It is rather pointless to argue that PE or CGE is the superior modelling approach since the literature indicates that each approach is suitable under different circumstances. The bottom line is to use the approach that is best suited to the research questions at hand. In light of the pros and cons of both models, a PE approach is suitable for the current study since it focuses on a single agri-food sector.

3.3. Empirical Comparisons of Simulation Models

A large number of PE and CGE models have been used to analyze the welfare impacts of agricultural trade policies internationally. Van Tongeren *et al* (2001) offer a comprehensive review of many of these empirical studies in the developed economies. On the other hand, Reimer (2002) reviews the approaches adopted in low-income economies. In general, studies comparing PE and CGE estimates such as Gylfason, (1995); Bautista *et al*, (2001) and Tokarick (2003) offer mixed results, some concluding the estimates are different and others finding the exact opposite.

However, it has long been empirically proved that the two models lead to different outcomes with CGE models typically yielding larger welfare gains and lower price impacts than PE models (Gohin and Moschini 2006). While welfare estimates often differ in sign, large differences are also common in the magnitudes of estimated losses and gains. Whereas economists might accept and even welcome these discrepancies, the conflicting results can create confusion and undermine the credibility of applied analysis among policy makers and the general public (Gohin and Moschini, 2006).

3.3.1. A Review of the Simulation Models used in Developed Countries

A wide range of evaluations of the welfare impacts of agricultural trade reforms have been performed in the developed world. The frameworks used range from aggregate measures of support through analysis of specific modality issues to the complex simulation of PE and CGE models. Meilke *et al*, (1996) offer a comprehensive review of the studies undertaken prior to 1995. Recent works by Hertel, 1993; Peterson *et al*, 1994; Gylfason, 1995; Tokarick, 2003 and Gohin and Moschini, 2006 have attempted to explain the differences between PE and GE estimates in the developed economies.

Hertel, (1993) uses both approaches to study the impacts of the Common Agricultural Policy (CAP) and non-CAP policy reforms in the European Union (EU). He finds that the market effects of CAP removal on agricultural markets are very similar across PE or CGE models. However, the removal of non-CAP supports, yields different estimates for the PE and CGE models. The author concludes that PE models have difficulties predicting changes in patterns of food production and trade when the trade reforms affect food and non-food sectors. However, when the shock is sector specific, PE models perform very well as compared to CGE models.

Peterson *et al*, (1994) estimate the impacts of a complete agricultural liberalization in the USA and the EU using both approaches. The authors use a variant of the Static World Policy Simulation (SWOPSIM) model with three regions and 24 commodities to generate PE and CGE estimates. The study finds world price impacts and percentage changes in agricultural factor returns to be similar under both approaches. The authors conclude that it is sufficient to treat the non-food sector as exogenous if one is only interested in the farm sector effects of farm policies.

Gylfason (1995) explains the differences between PE and CGE estimates in the developed world by reviewing fourteen studies measuring the cost of EU's agricultural support in the 1980's. Nine of these studies used PE models while the other five were CGE based. According to the PE based studies, the cost of the CAP represented 0.7 percent of EU GDP as opposed to CGE studies that estimated cost the CAP at 2.2 percent of EU GDP. The results indicate that on average, CGE estimates were about three times higher than PE estimates. The author attributes these huge differences to the large elasticity of agricultural supply assumed in most CGE models.

Tokarick (2003) compares estimated welfare impacts of a complete removal of agricultural policies of developed countries using a PE model covering ten commodities with the standard Global Trade Analysis (GTAP) CGE model calibrated with data for 1997. His results indicate that agricultural trade liberalization increases social welfare in the EU, US and Japan, though the magnitudes of the gains differ substantially between the two models. These differences are explained by the displacement of resources (labour and capital) from agriculture to other economic sectors (manufacturing and services) which can only be captured by CGE models.

Gohin and Moschini, (2006) analyze the market and welfare effects of a complete phase out of the EU's CAP by use of both PE and CGE approaches. The authors compare the estimates of two CGE models with those of a PE model and in contrast to Gylfason (1995) findings report that the cost of the CAP never exceeds 0.2 percent of the EU GDP in both approaches. The study also finds that the predicted market effects of abolishing the CAP are comparable across models, and indeed the magnitudes of aggregate welfare effects are also similar. The authors conclude that in analyzing the food sector of developed economies, PE and CGE models yield comparable results.

The foregoing literature review suggests that PE and CGE approaches yield comparable results in the developed economies that have limited market distortions and where agriculture accounts for a small share of the economy. The studies that find significant differences between PE and CGE estimates exclusively focus on welfare effects while those that report similar results focus on market effects (Gohin and Moschini, 2006). Thus, it would be prudent to simultaneously consider the market and welfare effects in trade policy evaluations in deriving more conclusive comparisons.

3.3.2. A Review of the Modelling Approaches used in Developing Countries

In the developing countries, studies' detailing the effects of trade reforms gained prominence in the early 1980's following the SAPs. Agriculture in developing countries represents a large share of the economy and is generally perceived as taxed relative to the industrial sectors (Gohin and Moschini, 2006). Not surprisingly, a body of literature that quantifies the impacts of international trade on the poor has emerged. The vast majority of these trade/poverty empirical evaluations employ some form of simulation analysis (Reimer, 2002).

Reimer (2002) presents a detailed analysis of the approaches used to evaluate the impacts of trade liberalization in low-income economies. He summarizes and classifies 35 trade and poverty studies into four methodological categories: cross-country regression, partial-equilibrium/cost-of-living analysis, general equilibrium simulations, and micro-macro synthesis. The continuum of approaches is bounded on one end by econometric household expenditure data, which has been labelled the "bottom-up" approach. On the other end of the continuum are CGE models based on national accounts data or what might be called the "top-down approach.

The cross-country regressions category comprises two studies that test for correlations among trade, growth, income, poverty and inequality variables observed at the national level. These studies classify countries into globalizers and non-globalizers based on changes in trade volumes and tariff rates and find that the former tend to have higher growth than the later. These findings lead to the classical conclusion that globalization tends to be associated with a decline in poverty. However, regression analysis found no relationship between changes in trade and the poor's income share.

In the second category of Reimer's (2002) review were eleven PE or cost of living studies that were typically based on household expenditure data and that generally focused on a limited number of commodity markets and their roles in determining poverty levels. The majority of studies in this category could be regarded as microsimulation models since they focused on behaviour at the household level as opposed to using any sort of a representative household. The salient finding that the author drew from the PE approaches was that very low income households were not insulated from international shocks, and in fact tended to be hurt the most.

Eighteen of the studies reviewed by Reimer (2002) were classified as CGE approaches that are generally calibrated to a Social Accounting Matrix (SAM) that is a complete, consistent and disaggregated data system. The salient feature of SAM's is that they quantify at a single point in time the interdependence of sectors and regions in an economy and hence the ability of CGE models to capture sector interlinkages. The findings from the CGE studies are that trade liberalization in agriculture will result in gains for the country as a whole, while the rural poor loses out.

The final category of Reimer's (2002) review were four micro-macro synthesis that represent a relatively recent CGE simulations coupled with some form of post-simulation analysis based on household survey data. This approach is two-step in nature. The CGE model is first shocked to get commodity and factor price changes which are then fed into a post-simulation framework that calculates the effects on actual or highly disaggregated representative households. The studies attributed the poverty increases in equal measure to external shocks and trade policies. Overall, the findings suggest that the available policy options resulted in poverty increases.

The general conclusion of Reimer's (2002) survey is that any analysis of trade and poverty needs to be informed by both econometric and simulation perspectives. Indeed, the recent two-step micro-macro studies sequentially link these two types of frameworks, such that general equilibrium mechanisms are incorporated along with detailed household survey information. However, the foregoing literature review suggests that trade policy analysis in the developing world seems to rely more on simulations approaches that employ partial equilibrium analytical frameworks.

A number of other empirical studies on the effects of trade policy reform that were not captured by Reimer (2002) are presented in Annex 1. These studies adopt varying modelling approaches and support the view that a substantial policy bias against agriculture exists in low-income economies. However, to date, only a few studies attempt to compare PE and CGE estimates. The findings of the comparative approaches are mixed but in favour of CGE estimates. However, the differences in the estimates emanate from different assumption on the degree of commodity tradability.

Brandao *et al*, 1993; Bautista *et al*, 2001 and Blake *et al*, 2001 (Annex 1) attempt to contrast CGE and PE model estimates in their analysis of the impacts of trade liberalization in developing countries. Brandao *et al*, (1993) analyzes the consequences of agricultural trade liberalization using 1985 data from developing and developed countries. The study reports comparable PE and CGE estimates globally. The authors conclude that developing countries as a whole only experience a small gain from agricultural trade liberalization while the developed countries are the major benefactors. The authors also report comparable PE and CGE estimates in the developed and developing world.

Blake *et al*, (2001) uses aggregate time series data from Uganda to evaluate the market impacts of world trade liberalization. The study finds comparable low impacts estimates from both the PE and the CGE models using a 1995 database. The authors concluded that the impacts of trade liberalization on low-income countries such as Uganda appear to be quite small, albeit positive, largely because there is only a slight impact on world prices of the food exports. However, the largest proportional gains accrue to the urban populations.

Bautista *et al*, (2001), compare PE and CGE evaluations of the policy bias against agriculture with a stylized version of a Tanzania-like economy. Various agricultural terms-of-trade indices from a 1992 database are calibrated into a CGE model and compared with earlier PE measures of trade policy distortions that were developed by Krueger *et al*, (1988). The study finds that PE measures miss much of the action operating through indirect product and factor market linkages. In conclusion, the authors point out that relative to CGE estimates, PE measures overstate the strength of the linkages between the exchange rate and price of traded agricultural goods.

In related studies, Karim *et al*, (2003) and Fabiosa *et al*, (2004) in Annex 1 use multi-market PE models to the economy wide effects of agricultural trade policy in developing countries. evaluate market effects. While the former uses aggregate time series data from Sudan for the 1990 – 2001 period, the later adopts the Food and Agricultural Policy Research Institute (FAFRI) database for the entire World. The authors conclude that free trade leads to an expansion of food exports but penalizes net food importers through higher market prices. However, these multi-market evaluations are weakened by the omission of the industrial sector.

CGE models have also been commonly used to contrast the impacts of trade liberalization on poverty across countries. Studies applying CGE models to compare the effects of trade liberalization on poverty across developing countries include: Sadoulet and De Janvry, (1992), Hertel *et al*, (2003a, 2003b), Boussard *et al*, (2004), Winters *et al*, (2004) and Valenzuela *et al*, 2004 (see Annex 1). These studies report significant cross-country differences on the effects of free trade on poverty. These findings agree with other PE findings reported earlier in this review that demonstrate the discrepancies of free trade effects across commodities, seasons and regions.

The foregoing literature review seems to suggest that CGE approaches have been widely applied in analyzing the economy wide effects of trade on poverty in the developing countries. These studies have tended to evaluate entire agricultural sectors, complicating the analysis of sub-sectors within agriculture since the data used have been highly aggregated. In cases where single agricultural sectors have been examined, PE frameworks have been the preferred modelling approach. Not surprisingly, relatively few studies have compared PE and CGE model estimates

It can, therefore, be concluded that PE and CGE modelling approaches yield significantly different estimates in the developing economies. Thus, like previous studies on developed countries that find significant differences between PE and CGE estimates, the developing country studies reveal that, to a large extent, the specification of price elasticities is what drives the result. Moreover, the differences between PE and CGE estimates are exacerbated by the existence of market distortions in the developing countries. Thus, the selection of an appropriate modelling approach in developing countries largely determines the suitability of the results.

3.4. A Review of the Trade Liberalization Literature in Kenya's Maize Sector

In Kenya, empirical evaluations on the effects of policy reform in the maize sector became common following the SAPs initiated in the mid 1980's. These studies as outlined in Annex 2 reviewed the structure of maize marketing and the associated changes in prices, production and consumption. A closer examination of the existing literature in Kenya reveals that there have been limited attempts to model the effects of trade liberalization using PE or CGE approaches in this sector largely due to data limitations. However, a few economy wide CGE evaluations exist (Karingi and Sirinwardana, 2001 and 2003).

The earliest attempt to evaluate the impacts of maize market liberalization in Kenya was perhaps made by Argwings-Kodhek *et al*, (1993). The authors use the traditional structure-conduct-performance (SCP) approach to market analysis to compare the structure of maize trade in the controlled period to that of the post liberalized era and derive trade impacts. The authors concluded that the benefits of maize market reforms ware great and recommend a reduction of the presence of the NCPB in the market. However, the study made no attempt to estimates the gains from trade liberalization.

Jayne and Kodhek (1997) analyze consumer's response to maize market liberalization in urban Kenya. The authors specify an equation that decomposes changes in maize meal prices to changes in grain prices and to milling margins. Results are derived from two household surveys undertaken before full market liberalization in 1993 and after liberalization in 1995. The authors conclude that maize market liberalization has conferred substantial benefits to urban consumers. However, the use of marketing margins in only one major urban area may obscure the gains to the whole country.

Nyangito and Ndirangu (1997) use price and production trends to analyze farmer's response to reforms in maize marketing. The authors quantify the market effects from a sample of 60 farmers in Trans Nzoia district, one of the major maize producing regions in Kenya. The study finds that the impacts of the reforms were mixed, with no conclusive evidence on farmer's responses. While the authors shed some light on maize production changes, they do not explicitly model farmer's response to price incentives. Thus, it might be incorrect to attribute the production changes to trade liberalization alone since other factors such as weather also influence farm output.

Karingi and Siriwardana (2001) use a Kenyan CGE (KENGEM) model with a 1986 database to analyze the effects of SAPs on the economy. The study finds that the Kenyan economy stood to gain from agricultural trade liberalization. In another study in 2003, the authors use a KENGEM model with a 1979 database to evaluate the effects of external shocks on the agricultural sector. The study found that high import tariff and indirect taxes reduce the positive impacts of reform policies on the economy. These findings are expected since lower tariffs normally hurt import competing sectors (industry) but positively impact exporting sectors (agriculture).

In a review of the impact of institutional and regulatory frameworks in the food crops sector, Nyangito and Ndirangu (2002) analyze the performance of the three major cereals in Kenya using a combination of the structure-conduct-performance analysis with the new institutional economics approach. The study reported declining producer prices and domestic production after the decontrol of prices in 1995. The authors conclude that the reforms did not provide adequate incentives for increased domestic production. However, the study failed to formally model supply response.

Nyangito *et al* (2004) use national household survey data for 1982, 1992 and 1997 to analyze the impacts of agricultural trade and related policy reforms on food security in Kenya. The authors employed trend analysis and compute food security indicators to contrast the countries food security status before and after the trade reforms of 1995. The study concluded that agricultural prices and production have generally declined post reforms. Moreover, the food security status of the country has worsened after 1995. However, these PE measures fail to capture the interlinkages of the food sector with other sectors that would have been aptly captured by a GE approach.

Jayne *et al.* (2005) use a Vector Autoregressive (VAR) model to estimate the effects of government policy on wholesale maize prices and their volatility in Kenya. The authors estimate a counterfactual set of maize prices that would have occurred over the 1990 – 2004 period had the NCPB not existed and had tariffs been abolished. The study finds that NCPB's operations raise wholesale market prices while the import tariff exerts only modest effects on open market maize price levels. While the VAR approach helps to overcome the Lucas critique by endogenizing policy variables, it is not as informative as the behavioural relationships used in simulation models.

In Kenya, the literature on the impacts of trade liberalization in the maize sector has been controversial. As Jayne *et al* 2001 observe, the effects of the trade reforms on farmer and consumer welfare have been the subject of speculation driven by preconceived notions on both sides. These distorted perceptions are worsened by the paucity of ground level-information on how farmers and consumers are responding to the reforms. To inform this controversy, there is need for rigorous research that can provide comparative empirical estimates from both PE and CGE models.

3.5. Chapter Summary

The literature review presented in this chapter explores the modelling approaches adopted in analyzing agricultural trade liberalization and discusses the empirical and literature gaps in the Kenyan maize sector. In practice, econometric and simulation models have been used to study the effects of agricultural policies. However, a vast majority of trade policy studies have employed simulation models owing to their ability to incorporate structural changes. PE and CGE approaches yield significantly different estimates in developing countries. However, PE and CGE models yield comparable estimates when price elasticities are well specified. The choice of the simulation approach to adopt therefore has to be informed by other considerations.

A PE approach is logical for the current study since the major objective is to analyze the effects of trade liberalization on a single agricultural sector. This choice is largely driven by the strengths and weaknesses of both approaches, which are enumerated earlier on in this chapter. Unlike CGE models that rely on outdated and highly aggregated data, PE approaches incorporate a greater scope of sectorial detail in theoretically consistent approaches. PE models are structurally more flexible than CGE models and are thus easier to calibrate.

The next chapter develops the conceptual framework used to quantify the market and welfare impacts of trade liberalization and their distributional effects on stakeholders in Kenya's maize sector. It offers a theoretically consistent approach to analyze the behaviour of economic agents and at the same time develops a graphical framework to quantify the impacts of trade liberalization. In addition, the next chapter derives theoretical comparative static's to guide the empirical estimations.

Chapter 4

Conceptual Framework

4.1. Introduction

This chapter explores the theoretical basis of an industry model and derives the behavior of economic agents at three market levels of the maize sector in Kenya. The chapter is organized into three parts. First, a complete structural model of the sector is formulated and used to derive comparative static's. This is followed by a description of the theoretical frameworks underlying the behavior of economic agents at various market levels. Finally, a graphical form of a partial equilibrium model (PEM) of trade is presented and used to evaluate the welfare impacts of trade liberalization.

4.2. A Structural Model of the Maize Sector in Kenya

This study uses the conceptual model developed by Wohlgenant (1989) for analyzing market interlinkages. Assuming perfect competition, the structural model is specified:

$Q_r^d = D_r(P_r, Z)$ (retail demand), (4.1)

$Q_r^s = \sum S_r^i(P_r, P_w, C)$ (retail supply), (4.2)

$Q_w^d = \sum D_w^i(P_r, P_w, C)$ (Wholesale demand), (4.3)

$Q_w^s = \sum S_w^i(P_f, P_w, C)$ (wholesale supply), (4.4)

$Q_f^d = \sum D_f^i(P_f, P_w, C)$ (farm derived demand), (4.5)

Q_f^s, predetermined (farm-level supply), (4.6)

$Q_r^d = Q_r^s = Q_r$ (retail market-clearing condition), (4.7)

$Q_w^d = Q_w^s = Q_w$ (wholesale market-clearing condition), (4.8)

$Q_f^d = Q_f^s = Q_f$ (farm-level market-clearing condition), (4.9)

Where Q_r^d and Q_r^s are the retail demand and supply quantities, P_r is the retail price and Z is an exogenous retail demand shifter. Q_w^d and Q_w^s are wholesale demand and supply quantities, P_w is the wholesale price and C is a wholesale marketing costs. Finally, Q_f^d and Q_f^s are the quantities of farm derived demand and farm output supply while P_f is the producer price. The model adopts market linkages that are similar to the theoretical frameworks provided for consumer demand and producer supply interrelationships.

The function for the farm derived demand and hence wholesale supply and that for wholesale derived demand and hence the retail supply are explicitly obtained as horizontal summations of the demand and supply functions of individual firms, where i denotes an individual firm. In conformity with the biological lags in agricultural production processes, supply at the farm level is a function of lagged, rather than current prices. Thus, the quantity of farm output is assumed to be predetermined with respect to the current period's producer price.

The retail and wholesale levels can be solved jointly and the results generalized for the farm level. Using the market-clearing conditions (4.7) and (4.8), the structural system in (4.1) to (4.4) may be rewritten as a two-equation system:

$$Q_w - \sum D_w^i(P_r, P_w, C) = 0 \text{, and} \qquad (4.10)$$

$$\sum S_r^i(P_r, P_w, C) - D_r(P_r, Z) = 0 . \qquad (4.11)$$

Following Wohlgenant, equations (4.10) and (4.11) are totally differentiated, expressed in elasticity form, and solved using $d\ln(P_r)$ and $d\ln(P_w)$ to yield:

$$d\ln(P_r) = A_{rz} * d\ln(Z) + A_{rc} * d\ln(c) + A_{rw} * d\ln(Q_w) \text{, and} \qquad (4.12)$$

$$d\ln(P_w) = A_{wz} * d\ln(Z) + A_{wc} * d\ln(c) + A_{ww} * d\ln(Q_w) , \qquad (4.13)$$

where

$$A_{rz} = -\varepsilon_{ww}^{D}\eta_{rz}^{D} / K, \tag{4.14}$$

$$A_{rc} = (\varepsilon_{ww}^{D}\xi_{rc}^{S} - \xi_{rw}^{S}\varepsilon_{wc}^{D}) / K, \tag{4.15}$$

$$A_{rw} = \xi_{rw}^{S} / K, \tag{4.16}$$

$$A_{wz} = -\varepsilon_{wr}^{D}\varepsilon_{rz}^{D} / K, \tag{4.17}$$

$$A_{wc} = [\varepsilon_{wr}^{D}\xi_{rw}^{s} - (\xi_{rr}^{s}\varepsilon_{rr}^{D})\varepsilon_{wc}^{D}] / K, \tag{4.18}$$

$$A_{ww} = (\xi_{rr}^{S} - \varepsilon_{rr}^{D}) / K, \tag{4.19}$$

$$K = -(-\xi_{rr}^{s} - \varepsilon_{rr}^{D})\varepsilon_{ww}^{D} + \xi_{rw}^{S}\varepsilon_{wr}^{D}. \tag{4.20}$$

The reciprocal of the A_{ij}'s are price elasticities at the respective market levels *ceteris paribus*. The variables in equations (4.14) to (4.20), with expected signs shown in parentheses, are as follows: ε^{D}_{ww} (-) is the elasticity of wholesale demand with respect to wholesale price; η^{D}_{rz} (+) is the elasticity of retail demand with respect to the retail demand shifter and ξ^{S}_{rc} (?) is the elasticity of retail supply with respect to the marketing cost, whose sign as implied by the question mark is ambiguous.

Assuming that the wholesale product is a normal good, ξ^{S}_{rw} (-) is the elasticity of retail supply with respect to wholesale price; ε^{D}_{wc} (?) is the elasticity of wholesale demand with respect to the marketing cost; ε^{D}_{wr} (+) is the elasticity of wholesale demand with respect to retail price; ξ^{S}_{rr} (+) is the elasticity of retail supply with respect to retail price; and ε^{D}_{rr} (-) is the elasticity of retail demand with respect to retail price. Thus, intuitively ε^{D}_{ff}(-) is the elasticity of the farm derived demand with respect to the producer price; ε^{D}_{fw} (+) is the elasticity of the farm derived demand with respect to the wholesale price and ε^{D}_{fc} (?) is the elasticity of the farm derived demand with respect to the wholesale marketing costs.

Given that K is negative, A_{rz}, and A_{ww}, are negative, A_{rw} and A_{wz} are positive, and A_{rc} and A_{wc} cannot be signed because the signs of ξ^{S}_{rc} and ε^{D}_{wc} are ambiguous. The expected sign of the elasticities listed in equations (4.14) to (4.20) enables one to assign directions to the elasticities generated from equations (4.12) and (4.13). Using the same intuition, the parameters of the farm derived demand: A_{ff}, A_{fw} and A_{fc} can be assigned negative, positive and ambiguous directions. The complete system is under-identified since there are eight reduced-form parameters and 10 elasticities of the structural equations. Thus, it is not possible to obtain unique values for ε's and ξ's.

However, if the values of the retail demand elasticities are known, then unique estimates of the elasticities of supply and demand can be obtained from the reduced-form estimates. An interesting parameter for this study is (n), the elasticity of price transmission across different market level prices that is derived as:

$$n_{fw} = A_{wf} / A_{ff} \tag{4.21}$$

$$n_{wr} = A_{rw} / A_{ww} \tag{4.22}$$

Where n_{fw} and n_{wr} are the elasticities of price transmission between the farm and wholesale prices; and wholesale and retail prices respectively.

4.3. Theoretical Considerations in Analysing Market Behaviour

This section presents consistent approaches for modeling the behavior of the various economic agents at the farm, wholesale and retail levels of the maize market in Kenya. It explores the theory of the firm to model the behavior under price risk of commercial and smallholder maize farmers in Kenya. In addition, the theory of the firm is used to derive intermediate demands. Finally, the theory of the consumer is explored as the basis of applied demand analysis for policy making.

4.3.1. Producer Behaviour under Price Risk

In this section, the behaviour of producers facing uncertain prices is modelled from the principles of expected utility maximization and used to derive output supply. Since the Kenyan maize sector consists of both commercial and smallholder farmers, two theoretical frameworks of producer behaviour are explored. Thus, the behaviour of pure producers and that of "marketed-surplus" producers are separately presented.

4.3.1a. Commercial Producer Behaviour under Risk

Commercial producers set their output levels to maximize the expected utility of profits. The firm's objective function can be algebraically specified as:

$$\text{Max}_{\{Y\}}\ E[U(\pi)] = EP_d \cdot Y - C(Y) - \frac{\Omega}{2}(Y^2\sigma^2{}_{P_d}) \qquad (4.23)$$

Where E is the expectations operator, $E\ [U\ (\pi)]$ is the expected utility of profits, EP_d is the expected producer price, Y is output and ($Y^2\sigma^2{}_{Pd}$) is the variance of profits (π). $C(Y)$ is the total cost of production. Ω is a risk aversion parameter where $\Omega > 0$ implies risk aversion while $\Omega < 0$ suggests risk loving.

Optimisation of equation (4.23) with respect to the output level yields:

$$\frac{\partial E[U(\pi)]}{\partial Y} = EP_d - C'(Y) - \Omega Y\sigma^2{}_{P_d} = 0 \qquad (4.24)$$

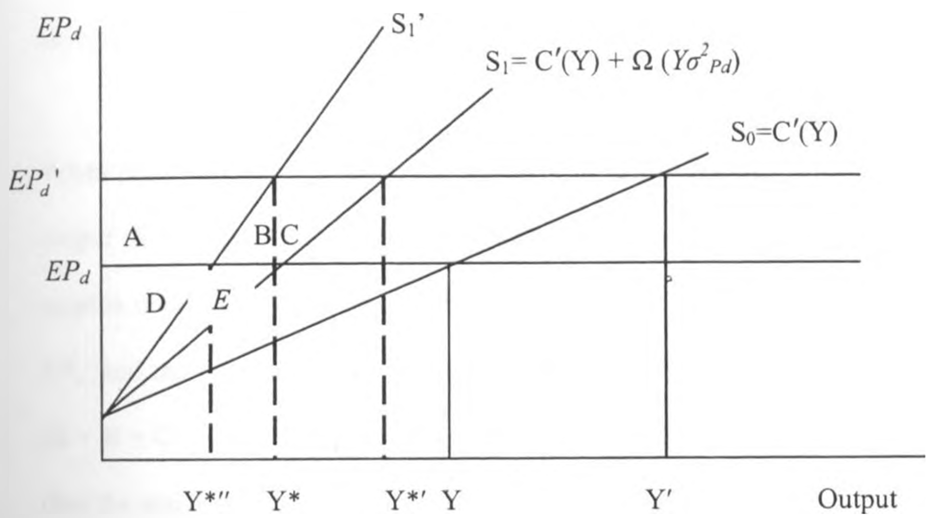
This optimality condition implies that the optimal output level under risk will be less than the corresponding output under certainty. The difference between these two outputs arises from the marginal cost of risk-bearing ($\Omega Y\sigma^2{}_{Pd}$) that reduces the firms output relative to production under certainty (Figure 4.1). Risk averse producers are thus expected to reduce their output by an amount equal to the cost of risk-bearing.

The first order conditions can be solved for the optimal output under risk as:

$$EP_d = C'(Y) + \Omega(Y\sigma^2{}_{P_d}) \qquad (4.25)$$

Unlike the competitive case under certainty where price equals marginal cost of production, the optimal decision under uncertainty obtains when the expected price equals to marginal cost of production plus the marginal cost of risk bearing. Thus, under price uncertainty, output is smaller than the certainty output (Sandmo, 1971). This observation is shown in Figure 4.1, where the output for risk-averse producers (Y*) is strictly less than the expected profit maximizing level (Y) at all output prices.

Figure 4.1. Marginal Cost under Certainty and Risk



Analytically $\frac{\partial y}{\partial EP_d} > 0$ and $\frac{\partial y}{\partial \sigma^2_{Pd}} < 0$ implying that an increase in the expected price increases output while an increase in price variability decreases output. These relationships can be used to demonstrate the behaviour of producers in response to changes in policies such as trade liberalization that affect producer prices and to measure the resulting welfare changes. The area above the supply curve falling below the expected price in Figure 4.1 represents producer surplus (PS) at the farm level. It can be analytically derived by integrating the supply function with respect to output.

$$PS = EP_d . Y^* - \int_0^{Y^*} \{C'(Y) + \Omega(Y\sigma P_d^{\ 2})\} dY \qquad (4.26)$$

The impacts of trade liberalization on the welfare of producers can be illustrated graphically by changing the values of the expected price while that the effects of price risk can be illustrated by the coefficient of price variability. The initial producer surplus under certainty at price level $P_0 = EP_d$ is represented by the area above supply curve (S_0) that lies below price EP_d (Figure 4.1). If the expected price increases to EP_d', output rises from (Y) to (Y′) and the producer surplus increases to the area below the new price line (EP_d') that is above the supply curve (S_0). Of course, the reverse is also true in the case of a decrease in the expected price.

When prices are uncertain, the supply curve pivots backwards to S_1 and the optimal output (Y*) is less than that achieved under certainty (Figure 4.1). At EP_d, producer surplus under risk is represented by area (D + E). If the expected price increases to EP_d' and the price variability remains unchanged, producer surplus increases to area (A + B + C + D + E) with an higher output of (Y*′). However, if price variability and thus the marginal cost of risk bearing increases at this new expected price, the supply curve S_1 pivots backwards to S_1' and output falls back to Y* (Figure 4.1).

The increased variability reduces producer surplus from area (A + B+ C+ D + E) to area (A + D) at price EP_d' (Figure 4.1). Thus, the change in producer surplus at the higher expected price and increased price variability from the original levels is area (A + D) – (D + E). Thus, the net effect is either positive if A > E or negative if E > A. Overall, an increase in the expected price and a decrease in price variability increases producer surplus. Conversely, a decrease in the expected price with increased price variability as has been witnessed in Kenya's maize sector after trade liberalization has the net effect of decreasing producer surplus.

4.3.1b. Small-Scale Farming Household Behaviour under Risk

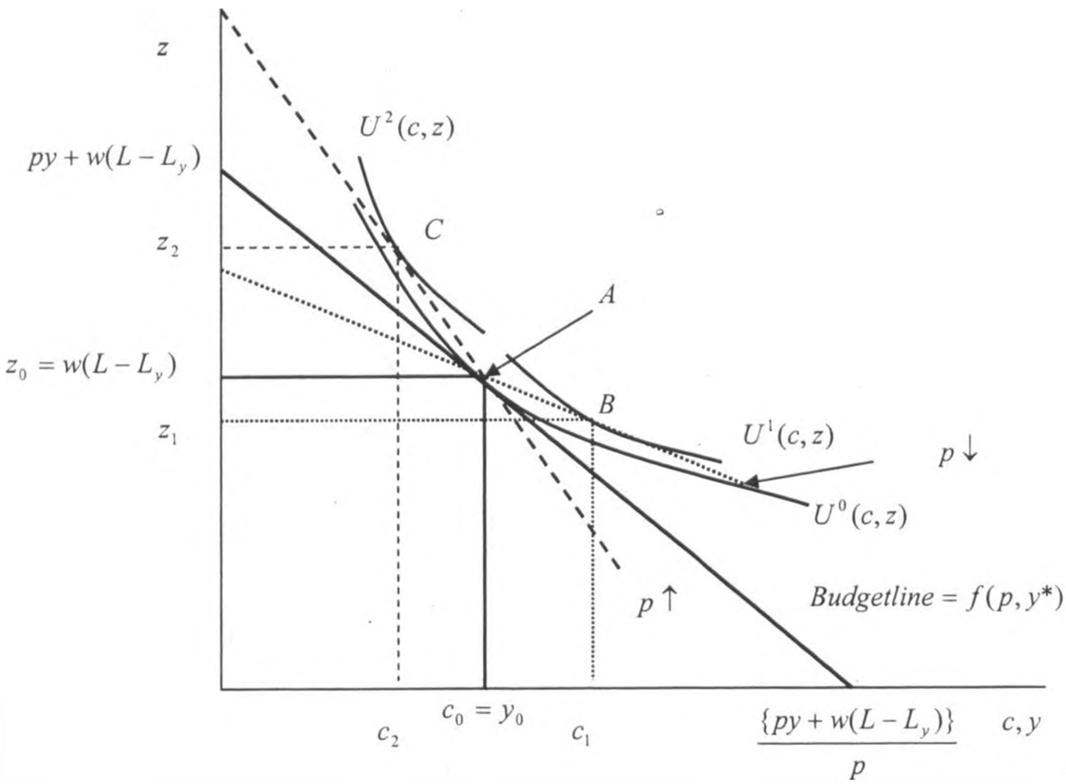
This section develops a framework to analyze the behaviour of a smallholder producing a staple commodity. The household consumes part of this commodity and markets the balance. Thus, household production and consumption decisions are jointly determined. However, these decisions are modeled separately in a simple graphical form of a two-period model of crop portfolio choice under output price risk as proposed by Finkelshtain and Chalfant, (1991) and applied in Fafchamps, (1992). The household objective is to maximize its expected utility under uncertain prices.

Consider a household with a fixed acreage of land that produces maize (y) using labour (L) as the only variable input. The household allocates its time between the production of maize that it either consumes (c) or markets (m) at uncertain prices (p) and working in the market for a wage (w). Consumption decisions concern a portion of the farm output (c) and a composite market good (z). The composite good is a *numeraire* showing the consumption of all other goods. Thus, all prices are measured relative to that of z. The household's labour is spent either in home production of maize (L_y) or in off-farm work (L_w) such that the total time available is ($L = L_y + L_w$).

This is a two-period model. Initially, the producer decides on his crop portfolio. Maize prices are unknown *ex ante* when production decisions are taken. In the second period, maize is harvested and its sales proceeds are used to purchase consumption goods, although some or even all of the maize may be consumed. Consequently, all consumption decisions are taken after harvest (*ex post*). Thus, the household faces income risk over the entire range of values taken by income and prices since its income is partly derived from the sale of maize at uncertain prices.

A graphical form of the composite good theory can be used to illustrate the effects of price risk on the *ex post* optimal consumption decisions for three household types; "purely" subsistent, net sellers and net buyers. Figure 4.2 represents the behaviour of a household that consumes almost all its output of maize ("purely" subsistent). The vertical axis measures the household's consumption of the composite market good (z), while the horizontal axis shows its consumption (c) and production of maize (y).

Figure 4.2. Subsistent Household Behaviour under Price Risk



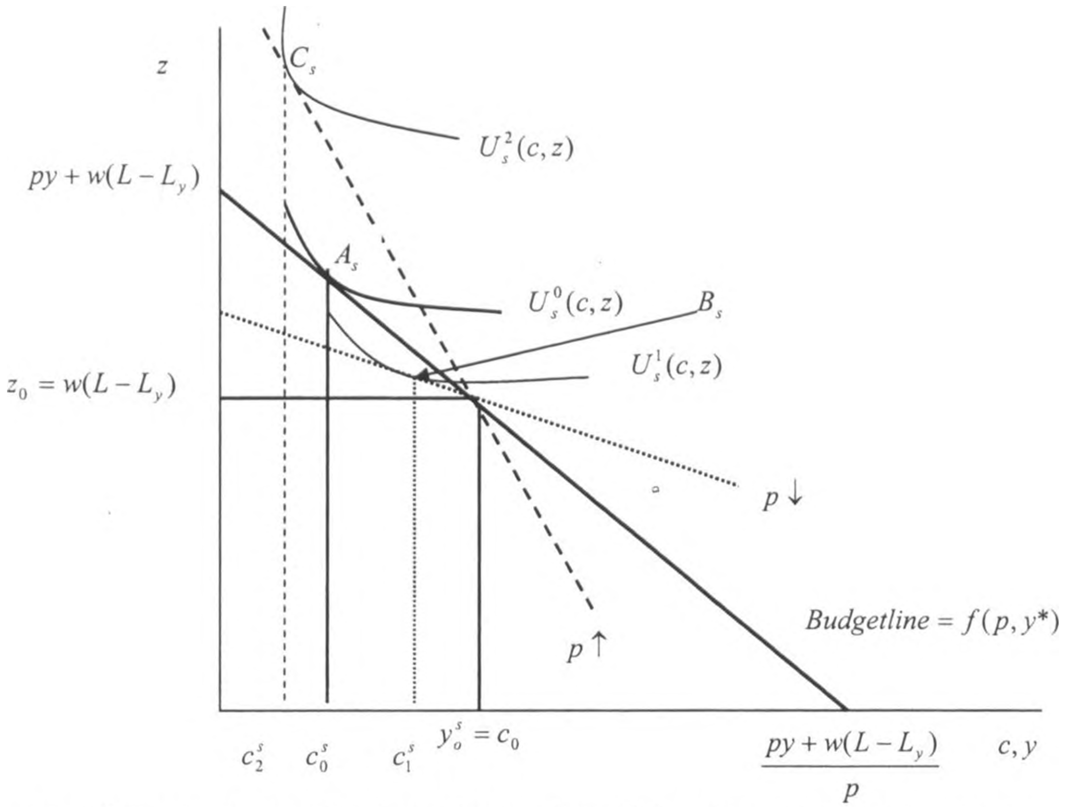
The optimal choices of c and z obtain at the points of tangency between the budget line and the indifference curves associated with the *ex post* utility $\{U(c, z)\}$. If the household spends all its income on maize consumption, it buys $[\{py + w(L - L_y)\}/p]$ units of maize. Conversely $py + w(L - L_y)$ units of the composite good are purchased when the household spends all its income on z. Of course, all allocations of c and z along the budget line associated with a given price of maize are also feasible.

To derive the optimal choices of c and z, the indifference map is superimposed on the budget line. The slope of the budget line is given by the ratio of the relative prices of c and z (in this case $-p$ since z is a *numeraire*). Suppose that, *ex post*, the price of maize is such that the household produces and consumes $c_0 = y_0$ units of maize at an arbitrary price p_0 (Figure 4.2). Household utility is maximized at point A where the household consumes all its output of maize and spends $\{ w(L - L_y) \}$ on z. The effects of price risk are shown by changing the price of maize from p_0. This alters the slope of the budget line and, ultimately, the optimal choices and resulting level of utility.

At prices lower than p_0, the household increases its consumption of maize to $c_1 > y_0$ but reduces its consumption of other goods to z_1. The household is "a slight net buyer" at this price. Its preferences at the lower price are maximized at point *B*, which represents a higher level of utility U^1 (Figure 4.2). Conversely, if the price of maize is higher than p_0, the household consumes less maize at $c_2 < y_0$ and more of z at z_2 through some sale of its maize production, hence becoming "a little bit of a net seller" at this price. Its utility with a price increase is maximized at a higher utility U^2 (point *C*). Thus, such a household is always better off *ex post* with price variability.

Figure 4.3 shows the behaviour under risk of a net selling household, which produces more maize than it consumes ($y_0 > c_0$) and sells its surplus. The household behaves as a commercial producer with regard to its "marketed-surplus" (m) and its indifference curves are steeper relative to the "purely" subsistent type. Alternatively, this could be a household with the same preferences as a "purely" subsistent type but with higher output due to reasons such as having higher acreage. Let the household produce (y'_0) units of maize and consume less c and more z relative to the "purely" subsistent type.

Figure 4.3. Net Selling Household Behaviour under Price Risk

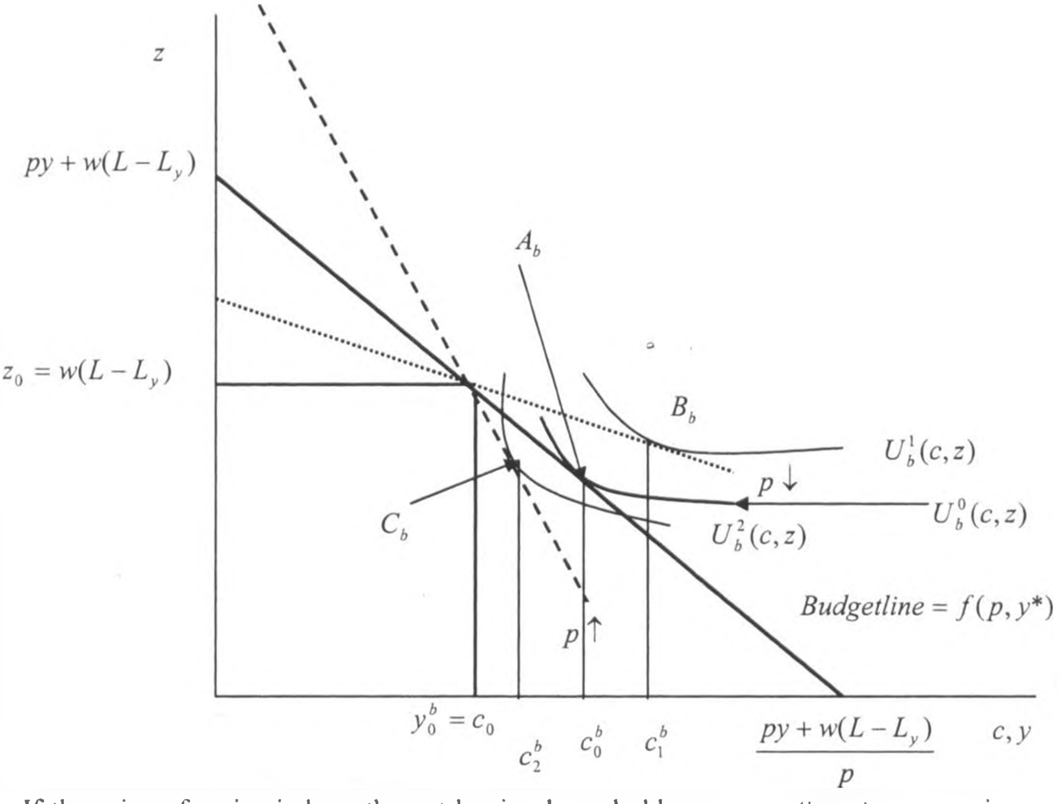


Its preferences are maximized at point A_s where $c^s{}_0$ is consumed and the surplus is marketed. Like pure producers, net-sellers derive a large share of their income from maize production and may be highly responsive to price variability. Of course, *ex ante* price variability may lead to changes in household production decisions. At lower prices, net sellers reduce their marketed surplus from ($y^s{}_0$ - $c^s{}_0$) to ($y^s{}_0$ - $c^s{}_1$) and maximize their utility at point B_s, making them worse off as utility falls to U^1.

In the event of higher prices, net selling households are made better off. They maximize utility at a higher level (point C_s) and market their surplus production ($y^s{}_0$ - $c^s{}_2$). Thus, net selling households care a lot about price variability since higher prices leave them better-off while lower prices make them worse off. Like pure producers, their output under price risk is likely to be lower than that under certainty.

The effects of risk on the behaviour of net buyers are shown in Figure 4.4. The net-buying household consumes all its output of maize and also relies on the market for a major part of its maize consumption needs. In this case, price uncertainty implies uncertainty about its purchased portion of maize. Suppose the household produces $y^b{}_0$ and consumes $c^b{}_0$ units of maize (Figure 4.4). In addition, it spends less on z than the "purely" subsistent type and purchases $(c^b{}_0 - y^b{}_0)$ units of maize for consumption.

Figure 4.4. Net Buying Household Behaviour under Price Risk



If the price of maize is low, the net buying household consumes (buys) more maize $(c^b{}_1)$ and less of the composite good (Figure 4.4). This makes the net-seller better off since utility is maximized at a higher level (point B_b). In contrast, higher maize prices force the household to reduce its market purchases of maize to $c^b{}_2$, which leaves it worse off since its utility is maximized at a lower level (point C_b).

The response to price risk among risk averse producers is highly differentiated[10]. On the basis of the *ex post* analysis of producer behaviour under risk, the output of pure producers is less than the certainty output. Similarly, it is plausible that net selling households reduce their production under risk but quite possibly by a lesser amount than pure producers since consuming part of their output offers some insulation against price shocks. Moreover, net buyers insure themselves by producing more in the face of risk while very risk averse food deficit households may produce more under uncertainty than under certainty to reduce their exposure to extreme prices.

Overall, it might appear as though subsistent producers do not care much about price risk since they insure themselves by altering their *ex post* consumption decisions. Thus, the "purely" subsistent household at least appears to be better off with price risk while net sellers and net buyers could either be better off or worse off. In this analysis, no attempt has been made to model the *ex ante* production decisions since the current focus is on the effect of price variability on *ex post* consumption decisions. However, these results might change when *ex ante* production decisions are taken into account.

Unlike the pure producer, the welfare of the subsistent household can be measured by aggregating the surplus from production with that attained from consumption. However, such an aggregate measure is analytically intractable given the pervasive nature of own consumption of home production. The only viable option to analyze the impact of price risk on small-scale producers is to ignore autarkic households and concentrate on market participants. The producer surplus for such households can be derived from the mean variance model adopted for commercial producers.

[10] While the behaviour of different household types under price risk can be analytically derived, researchers often have no access to data differentiated by producer types. Thus, empirical analyses in such cases rely on aggregate marketed production data. This approach is adopted in the current study.

Some stringent assumptions are required to derive the "marketed-surplus" producer surplus in a similar approach to that used for commercial producers. These include the requirement that the household's production technology and its risk premium are identical to those of the commercial producer. While the former can be imposed parametrically, the later is achieved by assuming no interaction between income and the consumption price, which reduces the risk premium to a univariate measure. The "marketed-surplus" producer welfare with price risk can be expressed as:

$$PS = EP_d.(y-c) - \int_0^y [C'(y-c) + \{\Omega(y-c)\sigma^2{}_{pd}\}]\partial y \qquad (4.27)$$

In this case, the income risk comes from the marketed surplus (*y-c*). Like the case of a pure producer, price variability reduces the welfare of "marketed-surplus" producers. However, unless one also knows the relative degree of risk aversion between a pure producer and a net seller/buyer or subsistent farmer, it is not possible to know which type is more adversely affected by price risk from an *ex ante* perspective. Thus, the impact of price risk on *ex ante* production decisions is dependent on the degree of risk aversion that is not necessarily revealed *ex post* by household choices.

The above argument follows because, households have unobserved heterogeneous preferences for risk, which affect the "type" of household they become (net sellers, almost "purely" subsistent, or net buyers) based on their degree of risk aversion. Thus, "purely" subsistent households may make this choice due to a very high degree of risk aversion that induces them to produce less output than they would if they were less risk averse. Therefore, although variation in price seems advantageous *ex post* to such households, it may be quite harmful from an *ex ante* perspective.

4.3.2. Aggregation across Different Producer Types

One of the major objectives of this study is to understand producer's response to trade policy changes at the aggregate national level. Consequently, the unit of analysis in this study is the industry rather than the individual firm. Thus, the output derived from pure producers and that from subsistent households should be aggregated to derive industry supply. It is therefore important to explore the necessary conditions for consistent aggregation of inputs and outputs across different producer groups.

In order to represent the aggregate choices made by the individuals in a household as to though they were made by a single optimizing agent, the preferences of these agents must be characterized by some form of transferable utility (Bardhan and Udry, 1999). A second and perhaps a slightly weaker assumption required for the validity of the unitary household representation is that of transferable utility conditional on the actions of the household members (Becker, 1981). These two assumptions are quite restrictive but are unavoidable in deriving marketed-surplus production given the data limitations in this study.

In order to aggregate the marketed-surplus from subsistence producers with the output from pure producers, two other aggregation conditions across outputs and firms (producers) must be satisfied. Consistent aggregation across inputs and outputs require the presence of weak separability. Moreover, aggregation across firms requires the existence of quasi-homothetic production functions. These conditions impose restrictions on the choice of functional forms for both producer types but are satisfied by assuming that the underlying cost functions for commercial producers and "marketed surplus" producers are quasi-homothetic and weakly separable.

4.4. Decision Making at the Wholesale Level

The behaviour of economic agents at the wholesale level of Kenya's maize market is characterized as that of competitive firms. The firm's choose their input and output levels to maximize expected profits. Their objective function can be expressed as:

$$Max_{\{X\}} EU[\pi(P,C)] = EU\{\sum_{j=1}^{N} P_j'Y_j - \sum_{k=2}^{K} C'_k X_k\} \tag{4.28}$$

Where $\sum_{j=1}^{N} P_j'Y_k$ and $\sum_{k=2}^{K} C_k X_k$ represents the firms total revenue and the total variable cost respectively. An application of Hotelling's lemma to equation 4.28 allows for the derivation of the firm's unconditional input demands and output supply.

$$\partial[\pi(P,C)]/\partial C = -X(P_i, P_j, C) \tag{4.29}$$

$$\partial[\pi(P,C)]/\partial Y = Y(P_i, P_j, C) \tag{4.30}$$

The farm-level demand is derived from supply at the wholesale level as a function of producer prices, wholesale prices and a marketing cost. Moreover, wholesale demand is derived from supply at the retail level as a function of wholesale and retail prices.

Thus, two welfare measures are derived at the wholesale level. One, the retailer surplus (*RS*) at the wholesale level that equals the producer surplus at the retail level:

$$RS = P \cdot X - \int_0^X C'(X)\partial X \tag{4.31}$$

Secondly, the consumer surplus at the farm level that is measured as the wholesaler surplus at the farm-level *(WS)* and specified as:

$$WS = \int_0^Y P \cdot \partial Y - P.Y \tag{4.32}$$

The impacts of trade liberalization at the intermediate level are an empirical question since the net effect of price changes is depended on farm, retail and wholesale prices.

4.5. Consumer Behaviour

Consumers form the demand side of the market and are assumed to maximize a utility function that represents their ordering of preferences. Consider an individual with a twice continuously differentiable quasi-concave utility function *U (Q, H)*, faced with a budget constraint $P_c'Q = M$ where Q is a vector of n commodities on which a consumption decision is to be made, H is a vector of individual characteristics, P'_c is a row vector of consumer prices and M is the income to be spent:

The individual's problem is to:

$$\text{Max}_{\{Q\,\lambda\}}\ U(Q,H) + \lambda(M - P_c'Q) \tag{4.33}$$

Where λ is a Lagrange multiplier interpreted as the marginal utility of money. The solution to this maximization problem is a set of n demand equations.

$$Q_i = Q_i(P_c, M, H) \qquad i = 1, 2, \ldots\ldots, n \tag{4.34}$$

The gains to consumers and their responses to trade liberalization can be analyzed using consumer surplus. Consumer surplus is the area above the price line that is below the demand curve. It is derived from an integration of the demand curve:

$$CS = \int_0^Q P \cdot \partial Q - P \cdot Q \tag{4.35}$$

Unlike the producers, decreases in maize retail prices such as those associated with trade liberalization always make consumer's better off since the declining prices increase consumer surplus. In addition, maize consumers are cushioned from price uncertainty since retail prices are determined in international markets and given that Kenya is a small open importing economy. Thus, it is expected that maize consumers in Kenya will have benefited from trade liberalization.

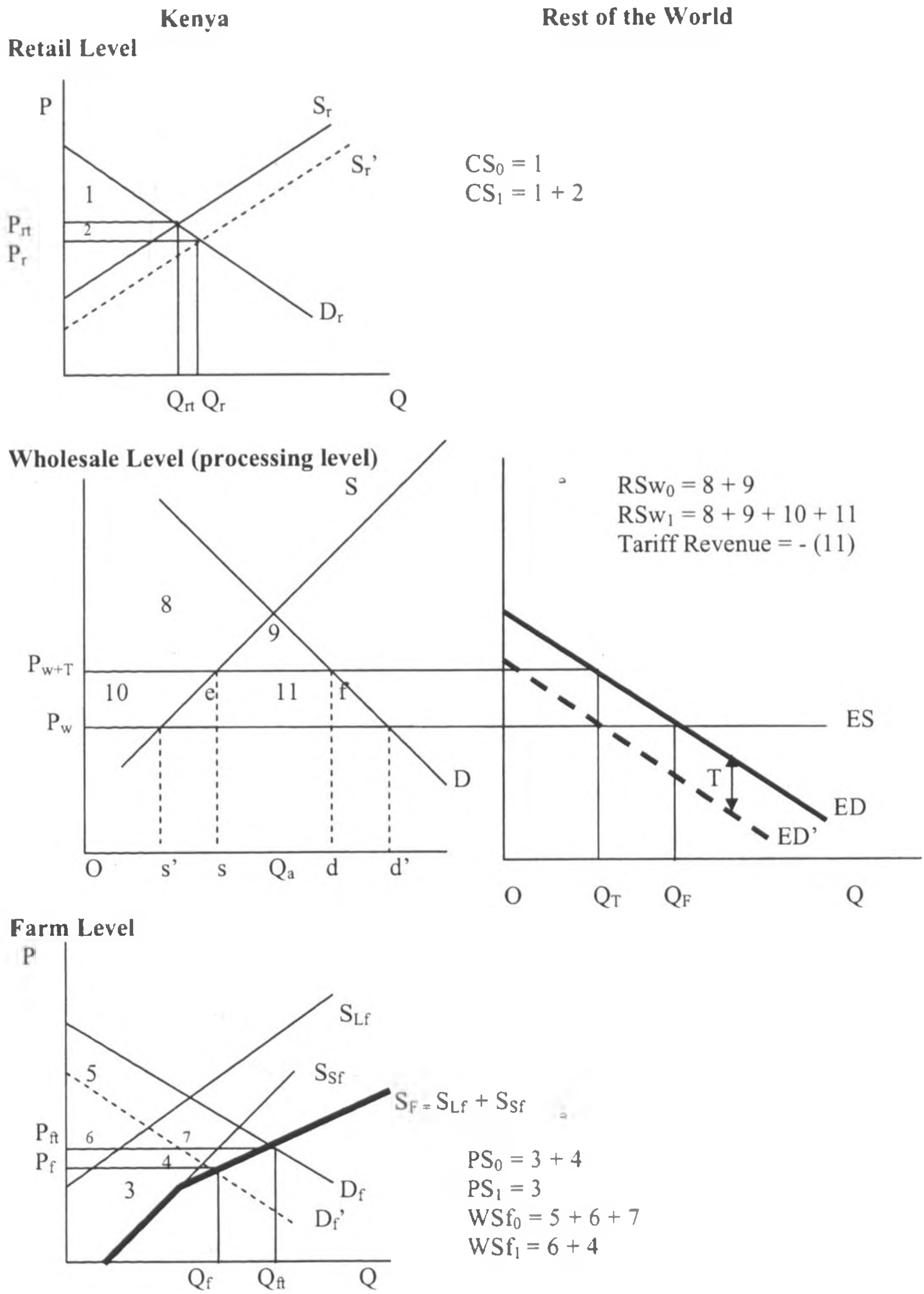
4.6. A Partial Equilibrium Model (PEM) of Maize Trade in Kenya

The basic PEM of agricultural trade follows the rule of spatial arbitrage that trade between two regions occurs when the price difference between them reaches the transfer cost (Krishnaiah, 1995). It assumes perfect substitutability between domestic and imported commodities. The model entails a demand equation to determine consumption, a supply equation to determine domestic production and a supply-demand identity to determine market clearing conditions. It can be illustrated by four panel diagrams representing the responses of agents at three market levels.

Figure 4.6 features trade in maize between two spatially separated markets; Kenya and the rest of the world (RoW). The model comprises of linear supply and demand schedules at the farm, wholesale and retail levels. It assumes a homogeneous commodity (maize) that is traded at a commonly defined currency. External maize trade occurs at the wholesale market level in the form of unprocessed grain. The model simulates the effects of a reduction in import tariff levels on the welfare of agents at the three market levels. The simulations undertaken (see chapter 7) are in line with Kenya's market access commitments at the WTO.

The small-country importer assumption is made in this model since Kenya is a net importer of maize that does not control a large share of the world market. Thus, domestic maize prices are fixed in the world market independently of the quantities imported. Suppose the demand and supply for maize in Kenya is represented by curves D and S respectively (Figure 4.6). In autarky, the domestic wholesale prices in Kenya are higher than the world price (Pw). Thus the country is in a potential excess demand (ED) situation equal to (d' – s') and imports OQ_F from the world market.

Figure 4.6. Effects of Import Tariffs Changes on the Maize Sector in Kenya



When external trade is allowed with a fixed import tariff (T), the initial equilibrium obtains at price $P_W + T$ where demand exceeds supply by (d – s). The tariff shifts the excess demand curve from ED to ED' and the quantity imported drops from OQ_F to OQ_T. The effects of trade liberalization at the wholesale market level can be analyzed by abolishing the import tariff. Subsequently, supply increases as wholesale prices decline from $P_w + T$ to P_w. This policy measure shifts the excess demand curve to the right, from ED' to ED as imports climb back to OQ_F (Figure 4.6).

The wholesale level is linked to the farm and retail sector through the derived market relationships. In this model, producer prices and consumer prices are predetermined and taken as given. In addition, the quantities at the wholesale and retail levels are linked by a technical coefficient of processing. Subsequently, the effect of the tariff reduction at the wholesale level is transmitted to the retail and farm level via the price transmission elasticities between wholesale and farm prices and between wholesale and retail prices respectively.

The reduction in wholesale prices shifts the derived supply at the retail level to the right, from S_r to S_r' (Figure 4.6). Subsequently, retail prices fall from P_{rt} to P_r as retail demand increases from Q_{rt} to Q_r. In this model, farm supply (S_F) is an aggregate function of the output generated from commercial (S_{Lf}) and subsistence farmers (S_{Sf}) owing to the dual nature of Kenya's maize production. It might have a negative price intercept since subsistence farmers will produce for home consumption even when prices are zero (Figure 4.6). The decline in prices at the wholesale level shifts the farm derived demand to the left, from D_f to D_f'. Consequently, farm prices fall from P_{ft} to P_f and the derived demand at the farm level falls from Q_{ft} to Q_f.

The tariff reduction yields welfare gains/losses that are distributed across the three market levels (Figure 4.6). At the retail level, consumer surplus increases from the initial surplus with a tariff equal to the area under triangle (1) to (1 + 2). In addition, retailer surplus at the wholesale level increases from area (8 + 9) to (8 + 9 + 10 + 11). However, the wholesaler surplus at the farm level declines from area (5 + 6 + 7) to (6 + 4). The tariff reduction leads to a loss of government revenue equal to area (11). In addition, producer surplus at the farm level declines from area (3 + 4) to area (3).

At the wholesale level, the tariff reduction results in efficiency gains that are equal to the mirror images of the areas under the triangles marked (e and f). Overall, the economic consequences of the tariff reduction might include an increase in maize consumption and imports, and a decrease in production. These translate to an increase in consumer and wholesaler surplus, but to a decrease in producer and retailer surplus and a loss in government revenue. However, the net effect of the tariff reduction depends on the actual sizes of the gains and losses made by the respective groups.

4.6. Chapter Summary

This chapter provides the theoretical basis for analyzing the behavior of economic agents in Kenya's maize sector. The chapter conceptualizes a structural framework for the maize industry in Kenya. It derives the behavior under risk of maize producers from the principles of utility maximization and uses the theory of the firm and consumer theory to model the behavior of wholesale market agents and consumers respectively. Finally, the chapter illustrates the effect of a tariff reduction on the maize sector. The next chapter specifies the empirical models and the econometric techniques used in estimating the theoretical relationships derived in chapter four.

Chapter 5

Specification of Empirical Models

5.1. Introduction

This chapter serves three purposes. First, it presents a framework for investigating the properties of times-series data. Secondly, it describes the econometric techniques used to estimate a system of acreage response functions for the four major cereal grains produced in Kenya along with a system of their intermediate demands at the wholesale level. Finally, the chapter specifies the empirical procedures used to estimate a partial demand system for the same cereal grains at the retail level.

The chapter is organized as follows. The next section provides a description of the data used, their sources, measurement units and a discussion of the techniques used to test for non-stationarity and cointegration. Section 5.3 and 5.4 specifies the functional forms of a cointegrated system of acreage response functions and an error correction model (ECM) of the intermediate demands respectively. Finally an ECM version of the almost ideal demand system (AIDS) for cereals in Kenya is specified.

5.2. Data Sources

This study uses data from secondary sources to generate elasticity estimates. A number of sources have been used to compile a 43 year annual time series for the period from 1963 to 2005 (Table 5.1). These include government departments in Kenya and international sources. The domestic sources consist of publications from Kenya's Central Bureau of Statistics (CBS) and annual reports from the Ministry of Agriculture (MOA). The United Nations Food and Agriculture Organizations (FAO) online database on agriculture (FAOSTAT) was the international source used.

Table 5.1. Data Sources and Description

Variable	Units	Source
Supply Side		
Cropped Area	Ha	Ministry of Agriculture
Output	MT	Ministry of Agriculture
Producer Prices	KES/MT	Ministry of Agriculture
Exports	MT	Central Bureau of Statistics, Kenya
Wage rate	KES/Man-day	Central Bureau of Statistics, Kenya
Inventories (NCPB)	KES/MT	National Cereals and Produce Board
Demand Side		
Population	Persons	Central Bureau of Statistics, Kenya
Consumer Prices	KES/MT	Central Bureau of Statistics, Kenya
Imports	MT	Central Bureau of Statistics, Kenya
Import prices	US$/MT	FAOSTAT
Exchange rate	KES/US$	Central Bank of Kenya
Import Tariffs	Percentage	Kenya Revenue Authority
Consumer Price Index	(1997=100)	Central Bureau of Statistics, Kenya
Consumption/person (Disappearance)	MT/Person/year	Computed as: (Production + Net Imports + Net NCPB sales)/Population
Expenditure	KES/person/year	Computed as: $M = \sum P_i X_i$
Budget Share	Percentage	Computed as: $S = P_i X_i / \sum P_i X_i$

The annual time series data compiled includes cropped acreages, domestic production, "marketed-surpluses" and consumption statistics for the four major cereals in Kenya: maize, wheat, rice and sorghum at the aggregate national level. Producer prices were compiled from the marketing division of the Ministry of Agriculture as annual averages of the market prices in six out of the eight Kenyan provinces. The retail prices were compiled from the Central Bureau of Statistics (CBS), Kenya as annual averages over all eight provinces.

In all cases, nominal prices are used to estimate the market relationships except in the case of retail demand where the nominal prices are normalized to one (1963 = 1) by dividing all prices by the value of price in the base year. The international commodity prices are converted into the domestic currency (KES) and adjusted for transportation and other transfer costs using costs compiled from the NCPB annual reports.

The descriptive statistics of the variables used to estimate the system of acreage responses and intermediate demands are shown in Table 5.2. All variable on the production side are transformed into logarithms before estimating the system of supply functions. The acreages values are adjusted using the share of marked-output[11] to reflect "marketed-surplus production". To estimate the intermediate demands, outputs, wholesale prices, retail prices and a marketing cost (the wage rate in this case) were used. All price values used on the supply side are nominal prices.

Table 5.2. Descriptive Statistics of the Variables used in Supply Estimation.

Variable	Description	Units	Mean	*Std*	*n*
Dependent Variables					
$Log\ A_1$	Acreage under maize	Ha	13.985	0.348	43
$Log\ A_2$	Acreage under wheat	Ha	11.783	0.155	43
$Log\ A_3$	Acreage under rice	Ha	9.0189	0.453	43
$Log\ A_4$	Acreage under sorghum	Ha	11.935	0.261	43
Explanatory Variables					
$Log\ Pd_1$	Log producer price of maize	KES/MT	3.274	0.637	43
$Log\ Pd_2$	Log producer price of wheat	KES/MT	3.451	0.612	43
$Log\ Pd_3$	Log producer price of rice	KES/MT	3.429	0.635	43
$Log\ Pd_4$	Log producer price sorghum	KES/MT	3.692	0.508	43
$Log\ w$	Log of the wage rate	KES/MD	4.827	0.172	43

Note: *Std*, *n* and MD denote the standard deviation, the sample size and man-days respectively.
Source: Author's Computations

Tables 5.3 presents the descriptive statistics of the variables used to estimate consumer demand. The budget shares were defines as the ratios of the nominal expenditure on any single commodity to total nominal expenditure on all four grain cereals. In addition, a corrected "Stone Price Index" is constructed from the nominal prices and budget shares and used to deflate the total expenditure variables in the demand system. Nominal log transformed consumer prices that are normalized to one in the base year (1963=1) are used as the exogenous variables on the demand side.

[11] Data on the marketed share of production for each cereal was collected from CBS publications

Table 5.3. Descriptive Statistics of the Variables used in Demand Estimation

Variable	Description	Units	Mean	*Std*	*n*
Dependent Variables					
S_1	Budget share of maize		0.525	0.124	43
S_2	Budget share of wheat		0.289	0.086	43
S_3	Budget share of rice		0.127	0.109	43
S_4	Budget share of sorghum		0.059	0.021	43
Explanatory Variables					
Log Pm_1	Log retail price of maize	KES/MT	3.422	0.567	43
Log Pm_2	Log retail price of wheat	KES/MT	3.909	0.522	43
Log Pm_3	Log retail price of rice	KES/MT	3.782	0.558	43
Log Pm_4	Log retail price of sorghum	KES/MT	3.677	0.480	43
Log M	Log of Total expenditure	KES	6.087	1.354	43

Note: *Std* and *n* denote the standard deviation and the sample size respectively.
Source: Author's computations

The combined budget shares for the other cereal commodities in Kenya account for less than the budget share for maize alone (Table 5.3). Overall, the budget shares of wheat and sorghum were 29 and 12 percent respectively while that of rice was below a tenth of total cereal consumption expenditure. These budget shares closely track the actual cereals consumption pattern in Kenya, where maize is the key staple food. Moreover, the average log-transformed and normalized prices of all the cereals are within the same range as that of maize.

5.2.1. Testing for Unit Roots

A commonly used, but often erroneous assumption in most time series analysis is that the underlying data are stationary. Stationarity implies that the mean, variance and covariance of a series are time invariant. Conversely, a data set is said to be nonstationary when its mean and variance are not constant. Many economic time series are nonstationary or have a unit root (Engle and Granger, 1987). In practice, OLS regressions on such nonstationary series often produce spurious results, thus the need to test for unit roots.

A time series that has a unit root is known as a random walk. Testing for the existence of a random walk or the presence of a unit root is a test for stationarity (Dickey and Fuller, 1979). It proceeds in a hierarchical manner from a simple test for a random walk. If a unit root is identified, the data is differenced to determine the order of integration. This is the number of times a series has to be differenced to transform it into a stationary series. A non stationary series (Y_t) is integrated of order *d* denoted I(*d*), if it becomes stationary after being differenced *d* times (Greene, 2000).

A number of empirical tests have been proposed in the literature to test for the existence of unit roots. The most frequently used test for unit roots are the *t*-like tests proposed by Dickey and Fuller (1979) and the alternative test proposed by Phillips and Perron (1988). An Augmented Dickey-Fuller (ADF) test can be specified as:

$$\Delta Y_t = \mu + \eta t + \tau * Y_{t-1} + \sum_{j=1}^{p} \phi_j \Delta Y_{t-j} + e_t \qquad (5.1)$$

Where Y_t is a random variable possibly with non zero mean, μ is a constant, *t* is a time trend and e_t is the error term with mean zero and a constant variance. The null hypothesis of a unit root (τ* = 1) is tested against the alternative of stationarity. However, the estimated τ* does not have a standard *t*-distribution and hence the critical values provided by Dickey and Fuller (1979) have to be used.

The alternative approach for testing for the presence of unit roots proposed by Philip-Perron (1988) follows a first-order auto-regression and is a more powerful test for unit roots than the ADF test in small samples. However, in most empirical analysis the performance of the ADF tests is comparable to that of the Philip-Perron test. In this study, the popular ADF test is used to investigate the existence of unit roots.

5.2.2. Cointegration Tests

A precondition for the existence of stable steady-state relationships in nonstationary economic time series is that the variables must be cointegrated. Cointegration implies the existence of a meaningful long-run equilibrium relationship (Granger, 1988). A vector of variables is said to be cointegrated if each variable in the vector has a unit root in its univariate representation, but some linear combination of these variables are stationary. Testing for cointegration amounts to testing for unit roots in the residuals of OLS regression equations (Ng, 1995; Attfield, 1997).

In the literature, three alternative approaches have been proposed to test for cointegration; the two-step procedure of Engle and Granger (1987), the dynamic OLS procedure of Stock and Watson (1988) and Johansen's systems approach (1988). These approaches test for the null hypothesis of no cointegration using ADF or PP and rank test statistics. The Engle-Granger procedure is a single-equation, regression residual-based test that can be conducted by use of ADF or PP tests (Sarker, 1993). It is a simple and attractive test for bivariate models but has been superseded by Johansen's maximum likelihood estimation (MLE) method in multivariate contexts.

Alternatively, a dynamic cointegration test suggested by Banerjee *et al*, (1986) is used when the static cointrgration tests fail. According to this procedure, at first instance, an error correction model is formulated and estimated. In the second stage, the hypothesis that the coefficient of the error correction (EC) term is not statistically significant is then tested using the conventional *t*-tests. If the null hypothesis is not rejected, the series concerned are not cointegrated, otherwise, the existence of cointegration between the relevant variables is ensured.

Johansen's approach (Johansen and Juselius, 1990) derives MLE of cointegrating vectors for a vector autoregressive system (VAR) and provides likelihood ratio tests for the existence of different numbers of co-integrating vectors. It extends the Engle-Granger (EG) procedure to a multivariate context where there may be more than one cointegrating relationship among a set of *n* variables. Thus, the two-step EG procedure can be used in multivariate contexts since error correction models (ECM) entail cointagration and cointegrated series imply ECM representations.

A system of reduced forms with cointegrated variables may be estimated in two ways: Either as a VAR in levels by the MLE method of Johansen and Juselius (1990) or as an ECM by the two-stage procedure of Engle and Granger (1987). The latter is a restricted form of the former. Furthermore, the EG representation theorem establishes that a VAR in levels with cointegrated variables can be written as an ECM. The VAR is appropriate in cases where commodity prices follow distributed lag processes or where there is a seasonal pattern (Karagiannis *et al*, 2000). However, the VAR is unsuitable in a demand system since it violates the restrictions implied by theory.

The MLE approach of Johansen (1988) starts from a VAR process that can be written:

$$Y_t = \sum_{j=1}^{K-1} \Gamma Y_{t-i} + \mu + \varepsilon_i \qquad (5.2)$$

Here, Y_t is a $(p \times 1)$ vector of a data series at time t, k is the maximum lag length, Γ_i is a $(p \times p)$ matrix of coefficients, μ is a $(p \times 1)$ vector of constants, and ε_t is a $(p \times 1)$ vector of independent identically-distributed (i.i.d.) errors. By the Engle-Granger (1987) Representation Theorem, an equivalent ECM, which traditionally is a first differenced VAR model can be specified in the following form:

$$\Delta Y_t = \sum_{j=1}^{K-1} \Gamma \Delta Y_{t-i} + \Pi Y_{t-k} + \mu + \varepsilon_t \qquad (5.3)$$

Where Δ is the first difference operator, Y_t is a $(p \times 1)$ vector of $I(1)$ variables and Y_{t-k} is the so-called error correction (EC) term. In this model Γ is a $(p \times p)$ matrix that represents short-term adjustments among variables across p equations at the j^{th} lag. The EC term $\Pi = \alpha\beta'$ is a $(p \times p)$ coefficient matrix containing information about the long-run relationships among variables in the data vector. The remaining variables retain the economic implications discussed under equation 5.2.

The long-run relationships among the variables in Y_t is determined by the rank (r) of the cointegrating matrix (Π). When the rank of Π is positive and less than the number of series, p, then $\Pi = \alpha\beta'$ where α and β are $(p \times r)$ matrices. The rows of the β matrix contain the number of cointegrating vectors (r) while α represents the loading weights or the speeds of adjustment. The matrix β is usually normalized by dividing all its elements by the values of the bottom row elements to make Π amenable to economic interpretation. Testing hypotheses on β offers information on the long-run structure, while testing hypotheses on α and Γ_i determines endogeneity and exogeneity.

Johansen's MLE approach provides two test statistics for the number of cointegrating vectors: the trace and maximum eigenvalue test statistics. The trace statistic tests the null hypothesis that the cointegration rank is equal to r against the alternative that it is equal to k. Conversely, the maximum eigenvalue statistic tests the null hypothesis that the cointegration rank is equal to r against the alternative that it is equal to $r+1$. When there is only one cointegrating relationship, the relevant cointegration vector is given by the first column of matrix β' (where $\Pi = \alpha\beta'$) under the largest eigenvalue.

5.3. Estimation Procedure for the System of Cereal Acreage Responses in Kenya

A system of acreage response functions for the four major cereal grains in Kenya is specified following the partial adjustment model of Nerlove (1956). The systems approach permits separate estimation of the substitution effects among alternative crops and the output effect on total cropland with the imposition of parametric restrictions (Meilke and Weersink, 1990). The direct estimation approach is adopted due to the usefulness of its estimates for policy analysis and since the partial adjustment model is a special case of an ECM.

In estimating the acreage response functions for grain cereal producers in Kenya[12], the substitutability between crops competing for the same land is taken into account. These substitution patterns vary across regions in Kenya due to ecological, agro-climatic and social conditions (Narayana and Shah, 1984). However, since the present study considers supply at the aggregate level, a national substitution pattern is considered. The overall pattern considers the sowing and harvesting seasons of grain cereals across all regions in Kenya for both small and large farms.

The surplus grain producing zones (west of the Rift Valley) have a single crop sown in March/April and harvested between October and December. In the Eastern deficit regions, two crops are grown annually. The first crop is sown March/April and harvested July/August. The second crop is sown October/November and harvested February/March. In general, maize, wheat and sorghum are competing crops with regard to land and other inputs in production. However, rice does not directly compliment or compete against the other crops since it is grown under irrigation.

[12] The cropped acreages for both small-scale and large-scale farms are adjusted by the share of marketed production each year to account for home consumption of own production.

The general Nerlove-type acreage response functions can be written as:

$$\ln H_{it} = \rho_{0i} + \rho_{ii} \ln P_{t-1} + \rho_{ij} \sum_{i=1}^{n} \ln P_{ijt-1} + \rho_{ii} \ln H_{t-1} + \Omega_{ii} R_{it} + \varepsilon_t \tag{5.4}$$

Where H_{it} is the cropped area in a given year, P_i is own-price, P_{ij} are the cross prices and *i* indexes maize, wheat, rice and sorghum. Since farm production is risky, the response to price risk (R_{it}) is measured by a weighted moving average of the standard deviation of own-prices over the past three periods. This period is considered long enough for producers of annual crops to respond to price shocks.

The measure of price risk is defined following Adesina and Brorsen (1987) as:

$$R_{it} = \left[\sum_{j=1}^{n} \theta_j \left(\frac{P_{it-j} - P_{it-j-1}}{p_{it-j-1}} \right)^2 \right]^{1/2} ; i = 1,2....5 \tag{5.5}$$

Where R_{it} is the price risk for crop *i* at time *t* and θ_j are the weighting factors. Researchers often assume equal or declining weights on the price risk parameter based on naïve expectations or a Fisher lag. In this study, the declining weights of 0.6, 0.3 and 0.1 used by Adesina and Brorsen, (1987) based on naïve expectations are adopted. The only price risks considered in each cereal's area response function is the crops own to avoid ambiguities associated with multiproduct firms.

The estimation begins by investigating the order of integration of the data. It is also anticipated that the acreages are jointly determined with their respective output prices suggesting the existence of long-run equilibrium relationships and thus, the need for cointegration tests. In multivariate cases where farm prices generally follow an autoregressive distributed lag (ADL) framework, the systems approach proposed by Johansen and Juselius, (1990) is appropriate in testing for cointegration.

The partial adjustment relationship implied by equation 5.4 is reformulated into a VAR (equation 5.6) and estimated using Johansen's MLE approach to yield long-run elasticities since all variables are log transformed. The VAR can be specified as:

$$Z_{it} = \Phi + \Gamma_{i1} Z_{it-1} + \Gamma_{i2} Z_{it-2} + \ldots.. + \Gamma_{iP-1} Z_{it-P+1} + \Pi Z_{t-p} + \psi_i X_{it} + \varepsilon_t \qquad (5.6)$$

Where Z_{it} is a $(p \times 1)$ vector of endogenous variables, Π is a $(p \times p)$ matrix determining the number of cointegrating vectors, X_{it} is a vector of exogenous variables, ψ_t and Γ_t are $(p \times p)$ matrices of parameters, Φ is a $(p \times 1)$ vector of constant terms and ε_t is a vector of random variables. The MLE estimation yields cointegrating vectors that are interpreted *ceteris paribus* as long-run price elasticities.

The cointegrating vectors among the variables in Z_{it} are given by the rank (r) of Π. If Π has a full rank, then Z_{it} is a stationary process. In this case an undifferenced VAR model is appropriate. If Π has a zero rank, then Π is a null matrix and Z_{it} is an integrated process; only in this case is a traditional first-differenced VAR appropriate. If, however, Π is of reduced rank, the model is subject to a unit root. Thus, when ($0 < r < P$), cointegration holds and Π can be decomposed into two $(p \times r)$ matrices, α and β such that $\Pi = \alpha\beta'$. The long-run equilibrium is unique only when $r = 1$.

The β's contains r distinct cointegrating vectors while the weights (α) represent the EC terms that measures the speed of adjustment in Z_{it}. In this study, Johansen's reduced rank regression procedure is adopted to estimate α, β, trace test statistics and the maximum eigenvalues. The trace and maximal eigenvalue statistics are used to test for cointegration under the null hypothesis of at most r cointegrating vectors against the alternative $\beta > r$. However, the VAR ignores short-run dynamics and violates symmetry. Thus an ECM is used to capture the short-run dynamics.

Having established the number of cointegrating relationships in the long-run, the next step in the estimation is to generate the short-run elasticities. The short-run elasticities are estimated from an ECM, which nests the Nerlovian partial adjustment model. The number of cointegrating vectors is used as a guide in specifying the short-run ECM. Thus, the VAR is reformulated to an ECM and specified as:

$$\Delta Z_{it} = \Phi + \Gamma_{i1}\Delta Z_{it-1} + \Gamma_{i2}\Delta Z_{it-2} + ... + \Gamma_{iP-1}\Delta Z_{it-P+1} + \Pi_i Z_{it-P} + \psi_i X_{it} + \varepsilon_t \quad (5.7)$$

Where Z_{it} is a vector of I (1) endogenous variables ($\Delta Z = Z_t - Z_{t-1}$), Φ is a ($p \times 1$) vector of constants, X_{it} is a vector of I (0) exogenous variables while Π_i and Γ_i are ($p \times p$) matrices of parameters that represent short-term adjustments across among variables. Z_{it} is composed of cereal's acreages and prices while X_{it} consists of own-price risks and the cost of labour. Estimation of the ECM follows a general to specific strategy (Hendry and Ericsson, 1991), where over-parameterization of the model is simplified via deletion of insignificant variables. The ECM is estimated via a systems approach using a seemingly unrelated regression (SUR) method in SHAZAM 9.0.

5.4. Estimation Procedure for the Intermediate Demands

An ad hock approach is employed to estimate the farm derived demand for grain cereals in Kenya by regressing farm output on producer prices, wholesale prices and marketing costs. To capture the cross effects, the model is estimated in a systems approach. It assumes an adjustment period and uses expected rather than actual prices at the farm level. Using the ADL framework, the system of farm derived demand's for cereals in Kenya is specified in the form;

$$Y_{it} = \alpha + \sum_{i=1}^{m} \vartheta_i Y_{it-1} + \sum_{j=1}^{k}\sum_{i=0}^{n} \gamma_{ij} P_{jt-i} + \varepsilon_{it} \quad (5.8)$$

Where Y_{it} is the farm output of a particular cereal at time t, P_j is a vector of exogenous prices (own and cross prices plus marketing costs) and ε_t is an error term. The estimation begins by determining the time series properties of the data. Given the demand system theoretical restrictions, static and dynamic cointegration tests rather than the MLE approach are used. To address the time series properties of the data used, equation (5.8) is reformulated into an ECM and specified as;

$$\Delta Y_{it} = \alpha + \sum_{i=1}^{m-1} \vartheta_i \Delta Y_{it-1} + \sum_{j=1}^{k} \sum_{i=0}^{n-1} \gamma_{ij} \Delta P_{jt-j} + \psi_i \mu_{it-1} + \varepsilon_{it} \qquad (5.9)$$

Where Δ is a difference operator and ψ is the EC term capturing the short-run effects.

Similarly, an ad hock approach is used to specify and estimate a system of wholesale demands for cereals in Kenya as a function of wholesale prices, retail prices and marketing costs. Unlike the farm-level demand, the wholesale demand uses actual rather than expected prices. The ECM form of the wholesale demand for grain cereals in Kenya is estimated after reparameterizing the OLS model as follows:

$$\Delta Y_i = \alpha + \vartheta \Delta Y_{it-1} + \sum_{i=1}^{n} \gamma_{ij} \Delta P_j + \psi_i \mu_{it-1} + \varepsilon_i \qquad (5.10)$$

The ECM versions of the intermediate demands are estimated using the two-step procedure of Engle-Granger (1987). In the first stage, OLS regressions of the undifferenced demand specifications are estimated to generate residuals. At the second stage, the residuals generated from the OLS estimates are used as the EC term in the estimation of the ECM to yield short-run elasticities when all variables are transformed into logarithms. The long-run elasticities in both cases are derived from the short-run effects as ($-\gamma_{ij}/\psi_i$) following Johnson *et al*, (1992). The models are estimated using a SUR procedure in the statistical package SHAZAM 9.0.

5.5. Consumer Demand Estimation

A two-stage budgeting procedure, which assumes that consumer preferences are weakly separable with respect to food is used in this study to estimate the demand for grain cereals in Kenya. In the first stage, consumers decide the proportion of their total expenditure to allocate to grain cereals and other consumption goods, and then, in the second stage, the demand for each cereal item is determined by the prices of the individual cereal items and the total cereal expenditure. The demand for cereals is estimated at the second stage of the two-stage budgeting process as an AIDS.

The AIDS is compatible with the step-wise budgeting procedure as it perfectly aggregates across goods. Unlike other models, the resulting demand equations of the AIDS model possess nonlinear Engel curves and allows for exact aggregation across consumers (Moschini, 1998). Moreover, the properties of homogeneity and symmetry of the AIDS model can be handled by simple parametric restriction. The model has been widely applied in demand analysis. It yields elasticities that are consistent with consumer theory and that are more flexible than the other commonly used models.

The AIDS derives from a utility function specified as a second-order approximation of any utility function (Sadoulet and De Janvry, 1995). Deaton and Muellbauer (1980a) start with the specification of an expenditure function which is of the PIGLOG[13] class of preferences that satisfy the necessary conditions for consistent aggregation across consumers. These conditions ensure that the functional forms of the market demand equations are consistent with the behaviour of a rational representative economic agent (Deaton and Muellbauer, 1980b).

[13] The PGLOG model was developed to treat aggregate consumer behavior as if it were the outcome of a single maximizing consumer.

The AIDS in budget share can be written as:

$$S_i = \alpha_i + \beta_i \ln\left(\frac{M}{P*}\right) + \sum_{j=1}^{n} \gamma_{ij} \ln P_j + \varepsilon_i \qquad (5.11)$$

Where S_i is the i'th budget share estimated as $S_i = P_jX_j/M$, P_j are nominal retail prices while γ_{ij} are price coefficients and M is the total expenditure on all goods. $P*$ is an aggregate price index that in the nonlinear AIDS specification is defined as:

$$\ln P* = \alpha_0 + \sum_{i=1}^{n} \alpha_i P_i + \frac{1}{2}\sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln P_i \ln P_j \qquad (5.12)$$

In this system, adding-up holds if $\sum_i \alpha_i = 1, \sum_i \gamma_{ij} = 0$ and $\sum_i \beta_i = 0$; homogeneity is satisfied if $\sum_i \gamma_{ij} = 0$ and the symmetry conditions are $\sum_i \gamma_{ij} = \sum_j \gamma_{ji}$. The adding up condition is automatically imposed on the system since the budget shares must sum up to unity. However, homogeneity and symmetry are empirically imposed by use of parametric restrictions.

Using the non-linear price index $P*$ in (5.12) often raises empirical difficulties, especially when aggregate annual time-series data are used. Deaton and Muellbauer (1980a) suggest use of the Stone Geometric Price Index $\overline{P*}$ instead of $P*$:

$$\ln \overline{P*} = \sum_{i=1}^{n} S_{it} \ln P_{it} \qquad (5.13)$$

The linear-approximate AIDS model (LAIDS) with the Stone index has been used extensively in applied demand analysis (Green and Alston, 1990). However, Moschini (1995) points out that the Stone's index fails to satisfy the "commensurability" property, in the sense that it is not invariant to the units of measurement of prices. He proposes three alternative indices to solve this problem. The first is the Tornqvist index ($P^T{}_t$) which is a discrete approximation of the Divisia index.

$$\ln P_t^T = \frac{1}{2}\sum_{i=1}^{n}(S_{it} + S_i^0)\ln\left[\frac{P_{it}}{P_i^0}\right] \tag{5.14}$$

The variables S_t^o and P_t^o denote the budget shares and prices in the base period. Another alternative index is the log-linear analogue to the Paasche index ($P^S{}_t$), which Moschini (1995) refers to as the "corrected" Stone price index.

$$\ln P_t^S = \sum_{i=1}^{n} S_{it} \ln\left[\frac{P_{it}}{P_i^0}\right] \tag{5.15}$$

If prices are normalized to one before the index is computed, Stone's price index is equal to the Paasche index. The final option of the indices proposed by Moschini (1995) is the log-linear version of the Laspeyres index ($P^L{}_t$) that may be written as:

$$\ln P_t^L = \sum_{i=1}^{n} S_i^0 \ln\left[\frac{P_{it}}{P_i^0}\right] \tag{5.16}$$

Asche and Wessells (1997) show that when all prices are normalized to unity, the elasticities derived from the linear and non-linear AIDS representations are identical when evaluated at the point of normalization. Consequently, the elasticity formula proposed by Chalfant (1987) correctly evaluates the elasticities of the LAIDS to equal those of the AIDS at the point of normalization. The Marshallian price and expenditure elasticities are then computed at the point of normalization following Chalfant's (1987) formula on the LAIDS model as:

$$\varepsilon_{ij}^M = -\delta_{ij} + \left(\frac{\gamma_{ij}}{S_i}\right) - \left(\frac{\beta_i}{S_i}\right)S_j,\ \eta_i = 1 + \left(\frac{\beta_i}{S_i}\right) \text{ and } \varepsilon_{ij}^H = -\delta_{ij} + \left(\frac{\gamma_{ij}}{S_i}\right) + S_j \tag{5.17}$$

Where δ is the Kronecker delta ($\delta_{ij} = 1$ for $i = j$ and $\delta_{ij} = 0$ if $i \neq j$). The Hicksian elasticities for good i with respect to j can be derived from the Marshallian price elasticities using the Slutsky equation as: $\varepsilon^H_{ij} = \varepsilon^M_{ij} + \eta_i w_j$ or $\varepsilon^H_{ij} = -\delta + (\gamma_{ij}/S_i) + S_j$.

This study estimates a LAIDS for cereals in Kenya using a "corrected" stone price index. The model is normalized to unity at the base period (1963) and all elasticities are evaluated at this point. At the point of normalization, there are no differences in the formulae used to compute elasticities for the AIDS and LAIDS (Asche and Wessels, 1997). Prior to the specification of the most appropriate dynamic form of the AIDS, it is necessary to investigate the time series properties of the data to determine whether the long-run relationships are economically useful or merely spurious.

Once the order of integration of the variables is established, the system is tested for cointegration. This can be implemented by use of either static cointrgration tests (ADF and PP tests) or the Johansen's test. Although Johansen's test is suitable in multivariate cases, may not be appropriate in applied demand analysis. A major limitation of the MLE approach in applied demand analysis is that there is no *a priori* information to exclude some vectors as theoretically inconsistent[14] variables whenever more than one cointegrated vectors is found (Karagiannis *et al*, 2000).

Given the low power of static cointegration tests to discriminate against alternative hypothesis, the dynamic modelling procedure proposed by Banerjee *et al*, (1986) and Kremers *et al*, (1992) is used in this study. This procedure uses the lagged residuals from the OLS regression of equation 5.11 to test for cointegration in the ECM. According to this test, the hypothesis that the coefficient of the EC term is not statistically different from zero is tested using a conventional *t*-test. If the null hypothesis is rejected, the series concerned is cointegrated. Once it is ensured that all the variables are cointegrated, an ECM version of the AIDS model is formulated.

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[14] This is because the sign of the elements in cointegrated vectors, indicating substitutability or complementary behavior between goods cannot be a priori restricted.

The ECM is a restricted form of a VAR model that produces efficient estimates in small samples. The estimated ECM form of the AIDS is specified as:

$$\Delta S_i = \vartheta \Delta S_{it-1} + \beta_i \Delta \ln\left(\frac{M}{P*}\right) + \sum_{i=1}^{n} \gamma_{ij} \Delta \ln P_j + \lambda_i \mu_{it-1} + \varepsilon_i \qquad (5.18)$$

Where Δ is the difference operator and μ_{it-1} are the estimated residuals from the cointegration equations (the EC component) and λ is expected to be negative. Equation 5.18 is estimated using the two-step method of Engle and Granger (1987) where the estimated residuals of equation 5.11 are substituted into the ECM (equation 5.18) and used as a regressor that represents the error correction (EC) term.

In this estimation, the short-run elasticity estimates are obtained by using the formulas in 5.17 and the estimated ECM parameters from equation 5.18. The short-run ECM parameter estimates are also used to compute their long-run counterparts using the partial adjustment formulation proposed by Johnson *et al*, (1992). Thus, the long-run estimates equal the negative of the short-run estimates divided by the EC term's parameter ($-\beta_0/\lambda_i$). Similarly, the long-run elasticity estimates are measured from the formulae in equation 5.17 and the long-run parameter estimates.

The ECM version of the AIDS for cereals in Kenya is estimated using a SUR in SHAZAM 9.0. The procedure adjusts for cross-equation contemporaneous correlation and consequently takes into account the optimization process behind any demand system. To avoid singularity of the estimated variance-covariance matrix, the demand equation for rice is dropped from the system. Since SUR is sensitive to the excluded equation, the procedure should be iterated (Karagiannis *et al*, 2001). Iteration ensures that the obtained estimates asymptotically approach the maximum likelihood estimates (MLE) (Judge *et al*, 1980).

5.5. Chapter Summary

This chapter specifies the econometric procedures adopted to estimate supply and demand. In going from the conceptual framework in the previous chapter to the empirical specifications of demand and supply, four separate issues are addressed. First, the data used, its sources and the units of measurement are presented. Secondly, the procedures used to test for unit roots are described. This is followed by a specification of the methods used to tests for cointegration. Finally, the functional forms used to estimate supply and demand are presented.

Chapter five presents the estimation procedures employed at the three market levels. At the farm-level, the empirical methods used to estimate acreage response functions and farm-derived demand are specified. This is followed by a specification of the empirical model used to estimate wholesale demand. Finally, an ECM version of the AIDS is specified at the retail level. When estimating demand, it is always an issue whether one should specify an ordinary (quantity depended) or inverse (price depended) equation. If the product can be stored and one is not restricted to a local market, an ordinary demand relationship is more appropriate (Asche *et al*, 1997).

Given that most staple grains are storable; this study estimates ordinary demand relationships at the farm, wholesale and retail levels. In addition, the study adopts a partial adjustment approach to estimate supply assuming that supply is to some extent based on expectations of prices rather than actual prices. In all cases, EC mechanisms are adopted to capture the dynamic relationships. The next chapter presents the empirical results generated from the statistical estimation of the specified econometric procedures and discusses their implications for the cereals sector in Kenya.

Chapter 6

Econometric Results and Discussions

6.1. Introduction

This chapter presents the econometric results derived from the estimation of supply and demand of the four major cereal grains in Kenya. The chapter presents the estimated results in three sections. First, the estimated acreage responses at the farm level are reported. Next, the elasticities of the derived demand for cereal grains at the intermediate level are discussed. In the last section, the estimated elasticities of consumer demand for cereal grains at the retail level are reported.

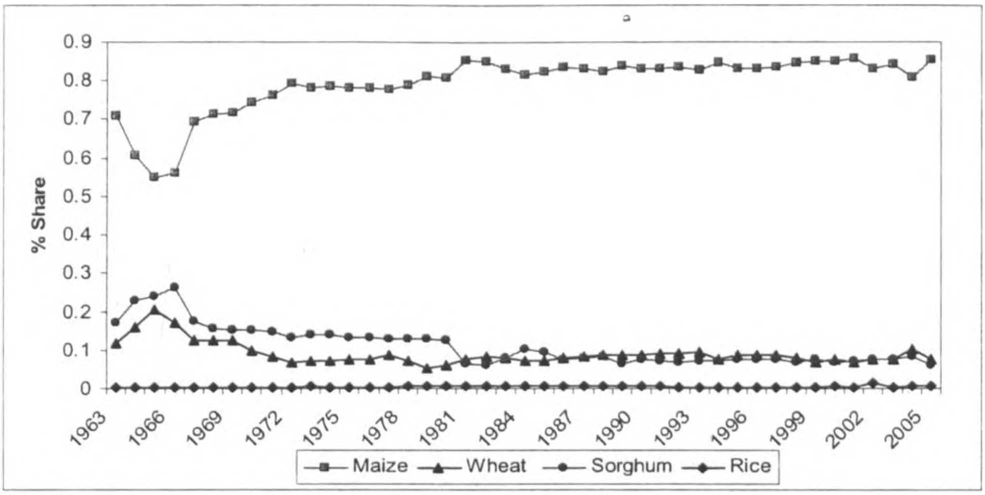
6.2. Estimates of Producer Supply Response

This section reports the acreage response estimates for cereal grains in Kenya. The results are presented in three parts. Initially, unit root test results and test results for determining the optimal lag length of the VAR are reported. These are followed by a presentation of the MLE's of the cointegrating vectors and the long-run elasticity estimates. Finally, the short-run estimates from an ECM of a system of acreage responses are reported along with the diagnostic test results for model adequacy.

6.2.1. Unit Root Tests results for the Acreage Response Series

The estimation of acreage response begins with a graphical illustration of the time series properties of the data. Figures 6.1 and 6.2 show the trends in the data series on acreage, producer prices and input costs. The graph for acreage shares restricts the areas cropped to maize, wheat, rice and sorghum to lie between zero and one and shows the magnitude of changes in cropped area from one year to the next. All the cereal acreage shares in Kenya appear to be trended (Figure 6.1).

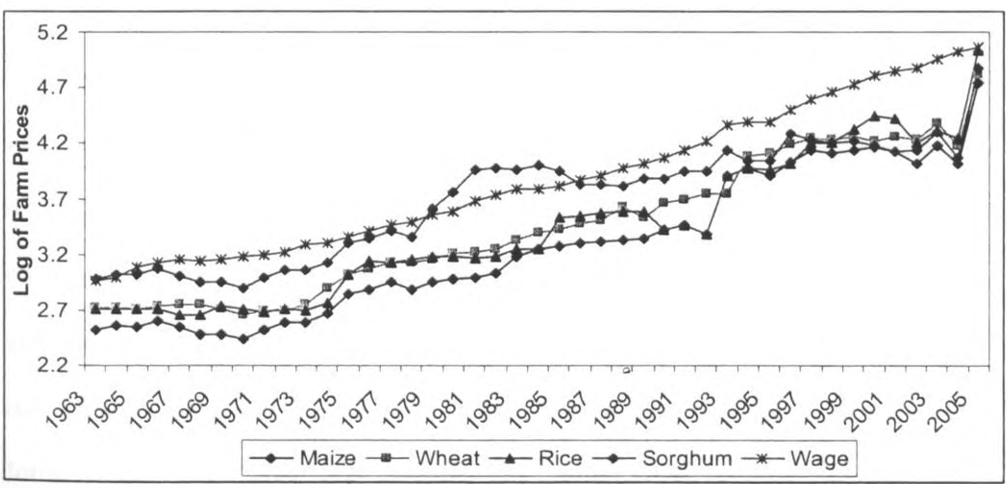
Figure 6.1. Cereal Acreage Shares, 1963 -2005



Source: Author's Computations

The acreage share of maize appears to be upward trended (Figure 6.1). Acreages under wheat, rice and sorghum initially fell but have been on an upward trend after 1980 albeit marginally. Figure 6.2 plots the logarithmic values of input and output prices. All producer prices and the wage rate exhibits an upward trend. These trends imply that the mean values of the series change overtime, which suggests nonstationary behaviour and thus the need for formal unit root tests.

Figure 6.2. Nominal Cereal Producer Prices



Source: Author's Computations

Table 6.1 reports the results of ADF and PP tests on the variables used in estimating the system of acreage responses from a trended model. All variables are transformed to logarithms while the prices used are nominal. The hypothesis of a unit root in the level series cannot be rejected at the five percent significance level for any of the series in both models (Table 6.1). However, the first differenced series reject nonstationarity in all cases. These results are consistent with the hypothesis that nonstationarity characterizes the series used in estimating supply in this study.

Table 6.1. Unit Root Tests (ADF) for Producer Prices and Cropped Acreage

Series	Level Series			First Differences		*I*(d)
	ADF	PP	Lags	ADF	PP	
Logarithm of Cropped Area (Ha)						
Maize (*Ha*)	-2.469	-2.616	1	-6.062 [c]	-6.081 [c]	*I*(1)
Wheat (*Ha*)	-2.377	-2.578	1	-3.802 [c]	-5.488 [c]	*I*(1)
Paddy Rice *(Ha)*	-2.588	-3.279	1	-4.398 [c]	-13.90 [c]	*I*(1)
Sorghum (*Ha*)	-3.221	-3.331	1	-4.211 [c]	-6.441 [c]	*I*(1)
Logarithm of Nominal Producer Prices (Log Pd)						
Log Pd Maize	-2.970	-2.779	1	-4.268 [c]	-6.901 [c]	*I*(1)
Log Pd Wheat	-2.550	-2.849	1	-3.593 [c]	-8.448 [c]	*I*(1)
Log Pd Paddy Rice	-2.637	-2.580	1	-3.596 [c]	-5.541 [c]	*I*(1)
Log Pd Sorghum	-2.557	-2.406	1	-3.592 [c]	-6.539 [c]	*I*(1)
Log Wage rate	-1.356	-1.371	1	-4.217 [c]	-6.009 [c]	*I*(1)
5 % Critical Values	-3.50	-3.50		-3.50	-3.50	

(c) Denotes rejection of the null hypothesis of a unit root at the 5 percent level (MacKinnon, 1991).
Source: Author's Computation

Since the series of cereal acreages and producer prices used in this study are all integrated of the same order; I*(1)*, it is expected that they are jointly determined and might be cointegrated. Formal cointegration tests are then undertaken to explore the existence of long run equilibrium relationships between the corresponding acreages and producer prices. In a multivariate context where more than one cointegrating relationships among variables may exist, the systems approach developed by Johansen (1988) and applied in Johansen and Juselius (1990) is recommended.

6.2.2. Model Specification and Estimation Strategy

The MLE procedure developed by Johansen (1988) provides a convenient framework for detecting the existence of long-run cointegrating relationships. It proceeds in a sequence of two steps. In the first step, the model's optimal lag-length is determined using Sim's modified likelihood ratio (LR) test. Secondly, the trace test statistic and the maximum eigenvalues are used to identify the number of cointegrating vectors after normalizing the eigen vector s, which provide the long-run relationships.

In this study, economic theory is used as a guide to specify four reduced form VAR models, one each for the acreages under maize, wheat, rice and sorghum. All models consist of seven variables that are ranked on the basis of economic reasoning prior to estimation. The producer prices for the four grain cereals are placed on top in a descending order followed by the wage rate, own price risk and finally the crop's acreage is placed at the bottom. This ordering allows variables at the top the greatest opportunity to affect the variables at the bottom, and not vice versa (Sarker, 1993).

6.2.3. Optimal Lag-Length Selection

The first step in Johansen's MLE procedure is to select the order of the VAR since the results are sensitive to the choice of lag-length (Mushtaq and Dawson, 2000). Although there are many alternative approaches to determine the appropriate lag length, Sim's (1980) modified likelihood ratio (LR) test is often used in studies with small sample sizes. Sim's test is based on the log likelihood values associated with various lag specifications. It tests for the equivalence of models with different lag-lengths (k) and is chi square (x^2) distributed with degrees of freedom equal to the number of restrictions imposed.

Table 6.2 presents the optimal lag-length results based on the Sim's[15] LR test. The equivalence of one-lagged and two-lagged models cannot be rejected for all crops at the five percent significance level since the critical values exceed the calculated values in all cases. However, the equivalence of two-lagged and three lagged models is rejected for all crops at the same level (Table 6.2). While the test should stop once an optimal lag is achieved, the third lag is presented here for comparison purposes.

Table 6.2. Sims Modified LR Test for Optimal Lag Length.

VAR Model	Lags	Log Likelihood	LR-Test Statistic	Critical x^2 Value	Test Result H_0: Lag X_i = Lag X_i
Maize	1	-29.517			
	2	-29.554	1.334	14.07	Fail to reject lag 1
	3	-31.714	77.753*	14.07	Reject lag 2
Wheat	1	-28.650			
	2	-28.713	2.273	14.07	Fail to reject lag 1
	3	-32.348	130.837*	14.07	Reject lag 2
Sorghum	1	-26.369			
	2	-26.456	3.118	14.07	Fail to reject lag 1
	3	-30.759	154.924*	14.07	Reject lag 2
Rice	1	-27.753			
	2	-27.889	4.881	14.07	Fail to reject lag 1
	3	-29.977	75.160*	14.07	Reject lag 2

Note: Asterisk (*) denotes significant chi-square values at seven degrees of freedom (df) and P=0.95
Source: Author's Computations

It can, therefore, be concluded that a single lag specification is appropriate for all variables in each crop's VAR model. Having established the optimal lag length, the next step is to estimate the cointegrating vectors using VAR models. Johansen's procedure assumes that all variables in the VAR are endogenous. Thus, the theoretical properties of homogeneity and symmetry cannot be parametrically imposed on such models. Subsequently, the restriction implied by theory cannot be tested.

[15] Sim's modified LR test can be defined as L= (T – k) {Ln|D_r| - ln|D_u|}~ X^2_d where T is the total number of observations, k is the number of variables in each unrestricted equation, d is the number of restrictions while D_r and D_u are the restricted and unrestricted covariance matrices respectively.

6.2.4. Maximum Likelihood Estimates of the Cointegrating Vectors

Acreage responses for maize, wheat, rice and sorghum are estimated separately as endogenous systems of seven variables based on the VAR in equation 5.6. In addition to each crop's acreage and price, the individual crop's VAR estimation involves the cross-prices of other cereals, the wage rate and the own-price risk. The risk variable is specified as a three year weighted moving average of the standard deviations of own-price. Each VAR is fitted with one lagged variables in their first differences.

Table 6.3. A VAR Acreage Response Model for Maize in Kenya, 1963-2005

Maximum Likelihood Cointegration Results: A seven -variable, one lag system							
Estimated Eigenvalues (λ's), Eigenvectors (β's) and Weights (α's)							
	Eigenvalues (λ's)						
Variable	0.701	0.634	0.584	0.412	0.354	0.246	0.001
Normalized Eigenvectors (β's)							
Maize	-2.168	-2.120	2.954	-3.816	5.754	-8.631	1.634
Wheat	-1.733	2.198	4.398	-6.201	-4.853	5.211	-3.229
Sorghum	0.444	0.279	0.581	8.233	-5.129	-4.856	0.627
Rice	3.962	-0.562	-2.609	5.273	-2.639	1.772	0.997
Wage	1.246	0.471	4.561	3.876	-1.988	-6.663	-1.797
Risk	0.645	0.092	0.678	7.487	-9.606	1.089	-1.198
Acreage	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Weights (α's)							
Maize	-0.080	-0.034	0.038	-0.072	0.007	0.005	-0.002
Wheat	0.024	0.025	0.032	-0.036	0.047	0.013	-0.002
Sorghum	0.037	0.025	0.024	-0.040	-0.014	-0.016	-0.004
Rice	-0.137	-0.069	-0.054	-0.062	0.028	-0.005	-0.002
Wage	0.015	0.007	0.000	-0.003	0.005	-0.019	0.000
Risk	-0.112	0.058	0.099	0.161	0.016	0.070	-0.005
Acreage	-0.045	0.055	-0.013	-0.010	-0.044	0.005	0.001

Testing for the Number of Cointegrating Vectors				
H_0:	Trace Statistic	Trace (0.95)	λ_{Max}	λ_{Max} (0.95)
$r = 0$	178.001*	146.76	49.493*	49.42
$r \leq 1$	128.508*	114.90	41.234	43.97
$r \leq 2$	87.274	87.31	35.937	37.52
$r \leq 3$	51.337	62.99	21.789	31.46
$r \leq 4$	29.547	42.44	17.923	25.54
$r \leq 5$	11.625	25.32	11.586	18.96
$r \leq 6$	0.039	12.25	0.039	12.25

Note: The critical values are taken from Osterwald-Lenum, (1992).

Source: Author's Computations

Tables 6.3 through 6.7 present the estimated eigenvalues (λ's), the normalized eigenvectors (β's), the adjustment weights (α's) and the rank test statistics for the acreage response models. The relevant cointegrating vector in each case is given by the first column of β under the largest eigenvalue. The estimated parameters represent the stable long-run relationships to which the variables in the system have a tendency to return to and can be interpreted as static long-run elasticities *ceteris paribus* since the variables are log-transformed.

The maximum eigenvalue test rejects the null hypothesis of more than one cointegrating vectors at the five percent significance level for the maize acreage VAR (Table 6.3). However, the trace test statistic suggests two cointegrating vectors. Although economic theory suggests use of both tests in identifying the number of cointegrating vectors, recent studies such as Lutkepohl *et al*, 2001 show that the critical asymptotic values of the two tests tend to overstate the number of statistically significant cointegrating vectors in small samples. The trace test often reports more cointegrating vectors than the maximum eigenvalue test (Lutkepohl *et al*, 2001).

The trace test statistic shows little bias in the presence of either skewness or excess kurtosis while the maximal eigenvalue test shows substantial bias in the presence of large skewness even though it is quite robust to excess kurtosis (Cheung and Lai, 1993). Lutkepohl *et al*, 2001 finds the maximum eigenvalue statistic to be more reliable than the trace test in such cases. Thus, the maximum eigenvalue test is used to select the number of cointegrating vectors for all individual crop's acreage VAR models in this study. Based on this test, it can be concluded that there is only one cointegrating vector in the maize acreage response function.

The normalized long-run equilibrium relationship implied by the estimated maize area response function can be written out as:

$$AM = \underset{(4.006)}{2.168P_m} + \underset{(3.892)}{1.733P_w} - \underset{(6.441)}{3.962P_r} - \underset{(4.721)}{0.444P_s} - \underset{(6.032)}{1.246R_m} - \underset{(6.384)}{0.645w} \qquad (6.1)$$

Equation 6.1 represents the stable equilibrium relationship to which the variables in the maize acreage response have a tendency to return to in the long-run. The numbers in parenthesis are x^2 values. All the estimated elasticities are significant at the 0.05 level since the computed x^2 values exceed the critical value at 3.84.

A one percentage increase in the price of maize leads to a 2.17 percentage increase in the acreage devoted to maize (Table 6.3). Maize and wheat are complementary in production since they can be grown on the same land each year. The negative cross-price effects in the VAR imply that maize, rice and sorghum compete for land and other inputs. However, the negative cross effect between maize and rice should be interpreted with caution since unlike the other cereals in Kenya, rice is an irrigated crop. These long-run cross price estimates reflect the actual production trends where cereal grains are both competing and complimentary in production.

The own-price risk elasticity of -0.645 has intuitively appealing implications. It shows that farmers divert crop land away from maize production as its own-price variability increases. Thus, farmers risk perceptions are appropriately measured in terms of output price variability and that maize farmer's in Kenya are responsive to price risk. However, a systematic investigation of the type of risk aversion exhibited by farmers is not undertaken due to data limitations. Maize producers also respond negatively to increases in input costs. The elasticity estimate with respect to wage at – 1.25 suggests that farmers are highly responsive to changes in input costs.

Table 6.4 presents the MLE results for the wheat acreage response function. The trace test statistic suggests the presence of two cointegrating relationships as opposed to the maximum eigenvalue statistic that indicates only one cointegrating vector. Like in the maize VAR model, it can be concluded that a single cointegrating relationship exists in the wheat area response function. When only one such vector exists, it can be interpreted as an estimate of the long-run cointegrating relationship between the variables in the system of equations for the wheat acreage response function.

Table 6.4. A VAR Acreage Response Model for Wheat in Kenya, 1963 – 2005

Maximum Likelihood Cointegration Results: A seven -variable, one lag system							
Estimated Eigenvalues (λ's), Eigenvectors (β's) and Weights (α's)							
	Eigenvalues (λ's)						
Variable	0.898	0.644	0.568	0.508	0.397	0.200	0.001
Normalized Eigenvectors (β's)							
Wheat	-0.797	1.155	0.578	-1.183	-12.001	-0.700	-2.040
Maize	-0.065	-1.167	8.040	1.234	8.144	3.866	0.189
Sorghum	0.436	0.280	1.427	0.149	1.969	-1.234	1.272
Rice	0.405	-0.742	-4.701	-0.057	-1.980	0.291	2.625
Wage	0.502	1.036	5.628	0.588	0.949	-4.200	-8.815
Risk	0.238	0.077	1.007	-0.056	0.279	-0.105	-0.750
Acreage	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Weights (α's)							
Wheat	0.003	-0.056	0.007	0.003	-0.060	0.001	0.002
Maize	0.053	0.051	0.022	-0.068	-0.072	0.000	0.001
Sorghum	0.036	-0.081	0.018	-0.070	-0.020	-0.001	0.001
Rice	0.131	0.087	0.080	-0.029	-0.064	0.006	-0.001
Wage	0.004	-0.019	-0.012	0.001	0.001	0.014	0.000
Risk	0.306	0.171	-0.196	0.190	0.151	-0.098	0.009
Acreage	0.011	-0.033	-0.012	-0.005	-0.014	-0.027	-0.001

Testing for the Number of Cointegrating Vectors				
H_0:	Trace Statistic	Trace (0.95)	λ_{Max}	λ_{Max} (0.95)
$r = 0$	229.273*	146.76	93.559*	49.42
$r \leq 1$	135.714*	114.90	42.326	43.97
$r \leq 2$	83.388	87.31	34.442	37.52
$r \leq 3$	58.946	62.99	29.051	31.46
$r \leq 4$	29.895	42.44	20.708	25.54
$r \leq 5$	9.187	25.32	9.136	18.96
$r \leq 6$	0.051	12.25	0.051	12.25

Note: The critical values are taken from Osterwald-Lenum, (1992).

Source: Author's Computations

The long-run cointegrating relationship can be summarized as follows.

$$AW = \underset{(33.31)}{0.798P_w} + \underset{(16.66)}{0.065P_m} - \underset{(55.49)}{0.405P_r} - \underset{(45.02)}{0.436P_s} - \underset{(52.65)}{0.238R_w} - \underset{(33.34)}{0.502w} \quad (6.2)$$

All estimates in the wheat VAR are significant at the five percent level as indicated by the x^2 values. The positive own-price elasticity implies that more crop land is committed to wheat production if its price increases. Like the maize acreage VAR, rice and sorghum compete with wheat while maize compliments wheat production. The wheat acreage response to wage and own-price risk is negative implying that these two effects reduce the acreage allocated to wheat production in any crop year.

The MLE estimates of the paddy rice acreage response model are presented in Table 6.5. Like in the earlier models, the trace test statistic indicates the existence of two cointegrating relationships while the maximum eigenvalue test statistic seem to suggest a single cointegrating vector at the five percent significance level (Table 6.5). A single cointegrating relationship can therefore be established for the paddy rice acreage model. The estimated long-run relationship can be represented as follows.

$$AR = \underset{(10.37)}{2.016P_r} - \underset{(12.25)}{1.300P_m} - \underset{(6.347)}{1.360P_w} + \underset{(12.48)}{0.259P_s} - \underset{(9.028)}{0.913R_r} - \underset{(15.48)}{0.824w} \quad (6.3)$$

All estimated long-run elasticities in the paddy rice VAR model are significant at the five percent level and consistent with the earlier estimates for the other crop's models. A one percentage increase in the price of rice results to a 2.02 percentage rise in the acreage under rice. The cross-price effects imply that rice competes with wheat and maize for land but compliments the production of sorghum. However, water requirements limit the production of rice in Kenya to public irrigation schemes and river valleys. As such the cross-effects should be interpreted with caution.

Table 6.5. A VAR Acreage Response Model for Paddy Rice in Kenya, 1963– 2005

Maximum Likelihood Cointegration Results: A seven -variable, one lag system							
Estimated Eigenvalues (λ's), Eigenvectors (β's) and Weights (α's)							
	Eigenvalues (λ's)						
Variable	0.748	0.625	0.524	0.430	0.381	0.188	0.009
Normalized Eigenvectors (β's)							
Rice	-2.016	7.767	2.324	0.078	-0.249	1.714	-1.334
Maize	1.300	0.426	-3.232	2.515	-1.168	-1.148	-0.905
Wheat	1.360	-9.611	2.231	-2.196	4.441	2.029	1.484
Sorghum	-0.259	-1.013	-1.562	0.204	-0.670	3.183	-0.407
Wage	0.824	-6.065	-4.677	-2.578	-0.315	2.385	3.492
Risk	0.913	-1.822	-1.278	0.213	-0.445	-0.063	-0.552
Acreage	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Weights (α's)							
Rice	-0.116	0.121	-0.001	0.008	-0.017	-0.014	-0.005
Maize	-0.098	0.029	0.053	0.008	-0.033	-0.001	-0.006
Wheat	-0.032	-0.052	-0.032	0.019	-0.039	0.001	-0.006
Sorghum	-0.057	-0.061	0.006	-0.014	0.024	-0.015	-0.011
Wage	-0.001	-0.014	-0.002	0.006	0.006	-0.016	0.001
Risk	-0.310	-0.177	-0.079	-0.093	0.075	0.046	0.005
Acreage	-0.014	-0.004	-0.023	-0.123	-0.008	-0.038	0.011

Testing for the Number of Cointegrating Vectors				
H_0:	Trace Statistic	Trace (0.95)	λ_{Max}	λ_{Max} (0.95)
$r = 0$	178.877*	146.76	56.500*	49.42
$r \leq 1$	122.378*	114.90	40.225	43.97
$r \leq 2$	82.152	87.31	30.453	37.52
$r \leq 3$	51.700	62.99	23.079	31.46
$r \leq 4$	28.621	42.44	19.695	25.54
$r \leq 5$	8.926	25.32	8.548	18.96
$r \leq 6$	0.378	12.25	0.378	12.25

Note: The critical values are taken from Osterwald-Lenum, (1992).

Source: Author's Computations

As expected, the response of rice producers to increases in wage rates and price variability is negative and significant at the five percent level (Table 6.5). Specifically, the negative response to price risk implies that rice farmers in Kenya are risk responsive and presumably risk averse. Rice producers could be expected to be highly risk responsive since the government procured all paddy at predetermined prices prior to the reforms. However, market reforms have exposed rice producers to greater risk after the collapse of organized government marketing.

The results for the cointegration analysis of the sorghum area response function are reported in Table 6.6. In this case, the trace test statistic suggests the presence of two cointegrating relationships but the maximum eigenvalue test indicates the presence of only one cointegrating relationship in the VAR. Thus, like in the earlier models for maize, rice and wheat, the existence of one cointegrating relationship is upheld in this model. The estimated long-run elasticities can be summarized as follows.

$$AS = \underset{(4.080)}{1.628P_s} + \underset{(5.451)}{0.064P_m} - \underset{(5.946)}{1.261P_w} + \underset{(22.83)}{0.701P_r} - \underset{(7.127)}{0.036R_r} - \underset{(6.576)}{0.047w} \qquad (6.4)$$

Table 6.6. A VAR for Sorghum Acreage Response in Kenya, 1963 – 2005

Maximum Likelihood Cointegration Results: A seven -variable, one lag system							
Estimated Eigenvalues (λ's), Eigenvectors (β's) and Weights (α's)							
	Eigenvalues (λ's)						
Variable	0.715	0.670	0.470	0.394	0.266	0.177	0.006
Normalized Eigenvectors (β's)							
Sorghum	-1.628	-0.488	-2.554	0.666	0.029	0.160	-2.729
Maize	-0.064	4.657	-8.956	3.496	-0.714	-1.396	-3.758
Wheat	1.261	-3.959	1.236	-3.904	6.321	-1.418	5.488
Rice	-0.701	-1.412	-2.451	-0.949	-1.034	0.453	4.811
Wage	0.047	2.756	-1.123	-0.982	-3.105	0.733	-4.041
Risk	0.036	-0.096	1.724	0.161	0.344	-0.128	2.382
Acreage	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Weights (α's)							
Sorghum	-0.033	0.051	0.042	0.031	0.033	-0.036	-0.005
Maize	0.087	0.021	0.066	0.049	-0.003	-0.011	-0.001
Wheat	-0.019	0.065	0.064	-0.015	-0.009	-0.012	0.000
Rice	0.106	-0.086	0.105	0.033	0.006	0.002	-0.001
Wage	-0.011	0.011	0.000	-0.004	0.018	0.009	0.000
Risk	0.114	0.018	-0.055	-0.132	-0.076	-0.069	-0.014
Acreage	0.013	-0.004	-0.015	-0.003	-0.035	0.026	-0.007

Testing for the Number of Cointegrating Vectors				
H_0:	Trace Statistic	Trace (0.95)	λ_{Max}	λ_{Max} (0.95)
$r = 0$	164.426*	146.76	51.468*	49.42
$r \leq 1$	112.958*	114.90	42.510	43.97
$r \leq 2$	67.448	87.31	26.000	37.52
$r \leq 3$	41.447	62.99	20.545	31.46
$r \leq 4$	20.902	42.44	12.681	25.54
$r \leq 5$	8.221	25.32	7.966	18.96
$r \leq 6$	0.255	12.25	0.255	12.25

Note: The critical values are taken from Osterwald-Lenum, (1992).

The positive own-price elasticity of 1.63 implies that sorghum farmers in Kenya are price responsive. However, unlike the earlier three systems, the cross price elasticities indicate sorghum competes for land with wheat but compliments the production of maize and rice. This is true when considering that sorghum is a draught tolerant crop that is grown in the drier regions of Kenya where wheat is typically not produced. These dry areas also house the major rice irrigation scheme in Kenya. Sorghum farmers also respond negatively to increases in the wage rate and price variability.

6.2.5. Speed of Adjustment to the Long-run Equilibrium

The average speed of adjustment of the variables in the different models towards their long-run equilibrium states are given by the first column of the vector of weights (α) corresponding to the cointegrating vectors in each equation. These are the weights with which cropped acreages enter the equations in each supply system. They represent the speed of adjustment of different variable following any disturbances or policy shocks to the long-run equilibriums. It is interesting to note that cropped acreages have lower speeds of adjustment than all the other variables except wages.

These slow speeds of adjustment imply the system takes a long time to get back to its equilibrium path if it is disturbed by any external forces. For example, the acreage under maize would take 22 years to converge to its long-run equilibrium while the other cereals would take astronomically long periods to reach their steady state equilibriums following any external policy shocks. This implies that the effects of exogenous policies such as the SAPs and trade reforms will continue to be felt in Kenya's cereal grains sector for a long period of time.

6.2.6. Significance of the Long-run Elasticities

The significance of the own-price elasticity estimates is formally tested by imposing linear restrictions on the variables in the various VAR models. A likelihood ratio (LR)[16] test is constructed following the general formulation of a linearly restricted model $\beta = \mathbf{H}\varphi$. It tests for the significance of restricting the relevant variable in the VAR or of excluding it. In this model, **H** is a $p \times s$ matrix with $r \leq s \leq p$ and s is equal to the number of variables minus the number of restrictions imposed. To test the significance of the price elasticities, the null hypothesis, $\beta_{pnce} = 0$ is constructed. An H matrix (6.5) containing the linear restriction is then used to implement the test.

$$H = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \qquad (6.5)$$

Table 6.7 presents the results of the tests for significance of the own-price supply elasticities. The significance of all other variable are presented in equations 6.1 to 6.4. The calculated LR statistic exceeds the critical x^2 value at the five percent level for all long-run own- price elasticities in the four acreage response models (Table 6.7). Thus, the null hypothesis of price non responsive producers is rejected in all cases. This implies that the estimated price, wage and price risk elasticities have significant influences on the corresponding acreages and are thus suitable for policy analysis.

[16] $LR = T\sum Ln\{(1-\lambda_{ij})/(1-\lambda_i)\}$ where λ_{ij} and λ_i are the eigenvalues from the restricted and unrestricted models respectively. The test is X distributed with *(r(p-s)* degrees of freedom where *r* is the number of cointegrating vectors in the original model, *p* is the number of variables in the model and *s* is the total number of restrictions. All models in this study have (1(6-5) = 1 degree of freedom.

Table 6.7. Long-run Test on Significance of Individual Elasticities

H_0: $\beta_{own\ price} = 0$, $\beta_{Lab} = 0$, $\beta_{risk} = 0$				
Likelihood Ratio (LR) Test Statistic				
Model	Critical Value*	$\beta_{own\text{-}price}$	β_{Lab}	β_{risk}
Maize	3.84	4.006	6.384	6.032
Wheat	3.84	33.31	33.34	52.65
Sorghum	3.84	10.37	15.48	9.028
Rice	3.84	4.080	6.576	7.127

Note: (*) denotes the critical x^2 values at the 5 percent level of significance with df = $r\ (p - s) = 1$

Source: Author's Computations

6.2.7. Short-Run Supply Relationships

An ECM is used to estimate the system of short-run acreage elasticities following the specification in equation 5.7. Initially, the theoretical properties of symmetry and homogeneity are statistically tested. All price parameters must sum to zero while the cross-price effects should be equal to satisfy the homogeneity and symmetry respectively. Based on a Wald test, the maintenance of both homogeneity and symmetry cannot be rejected at the one percent level. The calculated x^2 of 20.73 is below the critical value of 23.21 for 10 degrees of freedom at the one percent significance level. To be consistent with theory, the system of four acreage response functions is estimated with the parametric imposition of homogeneity and symmetry.

Table 6.8 reports the estimated short-run acreage elasticities from the ECM. The model fits the data well as indicated by the high system R^2 at 0.99. All estimated coefficients are jointly significant since the test of overall significance exceeds the critical $x^2_{22} = 33.92$ at the five percent significance level. The LR test of the diagonal covariance matrix exceeds the critical $x^2_6 = 12.59$ and thus the estimation procedure adequately corrects for heteroskedasticity. The EC terms of the four equations are negative and significant ensuring dynamic stability of the system.

Table 6.8. Short-Run Acreage Elasticities for Cereals in Kenya, 1963 – 2005

	Elasticity with Respect to the Price of					Response
Acreage of	Maize	Wheat	Rice	Sorghum	Labour	**to Risk**
Maize	0.335	0.304	0.286	0.308	-0.070	-0.026
	(2.700)	*(8.903)*	*(4.182)*	*(8.833)*	*(-22.82)*	*(-2.235)*
Wheat	0.278	0.370	0.187	0.252	-0.070	-0.034
	(8.903)	*(4.531)*	*(2.706)*	*(7.593)*	*(-19.82)*	*(-2.197)*
Rice	0.188	0.134	0.078	0.228	-0.067	-0.076
	(4.182)	*(2.706)*	*(2.525)*	*(6.095)*	*(-17.81)*	*(-2.394)*
Sorghum	0.325	0.291	0.366	0.281	-0.072	-0.003
	(8.833)	*(7.593)*	*(6.095)*	*(4.009)*	*(-20.93)*	*(-2.121)*
EC Term	-0.145	-0.618	-0.904	-0.703		
	(-1.758)	*(-3.474)*	*(-6.335)*	*(-4.708)*		
Diagnostic Tests	Systems R-Square = 0.987 Test of the overall significance (x^2_{22}) = 187.130 LR test of the diagonal covariance matrix (x^2_6) = 271.840					

Note: The figures in parenthesis are student t-values. The critical value at the 5 percent level is 1.960.
Source: Author's Computations

All short-run own-price acreage elasticities are positive and significant at the one percent level (Table 6.8). The short-run own-price acreage elasticities for maize, wheat, rice and sorghum are estimated at 0.34, 0.37, 0.08 and 0.28 respectively. They are broadly consistent with the results of Johansen's approach. In particular the ECM suggests long-run acreage elasticities of 2.31 and 0.60 for maize and wheat respectively, which compares reasonably well with the long-run estimates from the VAR of 2.17 and 0.80 for maize and wheat respectively.

All short-run own-price acreage elasticities from the ECM are smaller than their long-run counterparts from the VAR. Thus, the *LeChatelier*[17] *principle* is satisfied on the supply side. Contrary to the expectations, the cross-price elasticities are positive in all cases, to erroneously suggest that all cereal grains in Kenya are complementary in production. All elasticity estimates with respect to the cost of inputs are negative and significant at the one percent level (Table 6.8).

[17] The LeChateleir principle states that the long-run supply response to a change in price is at least as large as short-run response (Varian, 1992)

6.2.8. Comparison of the Current Supply Responses with Earlier Studies

The current acreage elasticities are broadly consistent with earlier findings in Kenya (Table 6.9). Maitha (1974), Booker (1983) and Kere *et al*, (1986) used time series methods to derive long-run elasticities that range from 0.95 to 2.43 for maize and 0.65 to 1.38 for wheat. Recently, Munyi (2000) and Renkow *et al*, (2004) used survey data to estimate short-run elasticities in the range of 0.32 to 0.66 for maize. However, previous supply elasticities for rice and sorghum in Kenya are not available. To the best of my knowledge, this thesis is the first study that reports acreage elasticities for rice and sorghum in Kenya.

Table 6.9. Comparison of Own-Price Acreage Elasticities

Study	Sample Period	Maize		Wheat	
		Short-run	Long-run	Short-run	Long-run
Maitha,(1974)	1950 - 1969	0.95	2.43	0.31	0.65
Booker, (1983)	1970 - 1982	0.40	0.95	-	-
Kere *et al*, (1986)	1965 - 1983	-	-	0.65	1.38
Munyi, (2000)	1999	0.32	-	-	-
Renkow *et al*, (2004)	1997	0.66	-	-	-
Current study	1963 - 2005	0.34	2.17	0.37	0.80

Source: Author's Compilations

These findings are consistent with Rao's (1989) survey of food supply response models in SSA that report short-run responses in the zero to 0.8 ranges while long-run estimates range from 0.3 to 1.2. The elasticity estimates also find support in the literature on agricultural supply response. According to Chhibber, (1989) the supply elasticity for developing countries could vary from as low as 0.2 for countries with poor infrastructure to about 0.9 for countries with advanced infrastructure. In addition, complimentary interventions to improve marketing infrastructure, access to inputs and improved technologies can be expected to make producers even more responsive.

6.3. Elasticity Estimates for Intermediate Demands

This section presents the estimated elasticities of demand for grain cereals in Kenya at the farm and wholesale levels. It is organized into two major parts. First, the elasticity estimates of farm derived demand for grain cereals in Kenya are presented. This is followed by a presentation of the results of estimating the wholesale demand for grain cereals in Kenya. Each part begins with an investigation of the time series properties of the data used before presenting the estimated parameters.

6.3.1. Farm-Level Derived Demand for Grain Cereals in Kenya

A graphical approach is adopted as the first step in determining the time series properties of the data used to estimate the farm derived demand for grain cereals in Kenya. All farm grain outputs appear to be trended upwards (Figure 6.3). In contrast producer prices are downward trended (Figure 6.2). Moreover, grain cereal wholesale prices appear to be downward trended (Figure 6.4). These trends in prices and output suggest non-constant means and variances, which imply nonstationary trends and hence highlight the need for formal unit root tests.

Figure 6.3. Domestic Cereal Production in Kenya, 1963-2005

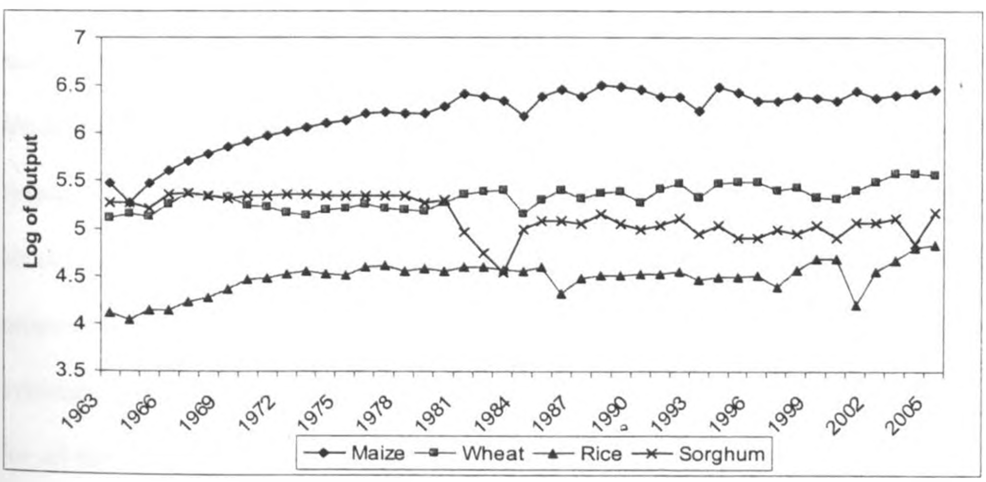


Table 6.10 presents the results for testing the series (in logarithms) for unit roots using trended ADF and PP tests. The hypothesis that the level series of outputs and prices at the farm-level contain a unit root cannot be rejected at the five percent level (Table 6.10). However, each series becomes stationary at the same significance level when first differences are taken. This implies that all the farm output and producer prices are integrated of order one I*(1)*. Thus, any demand analysis involving farm outputs and prices must address the issue of non-stationarity in these series.

Table 6.10. Unit Root Test Results for Farm Outputs and Producer Prices

Series	Level Series			First Differences		*I*(d)
	ADF	PP	Lags	ADF	PP	
Logarithm of Output (MT)						
Maize (*MT*)	-2.031	-1.888	1	-6.377 [c]	-9.427 [c]	*I*(1)
Wheat (*MT*)	-2.219	-2.179	1	-3.712 [c]	-7.314 [c]	*I*(1)
Paddy Rice *(MT)*	-3.179	-3.078	1	-3.628 [c]	-8.435 [c]	*I*(1)
Sorghum (*MT*)	-2.960	-2.961	1	-3.726 [c]	-7.006 [c]	*I*(1)
Logarithm of Nominal Producer Prices (Log Pd)						
Log Pd Maize	-2.970	-2.779	1	-4.268 [c]	-6.901 [c]	*I*(1)
Log Pd Wheat	-2.550	-2.849	1	-3.593 [c]	-8.448 [c]	*I*(1)
Log Pd Paddy Rice	-2.637	-2.580	1	-3.596 [c]	-5.541 [c]	*I*(1)
Log Pd Sorghum	-2.557	-2.406	1	-3.592 [c]	-6.539 [c]	*I*(1)
Log Wage rate	-1.356	-1.371	1	-4.217 [c]	-6.009 [c]	*I*(1)
5 % Critical Values	-3.50	-3.50		-3.50	-3.50	

Note: Asterisk (c) indicates significance at the 5 percent significance level (MacKinnon, 1991)
Source: Author's Computation

Having established that all price and output series at the farm are I(*1*), the analysis next focuses on testing for cointegration among the nonstationary series. Since Johansen's MLE approach violates the theoretical restrictions implied in demand systems, alternative approaches are used to test for cointegration at the intermediate level. Table 6.11 reports the results of two static cointegration tests and a dynamic test proposed by Banerjee *et al*, (1986). Even though the ADF test results do not offer any evidence of cointegration, the PP test results reject the hypothesis of no cointegration for all farm output demands at the five percent level (Table 6.11).

Table 6.11. Cointegration Tests: Farm Derived Demand series

Series	Dickey-Fuller Cointegration Test		Philips-Perron Cointegration Test		Dynamic Cointegration Test	
	No Trend	Trended	No Trend	Trended	EC term	t - value
Farm Output (MT)						
Maize	-3.017	-3.429	-3.539	-7.228[c]	-0.305[c]	-3.977
Wheat	-3.249	-4.250	-4.300[c]	-5.277[c]	-0.362[c]	-2.242
Rice	-3.462	-2.171	-3.483	-5.466[c]	-0.556[c]	-3.695
Sorghum	-3.795	-3.758	-4.565[c]	-5.052[c]	-0.964[c]	-6.594
5% Critical Values	-4.71	-5.03	-4.71	-5.03		-1.960

Note: (c) Indicates significance at the 5 percent significance level (Phillips and Ouliaris, 1990).
Source: Author's Computation.

In addition, the dynamic test rejects the hypothesis of no cointegration for all farm output demands at the five percent level (Table 6.11). This test is recommended when the static cointegration tests fail. It can, therefore, be concluded that the variables used to estimate the farm derived demands are nonstationary. To address the nonstationary nature of these variables, an ECM of the demand for farm output as specified in equation 5.9 is estimated. The estimation begins by specifying an unrestricted form of the ECM and testing it for the theoretical properties of demand.

The model rejects the maintenance of homogeneity and symmetry or just homogeneity at the five percent level. Similarly, neither condition holds when the system is estimated using conventional econometric methods probably due to the small sample size. Table 6.12 reports the estimated short-run elasticities of demand for cereals at the farm-level. All the estimated elasticities are jointly significant since the test of overall significance exceeds the critical x^2 value of 41.34 at 28 degrees of freedom. As expected, the estimated EC terms of the four equations are all negative and significant at the five percent level. These diagnostic tests results suggest that the residuals are well behaved and the model adequately approximates the data.

Table 6.12. Short-run Elasticities of Demand for Cereals at the Farm Level

Farm Quantity of	Elasticity with Respect to the Producer Price of			
	Maize	Wheat	Rice	Sorghum
Maize	-0.429	-0.089	-0.120	-0.152
	(-2.606)	*(-1.436)*	*(-1.572)*	*(-2.306)*
Wheat	-0.088	-0.283	-0.295	-0.113
	(-1.436)	*(-2.104)*	*(-3.993)*	*(-1.631)*
Rice	-0.099	-0.246	-0.177	0.003
	(-1.572)	*(-3.993)*	*(-1.818)*	*(0.047)*
Sorghum	-0.174	-0.130	0.004	-0.287
	(-2.306)	*(-1.631)*	*(0.047)*	*(-1.678)*
	Elasticity with Respect to the Wholesale Price of			
Maize	0.649	0.514	0.466	0.699
	(3.714)	*(4.293)*	*(4.732)*	*(4.012)*
Wheat	0.495	0.550	0.370	0.443
	(4.293)	*(4.293)*	*(3.916)*	*(3.294)*
Rice	0.402	0.331	0.517	0.409
	(4.732)	*(3.916)*	*(5.367)*	*(3.956)*
Sorghum	0.625	0.681	0.482	0.436
	(4.012)	*(3.294)*	*(3.956)*	*(1.808)*
Wage	-0.754	-0.672	-0.992	-1.415
	(-1.850)	*(4.545)*	*(-1.745)*	*(-2.211)*
EC Term	-0.305	-0.362	-0.556	-0.964
	(-3.977)	*(-2.242)*	*(-3.695)*	*(-6.594)*
Model Diagnostics	Systems R-Square = 0.973 Test of the overall significance (x^2_{28}) = 155.760 LR test of the diagonal covariance matrix (x^2_6) = 323.450			

Note: Values in parenthesis are *t*-values. The critical value at the 5 percent significance level is 1.960.
Source: Author's Computation

All estimated parameters carry the expected signs. The own-price derived demand elasticities with respect to own producer prices are negative and significant at least at the 10 percent level. The own-price derived demand elasticities at the farm for maize, wheat, rice and sorghum are -0.43, -0.28, -0.18 and -0.29 respectively (Table 6.12). Conversely, the farm-level elasticities with respect to own-wholesale prices are positive and significant at the same level. The latter elasticities represent wholesale supply and are estimated at 0.65, 0.55, 0.52 and 0.44 for maize, wheat, rice and sorghum respectively (Table 6.12). Overall, the supply of grain cereals in Kenya is more price responsive at the wholesale level than at the farm level.

Table 6.13 Long-run Elasticities of Demand for Cereals at the Farm Level

Farm Quantity of	Elasticity with Respect to the Producer Price of			
	Maize	Wheat	Rice	Sorghum
Maize	-1.407	-0.247	-0.216	-0.158
Wheat	-0.289	-0.783	-0.530	-0.117
Rice	-0.324	-0.678	-0.318	0.003
Sorghum	-0.570	-0.360	0.008	-0.297
	Elasticity with Respect to the Wholesale Price of			
Maize	2.130	1.420	0.838	0.691
Wheat	1.622	1.519	0.665	0.725
Rice	1.318	0.915	0.931	0.460
Sorghum	2.049	1.882	0.866	0.452
Wage	-2.470	-1.856	-1.245	-1.019

Note: Values in parenthesis are standard errors.

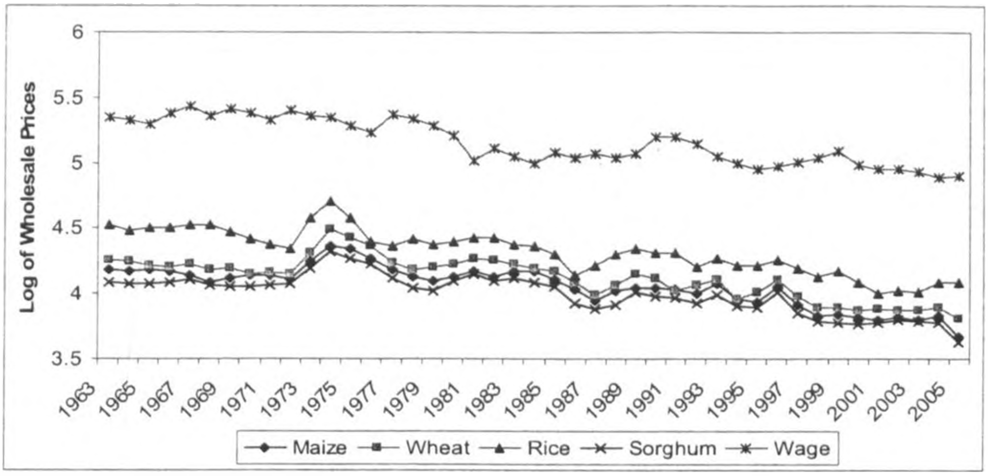
Source: Author's Computation.

Table 6.13 presents the long-run farm-level elasticities of demand for grain cereals in Kenya. They are generated from the short-run estimates by dividing the short-run estimates by the absolute value of the EC terms following Johnson *et al*, (1992). The long-run farm derived elasticities for maize, wheat, rice and sorghum are estimated at -1.41, -0.78, -0.32 and -0.30 while their corresponding wholesale supply elasticities are 2.13, 1.52, 0.93 and 0.45 respectively. All estimated long-run own price elasticities at the farm-level are greater than their short-run counterparts, thus the *LeChatelier* principle is satisfied with regard to the farm derived demands.

6.3.1. Wholesale Demand for Grain Cereals in Kenya

The analysis of the wholesale demand for grain cereals in Kenya begins with a graphical examination of the time series properties of the data used. Figure 6.4 shows that all cereal wholesale prices and the marketing costs (wage) move closely in the same direction and are downward trended. These trends in the wholesale price series are indicative of nonstationary processes. To confirm the presence of unit roots in the series, formal unit root tests are conducted in the next section.

Figure 6.4. Nominal Wholesale Prices of Cereal Grains in Kenya



Source: Authors compilations

The results relating to the time-series properties of the data are reported in Tables 6.14 and 6.15. Based on ADF and PP test results, the null hypothesis of a unit root in the level series cannot be rejected for all wholesale price and output series at the five percent significance level (Table 6.14). When first differences are used, unit root non-stationarity is rejected at the same level of significance for all series. These results indicate that the level series of the variables tested are integrated of order one.

Table 6.14. Unit Root Tests at the Wholesale Market

Series	Level Series			First Differences		*I*(d)
	ADF	PP	Lags	ADF	PP	
Logarithm of Wholesale Output (MT)						
Maize (*MT*)	-3.438	-2.201	1	-5.787^{c}	-11.23^{c}	*I*(1)
Wheat (*MT*)	-2.640	-1.194	1	-3.910^{c}	-7.294^{c}	*I*(1)
Paddy Rice *(MT)*	-1.572	-0.436	1	-5.012^{c}	-9.780^{c}	*I*(1)
Sorghum (*MT*)	-2.960	-2.952	1	-3.273^{c}	-7.006^{c}	*I*(1)
Logarithm of Wholesale Prices (Log Pw)						
Log Pw Maize	-2.988	-2.923	1	-3.548^{c}	-7.579^{c}	*I*(1)
Log Pw Wheat	-2.011	-2.087	1	-3.532^{c}	-5.411^{c}	*I*(1)
Log Pw Paddy Rice	-2.228	-2.306	1	-4.043^{c}	-5.373^{c}	*I*(1)
Log Pw Sorghum	-2.140	-2.162	1	-3.534^{c}	-6.700^{c}	*I*(1)
Log Wage rate	-1.355	-2.125	1	-3.754^{c}	-6.438^{c}	*I*(1)
5 % Critical Values	-3.50	-3.50		-3.50	-3.50	

Note: Asterisk (c) indicates significance at the 5 percent significance level (MacKinnon, 1991)

Source: Author's Computations

Since theory posits that a linear combination of two or more nonstationary variables may be cointegrated, the analysis focuses on tests for cointegration in the next stage. The ADF test fails to reject the hypothesis of no cointegration for the wholesale series (Table 6.15). However, the PP test rejects the hypothesis of no cointagration at the five percent level for all wholesale demands. Moreover, the dynamic cointegration test suggests that all wholesale outputs are cointegrated with the wholesale and retail prices as indicated by the significant EC terms at the one percent level (Table 6.15).

Table 6.15. Cointegration Tests: Wholesale Demand Series

Series	Dickey-Fuller Cointegration Test		Philips-Perron Cointegration Test		Dynamic Cointegration Test	
	No Trend	Trended	No Trend	Trended	EC term	t - value
Farm Output (MT)						
Maize	-3.086	-2.173	-4.296	-5.812^{c}	-0.429^{c}	-4.473
Wheat	-3.658	-4.031	-5.245^{c}	-5.297^{c}	-0.785^{c}	-4.379
Rice	-1.939	-2.205	-5.052^{c}	-7.531^{c}	-0.729^{c}	-5.048
Sorghum	-3.283	-4.023	5.054^{c}	-5.092^{c}	-0.992^{c}	-6.963
5% Critical Values	-4.71	-5.03	-4.71	-5.03		-1.960

Note: (c) Indicates significance at the 5 percent significance level (Phillips and Ouliaris, 1990).
Source: Author's Computations

To accommodate the nonstationary trends in the wholesale demand series, the study turns its focuses to the estimation of an ECM as specified in equation 5.10. The estimation starts with tests for homogeneity and symmetry from an unrestricted ECM, which are rejected at the five percent significance level. The short-run elasticities of wholesale demand for grain cereals are reported in Table 6.16. All estimated coefficients are jointly significant as indicated by the test of overall significance whose value exceed the critical value of 41.34 at 28 degrees of freedom (Table 6.16). Furthermore, all the EC terms are negative, less than one and significant at the one percent level, which suggests that the model is stable.

Table 6.16. Short-run Elasticities of Demand for Cereals at the Wholesale Level

Wholesale Quantity of	Elasticity with Respect to the Wholesale Price of			
	Maize	Wheat	Rice	Sorghum
Maize	-1.002	-0.658	-0.771	-0.942
	(-2.004)	*(-3.601)*	*(-4.600)*	*(-4.463)*
Wheat	-0.635	-2.416	-0.731	-0.445
	(-3.601)	*(-6.060)*	*(-4.578)*	*(-2.606)*
Rice	-0.684	-0.672	-1.260	-0.529
	(-4.600)	*(-4.578)*	*(-4.177)*	*(-3.370)*
Sorghum	-0.883	-0.442	-0.558	-1.717
	(-4.463)	*(-2.606)*	*(-3.370)*	*(-3.723)*
	Elasticity with Respect to the Retail Price of			
Maize	2.229	1.193	1.440	1.180
	(6.803)	*(7.515)*	*(8.037)*	*(7.348)*
Wheat	1.338	2.448	1.360	1.289
	(7.515)	*(8.262)*	*(6.475)*	*(7.003)*
Rice	1.238	1.043	1.449	1.163
	(8.037)	*(6.475)*	*(4.184)*	*(7.235)*
Sorghum	1.243	1.211	1.425	1.976
	(7.348)	*(7.003)*	*(7.236)*	*(6.007)*
Wage	-1.654	-1.490	-1.732	-1.406
	(-3.580)	*(-3.193)*	*(-3.566)*	*(-2.983)*
EC Term	-0.429	-0.785	-0.729	-0.992
	(-4.473)	*(-4.379)*	*(-5.047)*	*(-6.963)*
Model Diagnostics	Systems R-Square = 0.952 Test of the overall significance (x^2_{28}) = 130.790 LR test of the diagonal covariance matrix (x^2_6) = 392.790			

Note: Values in parenthesis are *t*-values. The critical value at the 5 percent significance level is 1.960.
Source: Author's Computation

All estimated elasticities posses the hypothesized signs and are significant at the five percent level. The elasticities of demand for maize, wheat, rice and sorghum with respect to own-wholesale price are -1.00, -2.42, -1.26 and -1.72 respectively while those with regard to the retail prices are is 2.23, 2.45, 1.45 and 1.98 respectively (Table 6.16). These estimates suggest that both the demand and supply for staple grains in Kenya is more responsive at the wholesale level than at the farm level. Perhaps this price responsiveness can be explained by the fact that Kenya is a small country importer, with trade occurring at the wholesale level. In general, supply is more responsive at the retail level than both the wholesale and farm levels.

Table 6.17 . Long-run Elasticities of Demand for Cereals at the Wholesale Level

Wholesale Quantity of	Elasticity with Respect to the Wholesale Price of			
	Maize	Wheat	Rice	Sorghum
Maize	-2.335	-0.838	-1.057	-0.950
Wheat	-1.481	-2.823	-1.003	-0.459
Rice	-1.594	-0.856	-1.729	-0.533
Sorghum	-2.058	-0.562	-0.766	-1.731
	Elasticity with Respect to the Retail Price of			
Maize	5.195	1.519	1.975	1.189
Wheat	3.118	3.118	1.866	1.299
Rice	2.886	1.329	1.988	1.172
Sorghum	2.898	1.542	1.954	1.992
Wage	-3.856	-1.898	-2.376	-1.417

Note: Values in parenthesis are standard errors.
Source: Authors Computations

As expected, all long-run estimates of wholesale demand are larger than their short-run counterparts in absolute terms (Table 6.17). Thus the *LeChateleir* principle is satisfied with regard to wholesale demand. The long-run own-price elasticities with respect to wholesale prices for maize, wheat, rice and sorghum are -2.34, -2.82, -1.72, and -1.73 respectively (Table 6.17). Conversely, the long-run own-price elasticities with respect to retail prices for maize, wheat, rice and sorghum are 5.20, 3.12, 1.98 and 1.99 respectively (Table 6.17).

The derived supply elasticities at the retail level are higher than those at the wholesale level. Similarly, the derived supply response at the wholesale level is quite high when compared with the acreage responses at the farm. These findings imply that the down stream markets are more response to price changes on the supply side. In contrast, the derived demand elasticities at the wholesale level are higher than the demand elasticities at the farm, which are higher than the consumer demand elasticities (see Table 6.23). Perhaps the high demand responses at the wholesale level of the maize market in Kenya could be attributed to the fact that trade occurs at this level.

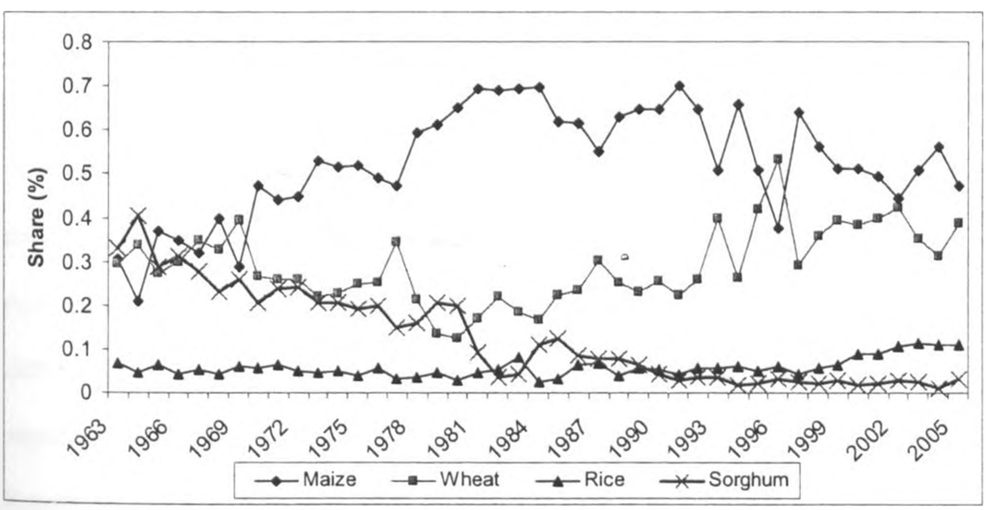
6.4. Consumer Demand Elasticity Estimates

This section comprises a four part presentation of the elasticity estimates of demand. Initially, ADF test results for unit roots are presented. Secondly, the results of testing for cointegration between the budget shares and prices are reported based on ADF, PP and a dynamic cointegration test. Next, the empirical results of statistical tests for the validity of the theoretical restrictions of homogeneity and symmetry are discussed. The section ends by a presentation of the elasticity estimates from an ECM form of the AIDS and a comparison of the current results with previous estimates.

6.4.1. Unit Root Test Results for the Demand System Series

The data set used in estimating the ECM form of the AIDS for cereal grains in Kenya is graphically examined for the existence of linear trends and later formally tested for the presence of unit roots by the use of ADF and PP tests. These tests serve as a first step towards establishing the time series properties of all variables included in the demand system.

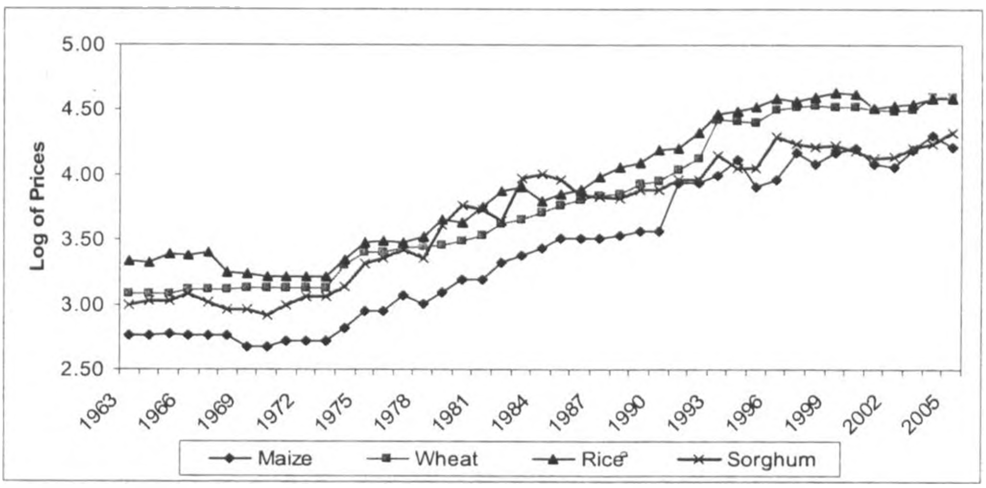
Figure 6.5. Cereal Expenditure Shares, 1963-2005



Source: Author's Computation.

Figure 6.5 presents the evolution of aggregate cereal budget shares in Kenya over the study period. The graph indicates the presence of trends in the budget shares of the four cereal grains. Moreover, the corresponding price graph shows that cereal retail prices appear to be upward trended (Figure 6.6). These figures do not tell us anything about stochastic trends in the data but may suggest nonstationary behaviour. Thus, formal unit root tests tests have to be undertaken to ascertain the presence of unit roots in all the data series used in estimating the demand system.

Figure 6.6. Nominal Consumer Prices, 1963-2005



Source: Author's Computation.

The results of formal unit root tests from a trended ADF and PP test for the variables of the demand system are summarized in Table 6.18. The hypothesis that all cereal consumer prices, total expenditure and budget shares contain a unit root cannot be rejected at the five percent significance level for both models (Table 6.18). When first differences are tested, data nonstationarity is firmly rejected at the same level of significance for all variables in both models. Thus, the results are consistent with the hypothesis that nonstationarity characterizes the time series of these variables.

The unit root test results imply that the level series of the variables used to estimate the demand system for cereal grains in Kenya are integrated of order one (Table 6.18). It can, therefore, be concluded that the time series data of all the variables used to estimate the demand system are generated by a unit root process. Thus, any time series estimation of demand for grain cereals in Kenya has to deal with the issue of non-stationarity of prices and test for cointegration between the quantity variables and the corresponding explanatory variables.

Table 6.18. ADF Test Results for Retail Prices and Total Expenditure

Series	Level Series			First Differences		*I*(d)
	ADF	PP	Lags	ADF	PP	
Budget Shares (w)						
w Maize	-1.440	-2.361	3	-4.141 [c]	-9.233 [c]	*I*(1)
W wheat	-1.618	-3.068	4	-3.584 [c]	-8.868 [c]	*I*(1)
w Rice	-1.602	-2.339	3	-3.611 [c]	-10.11 [c]	*I*(1)
w Sorghum	-1.709	-2.398	3	-3.878 [c]	-8.813 [c]	*I*(1)
Logarithm of Consumer Prices (Log Pc)						
Log Pc Maize	-2.988	-2.923	2	- 8.029 [c]	- 7.577 [c]	*I*(1)
Log Pc Wheat	-2.228	-2.305	2	- 7.438 [c]	- 5.371 [c]	*I*(1)
Log Pc Rice	-2.011	-2.087	2	- 6.315 [c]	- 5.411 [c]	*I*(1)
Log Pc Sorghum	-2.140	-2.162	2	- 6.579 [c]	- 6.700 [c]	*I*(1)
Total Expenditure	-1.694	-3.302	3	- 4.864 [c]	- 9.861 [c]	*I*(1)
5% Critical Values	-3.50	-3.50		-3.50	-3.50	

(c) Indicates rejection of the null hypothesis of a unit root at the 5 percent level (MacKinnon, 1991).
Source: Author's Computation

Having established that all the variables in the demand system are nonstationary, I next turn to testing the demand system for cointegration. Cointegration tests are necessary to investigate whether the budget shares are jointly determined with their respective prices. This is because the literature suggests that a linear combination of nonstationary variables might be stationary. In this study, two residue based cointegration tests and the dynamic test by Banerjee *et al*, (1986) are used to test for cointegration between the budget shares and the prices along with total expenditure.

Table 6.19. Cointegration Tests: Consumer Demand Series

Series	Dickey-Fuller Cointegration Test		Philips-Perron Cointegration Test		Dynamic Cointegration Test	
	No Trend	Trended	No Trend	Trended	EC term	t - value
Budget Shares (w)						
w Maize	-3.665	-3.547	-5.104 [c]	-4.986 [c]	-0.419 [c]	-1.718
w wheat	-3.727	-3.415	-6.136 [c]	-6.099 [c]	-0.886 [c]	-6.273
w Rice	-2.310	-1.969	-3.552	-5.618 [c]	-0.225 [c]	-4.679
w Sorghum	-3.507	-3.448	-5.165 [c]	-5.243 [c]	-0.682 [c]	-4.659
5% Critical Values	-4.71	-5.03	-4.71	-5.03		-1.960

(c) Reject the null hypothesis of no cointegration at the 5 percent level (Phillips and Ouliaris, 1990).
Source: Author's Computation.

Table 6.19 gives the results of the three alternative tests for cointegration between the budget shares and their corresponding explanatory variables using ADF tests, PP tests and a dynamic test that uses the EC term of the ECM. The ADF test fails to reject the hypothesis of no cointegration for all budget shares at the five percent significance level (Table 6.19). However, the PP test, a more powerful test in small samples rejects the hypothesis of no cointegration when a time trend is included for all budget shares at the same significance level. The latter finding supports Ng's (1995) suggestion that a deterministic time trend is sometimes needed for the identification of cointegration.

The dynamic cointegration test results suggest that the budget shares are cointegrated with their explanatory variables at least at the 10 percent significance level (Table 6.19). Cointegration ensures that shocks affecting commodity prices will be reflected on different budget shares in a similar way. The cointegrated variables move together in the long-run and obey an equilibrium constraint. Having established the existence of long-run cointegrating relationships, an ECM form of the AIDS as specified in equation 5.18 is estimated. Initially, the demand system is estimated in unrestricted form to test the theoretical restrictions of homogeneity and symmetry.

6.4.2. Testing Demand Theory Restrictions

The hypotheses of linear homogeneity, symmetry and both linear homogeneity and symmetry are tested based on the Wald test. To implement these statistical tests, the ECM form of the AIDS is estimated and statistically tested for symmetry and homogeneity. Based on the Wald test, the maintenance of linear homogeneity and symmetry either separately or jointly, cannot be rejected at the five percent significance level (Table 6.20). These findings suggest that the empirical results are at least theoretically consistent with symmetry and homogeneity and thus are valid for this functional specification.

Table 6.20. Systems Wald Tests for Homogeneity and Symmetry

Parametric Restriction	Calculated x^2 Values	Critical Value		Degrees of Freedom
		5%	1%	
Homogeneity	3.443	7.82	11.35	3
Symmetry	0.735	7.82	11.35	3
Homogeneity and Symmetry	3.730	12.59	16.81	6

Source: Author's Computations

As Attfield, (1985) suggests, the acceptance of the homogeneity property can be interpreted as an acceptance of the exogeneity of expenditures. Since the AIDS is separable, the model does not exhaust the consumption of other food products and changes in income are taken as exogenous. In addition, the estimated parameters satisfy monotonicity and concavity of the underlying (true) cost function. Monotonicity in prices requires that all budget shares are strictly positive and thus, it is satisfied at each data point since all budget shares in this model are strictly positive. Subsequently, the ECM version of the AIDS is estimated with the parametric imposition of symmetry and homogeneity and used to compute demand elasticities.

Furthermore, the concavity of the cost function at the sample mean is ensured since all own-price Hicksian elasticities are negative (see Table 6.24) and consequently the corresponding slutsky matrix is negative semi-definite. As expected, the EC terms are all negative and significant at the five percent level (Table 6.21). This finding suggests that the model is stable and that any deviations from the long-run equilibrium are corrected. Overall, the estimated parameters of consumer demand are theoretically consistent and thus the estimated elasticities are valid for policy analysis.

6.4.3. Parameter Estimates of the ECM Version of the AIDS

The parameter estimates of the restricted ECM form of the AIDS are presented in Table 6.21. The explanatory power of the model is satisfactory as indicated by the system's R^2 of 0.98. All the estimated parameters are jointly significant as indicated by the test of overall significance that rejects the null hypothesis that the slope coefficients are jointly zero. The calculated $x^2_{15} = 167.26$ exceeds the critical value of 25 at the five percent significance level (Table 6.21). In addition, the LR test of the diagonal covariance matrix shows that the model adequately corrects for the heteroskedasticity expected when demand systems are cointegrated.

Over two thirds of the estimated coefficients are statistically significant at least at the 10 percent level (Table 6.21). The expenditure coefficients (β) measure the change in the i^{th} budget share with respect to a change in total expenditure and indicate whether goods are necessities (β<0) or luxuries (β>0). All expenditure coefficients for staple grain cereals in Kenya with the exception of that for rice are negative and significant at least at the five percent level (Table 6.21). The negative β coefficients for maize, wheat and sorghum suggest that these cereals are necessities in Kenya.

Table 6.21. Parameter Estimates of an AIDS-ECM for Cereal Demand in Kenya

Parameter	Estimated Parameters with Respect to			
	Maize	Wheat	Sorghum	Rice
γ_{i1}	0.159			
	(2.728)			
γ_{i2}	-0.131	0.153		
	(-4.888)	*(4.417)*		
γ_{i3}	0.006	-0.026	0.031	
	(0.403)	*(-1.614)*	*(1.825)*	
γ_{i4}	-0.034	0.004	-0.011	0.041
	(-0.781)	*(0.157)*	*(-0.542)*	
β_i	-0.068	-0.104	-0.114	0.286
	(-2.517)	*(-8.843)*	*(-15.210)*	
λ_i	-0.419	-0.886	-0.682	
	(-1.718)	*(-6.273)*	*(-4.659)*	
Model Diagnostics	Systems R-Square = 0.980 Test of the overall significance (x^2_{15}) = 167.260 LR test of the diagonal covariance matrix (x^2_3) = 50.360			

Note: Figures in parenthesis are *t*-values. The critical value at the 5 percent significance level is 1.960.
Source: Author's Computations

6.4.4. Consumer Demand Elasticities

Tables 6.22 to 6.25 present the estimated elasticities of demand for grain cereals in Kenya. In general, all estimated elasticities are price and income inelastic. Specifically, own-price elasticities are all negative and significant at least at the five percent level. The own-price Marshallian elasticities of demand for maize, wheat, rice and sorghum in the short-run are -0.53, -0.26, -0.66 and –0.79 respectively (Table 6.22). The negative own-price elasticities suggest that the corresponding demand curves are downward sloping to satisfy the law of demand.

All expenditure elasticities are positive and significant at the five percent level (Tables 6.22 and 6.23). The expenditure elasticity for maize ranges from 0.83 in the short-run to 0.93 in the long-run. The positive expenditure elasticities suggest that cereals are normal goods in Kenya. Moreover, all grains are expenditure inelastic both in the short and long-run, implying that grain cereals are necessary goods in Kenya.

Table 6.22. Short-run Marshallian Elasticities for Cereals in Kenya, 1963-2005

Commodity	Elasticity with Respect to the Price of				Expenditure Elasticity
	Maize	Wheat	Sorghum	Rice	
Maize	-0.531	-0.432	0.101	-0.226	0.828
	(0.120)	*(0.062)*	*(0.049)*	*(0.620)*	*(0.068)*
Wheat	-0.290	-0.260	0.089	-0.045	0.568
	(0.050)	*(0.132)*	*(0.126)*	*(0.483)*	*(0.049)*
Sorghum	0.073	0.162	-0.794	-0.878	0.657
	(0.033)	*(0.063)*	*(0.043)*	*(0.321)*	*(0.023)*
Rice	-0.081	-0.096	-0.021	-0.659	0.643
	(0.106)	*(0.115)*	*(0.058)*	*(0.160)*	*(0.032)*

Note: Figures in parenthesis are standard errors
Source: Author's Computations

The consumer demand elasticity estimates show only minimal changes in price responses between the short-run and the long-run (Table 6.22 and 6.23). All long-run own-price Marshallian elasticities are larger in absolute terms than their short-run counterparts. Further, all the estimated long-run expenditure elasticities are positive and larger than their short-run counterparts. Given that the short-run elasticities are smaller than their long-run counterparts for the four major grain cereals in Kenya, the *LeChatelier*[18] *principle* is satisfied with regard to the price and income elasticities.

Table 6.23. Long-run Marshallian Elasticities for Cereals in Kenya 1963 -2005

Commodity	Elasticity with Respect to the Price of				Expenditure Elasticity
	Maize	Wheat	Sorghum	Rice	
Maize	-0.803	-0.171	0.050	-0.012	0.928
	(0.286)	*(0.147)*	*(0.117)*	*(0.479)*	*(0.163)*
Wheat	-0.118	-0.345	0.085	-0.022	0.618
	(0.119)	*(0.149)*	*(0.142)*	*(0.545)*	*(0.055)*
Sorghum	0.036	0.154	-0.860	-0.769	0.766
	(0.079)	*(0.071)*	*(0.063)*	*(0.471)*	*(0.033)*
Rice	-0.033	-0.084	-0.013	-0.923	0.920
	(0.254)	*(0.130)*	*(0.084)*	*(0.712)*	*(0.143)*

Note: Figures in parenthesis are standard errors

[18] The LeChatelier principle states that long-run demand functions are more price and expenditure responsive than their short-run counterparts. Thus at the optimum price and expenditure elasticities are greater in long rather than short-run (Silberberg, 1992 pp. 216-222).

In general, the Marshallian estimates suggest that the consumer demand for any particular grain cereal is more responsive to its own-price than to the cross-prices. The cross-price Marshallian elasticities posses similar signs both in the short-run and in the long-run but are fairly low in magnitude (Tables 6.22 and 6.23). They conform to the actual grain consumption pattern in Kenya where maize compliments rice and wheat but is a substitute for sorghum. However, Hicksian elasticities are a better measure of substitutability between any two goods since they only capture the substitution effect and leave out the income effect and thus are reported next.

Table 6.24. Short-run Hicksian Elasticities of Demand for Cereals in Kenya

Commodity	Elasticity with Respect to the Price of			
	Maize	Wheat	Sorghum	Rice
Maize	-0.203	-0.149	0.415	-0.702
	(0.120)	*(0.147)*	*(0.117)*	*(0.479)*
Wheat	-0.090	-0.123	0.254	-0.612
	(0.050)	*(0.132)*	*(0.142)*	*(0.545)*
Sorghum	0.348	0.351	-0.576	0.009
	(0.033)	*(0.063)*	*(0.043)*	*(0.471)*
Rice	-0.055	-0.079	0.001	-0.639
	(0.106)	*(0.115)*	*(0.058)*	*(0.160)*

Note: Figures in parenthesis are standard errors
Source: Author's Computations

The own-price Hicksian elasticities of demand for grain cereals in Kenya are negative but smaller than their corresponding Marshallian estimates both in the short-run and in the long-run (Tables 6.24 and 6.25). The Hicksian elasticities for maize, wheat, rice and sorghum are -0.20, -0.12, -0.64 and -0.58 respectively in the short-run and -0.44, -0.20, -0.61 and -0.90 in the long-run. The cross-price Hickisian effects are in agreement with their Marshallian counterparts. Thus, in conformity to the actual cereal grain consumption pattern in Kenya, maize acts as a net substitute for sorghum but as a net compliment for rice and wheat.

Table 6.25. Long-run Hicksian Elasticities of Demand for Cereals in Kenya

Commodity	Elasticity with Respect to the Price of			
	Maize	Wheat	Sorghum	Rice
Maize	-0.436	-0.168	0.404	-0.064
	(0.286)	*(0.147)*	*(0.117)*	*(0.479)*
Wheat	-0.102	-0.196	0.253	-0.515
	(0.119)	*(0.149)*	*(0.142)*	*(0.545)*
Sorghum	0.339	0.348	-0.605	0.099
	(0.079)	*(0.071)*	*(0.063)*	*(0.471)*
Rice	-0.005	-0.066	0.009	-0.895
	(0.254)	*(0.130)*	*(0.084)*	*(0.712)*

Note: Figures in parenthesis are standard errors

Source: Author's Computations

6.4.5. Comparison of the Current Demand Elasticities with Previous Studies

Overall, the current elasticities of demand for maize in Kenya are consistent with other studies in this region (Table 6.26). The current estimates compare well with the recent estimates by Munyi, (2000); Seale *et al*, (2003) and Renkow *et al*, 2004. However, the current estimates are lower than the estimates by Bezuneh *et al*, (1988) and Renkow *et al*, 2004. However, previous elasticity estimates of demand for wheat, rice and sorghum in Kenya are unavailable. To the best of my knowledge, this thesis is the first study that reports elasticity estimates of demand for wheat, rice and sorghum in Kenya.

Table 6.26. Comparison of own-price elasticities of demand for Maize

Study	Sample Period	Marshallian Estimate		Hicksian Estimate	
		Short-run	Long-run	Short-run	Long-run
Bezuneh *et al*,(1988)	1983 - 1984	-1.19	-	-1.11	-
Munyi, (2000)	1999	-0.45	-	-	-
Seale *et al*, (2003)	1993 - 1996	-0.46	-	-	-
Waliweta *et al*, 2003	2003	-0.90	-	-0.71	-
Renkow *et al*, (2004)	1997	-	-	-0.42	-
Current study	1963 - 2005	-0.53	-0.80	-0.20	-0.44

6.5. Chapter Summary

This chapter presents the estimated elasticities of demand and supply for cereals grains in Kenya at three market levels. At each market level, the chapter begins with an examination of the time series properties of the data set used. This is followed by a report of the elasticities derived from cointegrated relationships using error correction methods. The chapter also presents the results of a series of diagnostic tests to ensure model adequacy and a comparison of the current estimates with previous studies.

In all cases, the estimated elasticities carry the expected signs and are statistically significant. The own-price acreage elasticities for maize, wheat, rice and sorghum are 0.34, 0.37, 0.08 and 0.28 in the short-run while the corresponding long-run estimates are 2.17, 0.8, 2.02 and 1.63 respectively. At the intermediate level, the own-price elasticities of farm derived demand for maize, wheat, rice and sorghum are estimated at -0.43, -0.28, -0.18 and -0.29 in the short-run while their long-run counterparts are -1.41, -0.78, -0.32 and -0.30 respectively. The wholesale elasticities of demand for maize, wheat, rice and sorghum are -1.00, -2.22, -1.26 and -1.72 in the short-run and -2.34, -2.82, -1.72 and -1.73 respectively in the long-run.

The own-price Marshallian elasticities for maize, wheat, rice and sorghum are -0.53, -0.26, -0.66 and -0.79 in the short-run while their long-run counterparts are -0.8, -0.35, -0.92 and -0.86 respectively. These elasticities are broadly consistent with earlier estimates and are reasonable for a small importing country. All short-run elasticities are smaller than their long-run counterparts in absolute terms. Thus, the *LeChatelier principle* is satisfied at all market levels. Overall, the results from this analysis are suitable for policy analysis and are used for welfare analysis in the next chapter.

Chapter 7

Policy Analysis

7.1. Introduction

This chapter quantifies the long-run impacts of trade liberalization on Kenya's maize sector by simulating the effects of a reduction in tariffs. A PEM of trade calibrated from the elasticities estimated in chapter six is used to simulate policy changes and to compute the welfare measures. The chapter is organized into three sections. First, the structure of the simulation model is described. Next, the effects of reducing border tariffs are discussed. Finally, the results of a sensitivity analysis are presented.

7.2. A Partial Equilibrium Model for the Maize Market in Kenya

The model comprises of four blocks of equations: prices, supply, consumption and market clearing identities for maize at three market levels (Table 7.1). It is a static partial equilibrium model that considers only a single market. The price block defines the relationship between international commodity (world) prices and border (wholesale) prices. The production block is composed of three equations representing supply at the three market levels. Conversely, the consumption block shows the demand for maize at the retail, wholesale and farm levels. Finally, the equilibrium conditions equate supply to demand at all three market levels.

The law of one price is the only price relationship considered in this model. It links border prices to world prices. Since producer (P_f) and consumer (P_r) prices are endogenously determined, they are taken as predetermined (Table 7.1). The border price is linked to the fixed world price (P_l), adjusted by the exchange rate (EXR) and the applied import tariff (T) (Table 7.1).

Supply at the wholesale and retail levels are derived from primary supply at the farm level. Similarly, demand at the wholesale and farm level is derived from primary demand at the retail level. These derived market relationships link the three market levels. The wholesale and retail levels are linked via the wholesale elasticity with respect to the retail price. Conversely, the wholesale and farm levels are linked via the farm-output elasticity with respect to the wholesale price.

Table 7.1. Description of the Partial Equilibrium Model of Trade

Market Relationship	Mnemonic	Behavioural Equation
Price Block (KES/MT)		
Consumer Prices	P_r	Predetermined
Border (Wholesale) Prices	P_w	$P_w = P_t * EXR * (1+T)$
Producer Prices	P_f	Predetermined
Consumption Block ('000' MT)		
Retail Demand	Q_r^d	$Q_r^d = \alpha_0 + \gamma_i P_r$
Wholesale Demand	Q_w^d	$Q_w^d = \alpha_0 + \gamma_i P_w + \gamma_j P_r$
Farm-Level Derived Demand	Q_f^d	$Q_f^d = \alpha_0 + \gamma_i P_{ft-1} + \gamma_j P_w$
Production Block ('000' MT)		
Retail Supply	Q_r^s	$Q_r^s = \theta Q_w^d$
Wholesale Supply	Q_w^s	$Q_w^s = Q_f^d + Q_T$
Domestic Production	Q_f^s	$Q_f^s = \rho_0 + \rho_i P_{ft-1}$
Market Clearing Identities		
Retail	Q_r	$Q_r^d = Q_r^s$
Wholesale	Q_w	$Q_w^d = Q_w^s$
Farm	Q_f	$Q_f^d = Q_f^s$

Specifically, wholesale demand is the sum of supply at the wholesale level plus imports. On the other hand, wholesale supply is identically equal to the output at the farm level (Table 7.1). The quantity supply at the retail level is the product of wholesale demand multiplied by a coefficient of processing (θ). In this study, an average grain extraction rate of 97 percent is used as the coefficient of processing.

The model is closed by a block of three equations equating demand and supply at the three market levels. At the farm level, the model is closed by equating domestic supply to demand. External trade occurs only at the wholesale level. The model is shocked by changing the tariff rates at the wholesale level. The effects of policy changes at the wholesale level are transmitted to the farm level via the farm derived demand, which is a function of producers and wholesale prices. Moreover, the policy shocks are transmitted to the retail level via the retail supply, which is a function of wholesale and retail prices.

The General Algebraic Modeling Systems (GAMS) package is used to solve the equations in the model. It is constructed to reproduce the 1995/96 base values, which represents the period when Kenya began implementing the WTO market access commitments. The Uruguay Round negotiations in 1995 produced an agreement for developing countries to cut tariffs on agricultural products by an average of 24 percent over ten years with a minimum cut of ten percent. During this period, maize imports into Kenya were subjected to an ad valorem tariff of 25 percent.

Subsequently, a tariff reduction of 24 percent is simulated using the 1995/96 base values and used to quantify the impacts of trade liberalization. Given the existing applied tariff on maize imports, the change in tariffs amounts to a six percentage reduction and thus, the impacts of a 19 percent applied tariff are simulated and compared with the base solution values. In addition, a complete removal of border tariffs on maize imports into Kenya is simulated for comparison purposes. The tariff reductions are assumed to be implemented in 1995/96 and maintained at that level through 2004/05 when the 10 year WTO grace period expired.

The simulation provides quantitative measures of the welfare impacts of tariff reductions, which helps to weigh the benefits and costs of trade liberalization. It is calibrated to the price and quantity values for the 1995/96 data based on the long-run elasticities reported in chapter six. To solve the model, estimates are required for the quantities supplied and consumed at the three market levels, their elasticities and the corresponding prices. In addition, data is required on import tariff rates, exchange rates and transfer costs. The data for prices and quantities required for the base policy simulations along with their definitions are shown in Table 7.2.

Table 7.2. Base Data for Policy Simulation

Variable	Mnemonic	Base Values
Market Clearing Quantities ('000') MT		
Retail Level	Q_r	2662
Wholesale Level	Q_w	2755
Farm Level	Q_f	2445
Real Prices (KES/MT)		
Retail Level	P_r	11314
Wholesale Level	P_w	11249
Farm Level	P_f	10542

Source: Author's Computations from Economic Surveys and MOA Annual Reports

The reliability of the results in any simulation is driven by the choice of base scenario values and the range of parameter values. A Monte Carlo experiment featuring 1000 replications of the PEM is used to determine the sensitivity of the simulated results to changes in the base elasticities at the three market levels. The experiment generates random numbers from a multivariate normal distribution of the base elasticity values. These random numbers are then used to estimate normal distributions of prices, quantities and welfare measures for the two policy scenarios simulated. Table 7.3 reports the base values for the elasticities along with their standard errors.

Table 7.3. Base Elasticity Values for Sensitivity Analysis

Parameter	Base Value	Standard Deviation
Own-Price Elasticities of Demand		
Retail Level	-0.80	0.120
Wholesale Level	-2.34	0.500
Farm Level	-1.41	0.165
Own-Price Elasticities of Supply		
Retail Level	5.20	0.328
Wholesale Level	2.13	0.175
Farm Level	2.17	0.124
Cross-Market Elasticities		
Retail Level	2.34	0.500
Wholesale Level	5.20	0.328
Farm Level	2.13	0.175

Source: Author's Computations

On the production side, acreage response for maize is assumed to depend on the expected future market prices with producers having adaptive expectations. The own-price elasticity of supply for maize at the farm-level is set at 2.17 while the elasticities at the wholesale and retail level are 2.13 and 5.20 respectively (Table 7.3). These elasticities are imposed on price values of 10542, 11249 and 11314 KES/MT for the farm, wholesale and market levels respectively. Further, the elasticities are imposed on quantities of 2.4, 2.8 and 2.7 million MT respectively for the same market levels.

On the consumption side, aggregate demand for maize depends on its own price and the prices of other grains, all relating to the current period. Consumer expenditures in this study are held constant since income is exogenously determined. All other effects such as the cross-effects and the effects of price variability are assumed to be subsumed in the constant during calibration. The own-price elasticity of retail demand for maize is set at -0.80 while the own-price elasticities at the wholesale and farm levels are -2.34 and -1.41 respectively (Table 7.3). These elasticities are applied on the price and quantity values presented in Table 7.2.

7.3. Impact of Trade Liberalization on Welfare Measures

To quantify the long-run impacts of trade liberalization on Kenya's maize sector, a 24 percent import tariff reduction is simulated and compared with the existing tariff regime. In addition, a scenario with a zero tariffs is simulated for comparison purposes. The small-country importer assumption is used in these simulations since domestic maize prices in Kenya are determined in the world market. Thus, domestic prices are derived by adjusting the world price by the transfer costs (Table 7.4).

The free trade simulations use price and quantity values for the 1995/96 base period. Over this period, the applied tariff was pegged at 25 percent of the cost insurance and freight (cif) value of maize imports into the Kenyan port of Mombasa from offshore destinations. The major offshore sources of maize imports in order of importance were South Africa, USA and Argentina. Thus, the free on board (FOB) price of maize at the South African port of Durban is used as the reference point with international commodity prices compiled from FAOSTATS.

Table 7.4. Import Parity Price for Maize in Kenya, 1995/6

Item	Price Estimation	
	US$/MT	KES/MT (1997=100)
FOB Durban	128.08	7065.00
Freight	10.07	555.61
C& F Mombasa	138.15	7620.61
Insurance (1% of C&F)	1.39	76.21
CIF Mombasa	139.54	7696.82
Import Duty (25%)	34.89	1924.20
IDF Levy (2.75 of C & F)	3.79	209.57
Stevedoring	10.07	555.61
Kenya Ports Authority (KPA) Handling	3.99	220.00
Bagging charges	6.50	358.55
Transport to warehouse	3.00	165.48
Landed Mombasa (KES/MT)	201.78	11130.23

Source: NCPB Annual Reports, various years

Table 7.4 presents a breakdown of the costs incurred in importing maize into Kenya from offshore sources. After adjusting the FOB price in Durban for various charges, the landed price at the port of Mombasa was about 11130 KES/MT. This price fell below the wholesale price of about 11249 KES/MT creating an arbitrage opportunity for wholesalers. The welfare simulations are then undertaken using the base scenario maize prices, quantities and elasticity values reported in Tables 7.2 and 7.3.

At the base solution, a producer surplus of about KES 20 billion is estimated (Table 7.5). In addition, a retailer surplus at the wholesale level of KES 34 billion and a wholesaler surplus at the farm level of KES 15 billion are generated. Overall, the intermediate level generates a surplus of about KES 50 billion (Table 7.5). Furthermore, consumers gain about KES 49 billion while the government generates a tariff revenue of KES 0.39 billion (Table 7.5).

Table 7.5. Impacts of the URAA Trade Commitments on Kenya's Maize sector

	Trade Liberalization Scenario		
Variable Description	Base Values	24% Tariff Cut	% Change
Retail Level			
Equilibrium Price (KES/MT)	11306.693	11140.331	-1.47
Equilibrium Quantity ('000' MT)	2663.375	2694.689	1.18
Consumer Surplus (Billion KES)	48.957	49.309	0.72
Wholesale Level			
Equilibrium Price (KES/MT)	11249.000	10825.100	-3.77
Equilibrium Quantity ('000' MT)	2745.748	2778.030	1.18
Imports ('000' MT)	218.375	368.645	68.81
Tariff Revenue (Billion KES)	0.386	0.495	28.24
Retailer Surplus (Billion KES)	34.006	34.182	0.518
Wholesaler Surplus (Billion KES)	15.447	14.420	-6.65
Intermediate Level Surplus	49.453	48.602	-1.721
Farm-Level			
Equilibrium Price (KES/MT)	10542.000	10305.643	-2.24
Equilibrium Quantity ('000' MT)	2445.000	2326.044	-4.87
Producer Surplus (Billion KES)	19.836	18.596	-6.25
Social Surplus (Billion KES)	**118.246**	**116.507**	**-1.471**

Source: Author's Computations in GAMS

Overall, a social surplus of KES 118 billion is generated for the entire maize sector at the existing tariff levels. The results of the welfare analysis seem to suggest that consumers are the single largest (relative) beneficiaries from maize trade reforms in Kenya while the highest welfare gains are generated at the intermediate level. This is expected given that external trade occurs at the wholesale level. On the other hand, producers appear to be the least beneficiaries of the trade policy reforms since the farm level generates the lowest welfare benefits.

7.3.1. Impacts of a 24 Percentage Tariff Reduction

Table 7.5 also reports the impacts of a 24 percent tariff cut in line with Kenya's market access commitments at the UR negotiations. Relative to the base solution values, the 24 percent tariff reduction leads to a decrease in maize prices across all the three market levels. At the wholesale level, prices decline by about four percent while both farm and retail prices decrease by about two percent (Table 7.5). The price fall causes a one percentage increase in consumption and a 69 percent increase in imports, but leads to a two percent decrease in domestic maize production (Table 7.5).

Consequently, the 24 percent tariff reduction led to a six percent fall in producer surplus and a 0.72 percent increase in consumer surplus (Table 7.5). At the intermediate level, retailer surplus at the wholesale level rises by 0.52 percent while wholesaler surplus at the farm level falls by seven percent (Table 7.5). The increased imports lead to a 28 percent rise in government tariff revenue. The net effect of the tariff cut at the intermediate level is a 1.72 percent decline in surplus. Overall, the 24 percent reduction in tariffs lead to a 1.47 percent decline in social surplus which translated to a loss of welfare of about KES 1.74 billion (Table 7.5).

To put matters into perspective, the KES 1.74 billion loss in social surplus is equivalent to 17 percent of the annual expenditure on agriculture in 2006/7, which amounted to KES 10.28 billion (GoK, 2007). Overall, the gain to consumers was not large enough to offset the loss to producers. Thus, tariff reductions as a trade liberalization policy have no compensating potential in Kenya's maize sector. In practice, policy changes that have no compensating potential cannot be recommended based on Harberger's (1971) welfare postulates.

7.3.2. Impacts of Complete Removal of Tariffs

A complete abolishment of import tariffs reduced maize prices by nine, 15 and six percent respectively at the farm, wholesale and retail levels respectively relative to the 1995/96 base prices (Table 7.6). This reduction in prices lead to a 286 percent increases in imports and a five percent increase in maize consumption, but yields 20 percentage decrease in domestic maize production in Kenya (Table 7.6).

Table 7.6. Impacts of the Abolishment of Tariffs on Kenya's Maize Sector

	Trade Liberalization Scenario		
Variable Description	Base Values	Zero Tariffs	% Change
Retail Level			
Equilibrium Price (KES/MT)	11306.693	10613.517	-6.13
Equilibrium Quantity ('000' MT)	2663.375	2793.850	4.90
Consumer Surplus (Billion KES)	48.957	50.387	2.92
Wholesale Level			
Equilibrium Price (KES/MT)	11249.000	9482.750	-15.70
Equilibrium Quantity ('000' MT)	2745.748	2880.257	4.90
Imports ('000' MT)	218.375	844.498	286.72
Tariff Revenue (Billion KES)	0.386	0.000	-100.00
Retailer Surplus (Billion KES)	34.006	34.704	2.053
Wholesaler Surplus (Billion KES)	15.447	11.356	-26.48
Intermediate Level Surplus	49.453	46.060	-6.861
Farm-Level			
Equilibrium Price (KES/MT)	10542.000	9557.178	-9.34
Equilibrium Quantity ('000' MT)	2445.000	1949.352	-20.27
Producer Surplus (Billion KES)	19.836	14.855	-25.11
Social Surplus (Billion KES)	**118.246**	**111.302**	**-5.873**

Source: Author's Computations in GAMS

Consequently, the abolishment of import tariffs would yield a 25 percent decline in producer surplus, but increases consumer surplus by three percentage points (Table 7.6). At the intermediate level, wholesaler surplus at the farm level falls by 26 percent while retailer surplus at the wholesale level increases by two percent. In addition, the implementation of a zero tariff policy on maize imports would deny Kenya an important source of government revenue. In this scenario, tariff revenue falls by 100 percent. The net effect was a seven percentage decline in intermediate surplus.

Overall, the abolishment of maize import tariffs would lead to a six percent decline in social surplus (Table 7.6). An important component of the declining surplus is the loss in tariff revenue that amounts to KES 0.39 billion. This revenue loss would be sufficient to fund the budgetary allocation for agricultural research in Kenya, which averaged KES 0.43 billion in 2005 (GoK, 2007). The welfare impacts of a complete removal of maize import tariffs in Kenya would generally be negative. Specifically, the loss in producer surplus outweighs the gain in consumer surplus. Thus, a zero import tariff policy has no compensating potential in Kenya's maize sector.

Recent household surveys such as Karanja *et al*, 2004 show that about two-thirds of the maize producers in Kenya are also net purchasers of the grain. Thus, it may be true that most smallholders who are also net purchasers of maize are among the winners of falling maize prices associated with trade liberalization. It should also be noted that about 70 percent of the "marketed maize surplus" is generated from large-scale farmers, who only constitute 30 percent of the total maize producers. In light of these production and consumption trends, a more nuanced analysis perhaps based on survey data may be necessary to shed more light on the distributional effects.

7.4. Sensitivity Analysis

In order to verify the validity of the estimated impacts of trade liberalization, the simulation results were subjected to a sensitivity analysis. The Monte Carlo experiment replicates the welfare measures 1000 times. The random outcomes were generated from a multivariate normal distribution of the base values using the mean and standard deviations of the elasticities at all the three market levels. The mean and standard errors of the surplus measures were used to compute confidence intervals.

Table 7.7. Confidence Intervals of the Base Solution Welfare Values

	Moment		95 % Confidence Intervals	
Surplus Measure	**Mean**	**STD**	**Lower Bound**	**Upper Bound**
Producer Surplus (Billion KES)	19.816 (1.74)	0.342	19.714	19.918
Wholesaler Surplus (Billion KES)	49.610 (5.18)	2.569	48.842	50.378
Consumer Surplus (Billion KES)	49.385 (5.93)	2.930	48.509	50.261
Social Surplus (Billion KES)	118.811 (3.18)	3.780	118.067	120.327

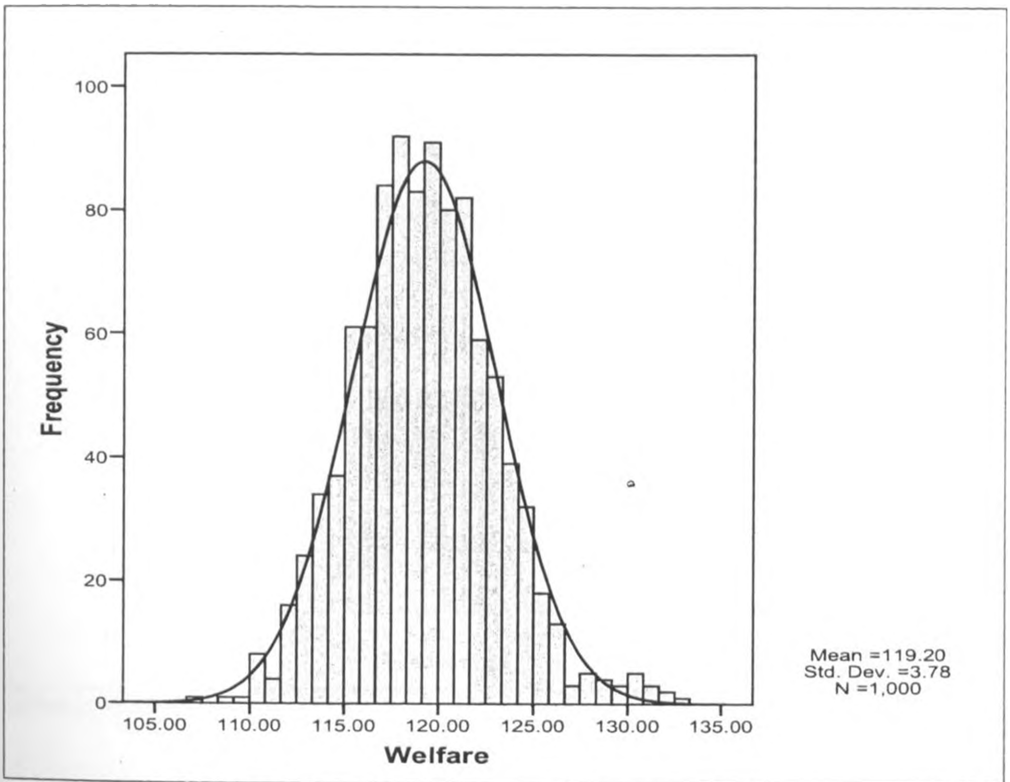
Notes. The figures in parenthesis give the coefficients of variation of the variables. All numbers in the table are average values derived from model runs for 1000 periods

Source: Author's Computations in GAMS

Table 7.7 reports the simulated welfare measures from the Monte Carlo analysis at their 95 percent confidence intervals. The mean values of the surplus measures generated at the three market levels were within the bounds of the 95 percent confidence interval. Thus, the estimated surplus measures in all cases were significant at the five percent level. While producer surplus was the most stable welfare measure, wholesaler surplus had the highest level of variability (Table 7.7). However, the variability of all welfare measures is quite low as indicated by the coefficients of variation, implying that the estimated surplus measures are stable at their means.

To highlight the robustness of the estimated welfare measures, a histogram of the base social surplus is generated. Figure 7.1 shows the probability distribution function of the simulated social surplus at the 95 percent confidence interval. The mean, mode and median values of the social surplus run quite close to the centre of the density function (Figure 7.1). The histogram suggests that the simulated social surplus is quite stable at its mean.

Figure 7.1. Probability Density Function of the Base Social Surplus

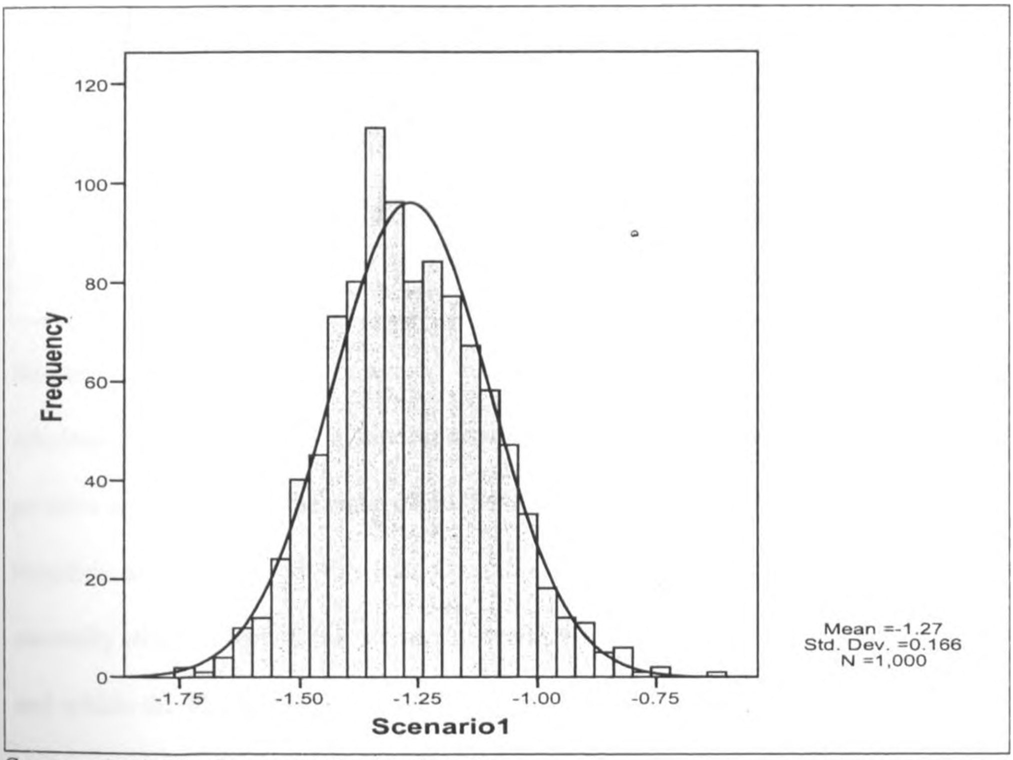


Source: Author's Computations in GAMS

Histograms of the base solution values for producer, wholesaler and consumer surpluses were also developed but are not presented since they are embodied in the social surplus. In all cases, the simulated welfare measures were within their respective 95 percent confidence intervals and produced normally distributed density curves. These density curves illustrate the stability of the estimated welfare results.

To further explore the stability of the simulated results, the percentage changes in social surplus for the 24 percent tariff reduction scenario were mapped into a histogram (Figure 7.2). As expected, social surplus declined by a percentage point and lay within the 95 percent confidence interval. Figure 7.2 is slightly skewed to the left but highly peaked suggesting that the estimated surplus changes were quite stable.

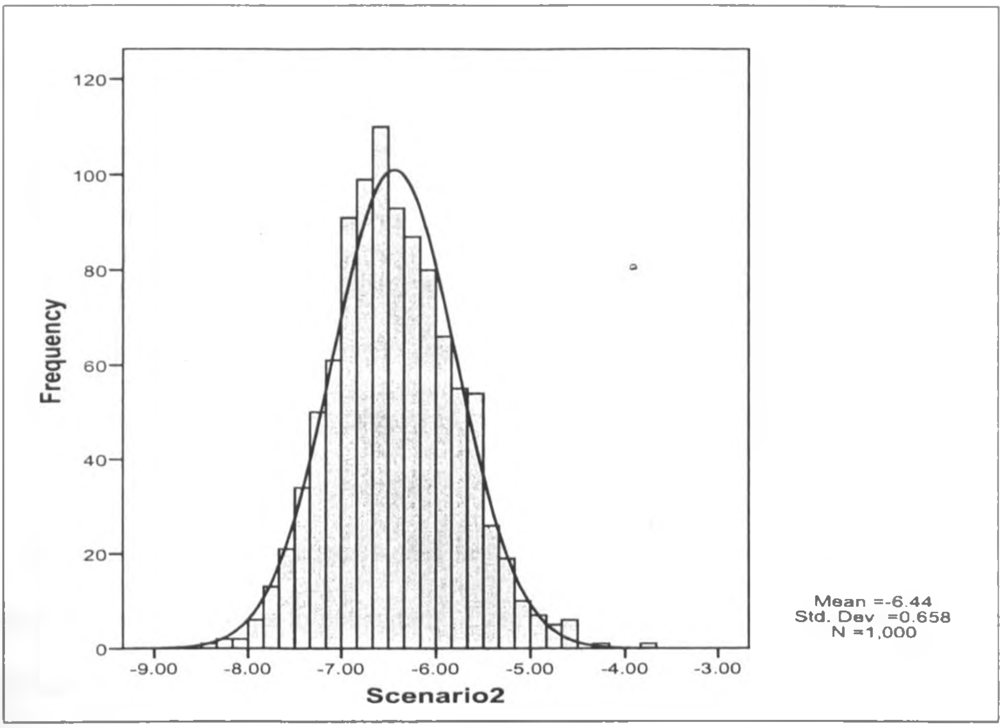
Figure 7.2. Histogram of the Changes in Social Surplus at the 24% Tariff Cut



Source: Author's Computations in GAMS

In addition, a histogram was developed for the percentage changes in social surplus at the zero tariff scenario relative to the base solution value (Figure 7.3). The fall in total surplus when tariffs are removed would be on average 12 percent and were within the 95 percent confidence interval. However, the percentage changes simulated from a no tariff scenario were more variable than the 24 percent reduction scenario. Overall, the percentage changes in social surplus were negative.

Figure 7.3. Histogram of the Changes in Social Surplus at a Zero Tariff



Similar histograms were generated for the changes in producer, consumer and wholesaler surplus, but are not reported. The changes in consumer surplus were positive and skewed to the right while those for producer and wholesaler surplus were negative and skewed to the left. Overall, the probability density functions were normally distributed and the simulated welfare measures were stable at their means and within the 95 percent confidence intervals.

The results of the sensitivity analysis highlights the robustness of the simulated welfare measures with regard to the base solution values. Specifically, the results of the Monte Carlo experiment suggest that the simulated welfare measures were stable and significant at the five percent level. It can, therefore, be concluded that the GAMS simulation model performs quite well. Thus, the results generated were accurate and reliable for policy analysis.

7.5. Chapter Summary

This chapter reports the simulated impacts of trade liberalization in Kenya's maize sector. A PEM model of trade that takes into account the market interrelationships across three levels was used. The model incorporated external trade and simulated the welfare effects of reducing import tariffs over the liberalized period. A major finding of this analysis is that a 24 percent tariff cut would lower market prices and increases maize consumption but reduces domestic production in Kenya. Moreover, tariff reductions would stimulate increases in maize imports.

However, the declining prices would be accompanied by increased price variability that dampens the gains to consumers. Even though consumers benefited from tariff reductions, the loss in producer surplus outstriped consumer benefits, which curtails any potential for producer compensation. The net effect was a loss in social welfare. This implies that the URAA trade commitments with regard to Kenya's maize sector cannot be passes based on the compensation principle. Instead policies that improve the responses of producers should be advocated while maize consumers should be encouraged to diversify their consumption to other cereals.

In general, producer incentives can be improved by investing in infrastructure, market information services and agricultural research and extension. These incentives could potentially cushion producers from the adverse effects of trade liberalization while at the same time aiding consumers to diversify their consumption to other competing cereal commodities. The next chapter summarizes the findings of this study and draws policy recommendations for the maize sector in Kenya that can also be applied to other countries in Eastern and Southern Africa.

Chapter 8

Summary and Conclusions

8.1. Introduction

This main purpose of this study was to analyze the market and welfare impacts of trade liberalization and their distribution among stakeholders in Kenya's maize sector. It addressed a major policy concern in Kenya and other countries in SSA where maize is the key staple food. Specifically, the objectives of this study were twofold. First, to estimate the elasticities of demand and supply for grain cereals; second to use the elasticity estimates in the calibration of a PEM that was used for policy analysis.

The study sought to identify the sizes of the gains/losses from trade liberalization and examined how the benefits and losses would be distributed among key stakeholders in the sector. To examine these issues, a PEM of Kenya's maize sector was constructed. It assumes Kenya to be a small-country importer of maize. The model comprised of four blocks of equations: prices, supply, demand and market clearing identities, which equated sources and uses of maize at three market level. It was calibrated from elasticities values, quantities and prices to reproduce data for the 1995/96 base period.

It was necessary to estimate supply and demand elasticities in this study because reliable empirical estimates of these parameters were not available for Kenya. The study applies recent developments in time series techniques for testing nonstationarity in all relevant variables used in this study. On the demand side, a dynamic specification of the AIDS was estimated based on cointegration techniques and error correction models. The demand system was adjusted accordingly to estimate an ECM version of the AIDS.

On the supply side, a system of acreage response functions was estimated using Johansen's MLE technique. However, an ECM was employed to estimate the dynamic short-run relationships. The supply side ECM was specified based on a general Nerlovina partial adjustment model that is nested within the general VAR distributed lag model. In addition, error correction models were used to estimate the elasticities of derived demand at the intermediate level as functions of prices at the farm, wholesale and retail levels.

Prior to estimation, the study explored maize production and consumption patterns in Kenya. Specifically, the study recognized the dual nature of maize production in Kenya and derived theoretically consistent models to analyze the behavior of commercial and small-scale farmers under price risk. While a mean-variance model was used to analyze the behavior of commercial producers, a simplified graphical approach based on the composite good theorem was used to show the effects of risk on small-scale farming households *ex post* consumption decisions. It can be extended to measure the effects of price stabilization schemes on household behaviour.

Given the desire to derive detailed sector specific information, a partial equilibrium approach was adopted for investigating the effects of trade liberalization on the maize sector in Kenya. The PEM was used to simulate two hypothetical policy scenarios and quantify the resulting welfare changes. Finally, a Monte Carlo experiment was performed to determine the sensitivity of the simulation results to the base parameter values. The Monte Carlo experiment used random numbers generated from a multivariate normal distribution to replicate the welfare measures 1000 and estimate the 95 percent confidence intervals.

8.2. Summary of Major Findings

This section reports two distinct types of findings in conformity with the dual objectives of this study. Initially, the empirical estimates of the elasticities of supply and demand for cereal grains in Kenya at the three market levels along with their theoretical and policy implications are reported. In the second part, the economic surplus measures of welfare transfers generated from a partial equilibrium model that was calibrated from the estimated elasticities are reported.

The time series analysis of the data used to estimate acreage responses indicated the existence of data nonstationary and cointegration. Johansen's MLE approach was used in this case since producer prices follow distributed lag processes. All VAR systems were found to posses a single lag and a rank of one. The former finding supported use of annual time series data while the latter confirmed the existence stable long-run relationships. Moreover, the data used in the short-run ECM of the system of acreage responses was found to support the theoretical restrictions of symmetry and thus are valid for policy analysis.

All own-price acreage responses for cereals in Kenya have the expected positive signs. The own-price supply elasticities for maize, wheat, rice and sorghum were estimated at 0.34, 0.37, 0.08 and 0.28 in the short-run while the corresponding long-run estimates were 2.17, 0.8, 2.02 and 1.63 respectively. In all cases, the long-run supply elasticities were larger than their short-run counterparts and thus, the *LeChatelier principle* was satisfied on the supply side. In addition, the 'shift variable' (wage) and the response to price risk were negative in all cases. These findings implied that cereal producers in Kenya respond rationally to price incentives and risk.

Contrary to the expectations, the short-run cross-price elasticities of supply were found to be positive in all cases, to imply that maize, wheat, rice and sorghum are complementary in production. However, the long-run cross-price elasticities reflect the actual cereal production pattern in Kenya where grain cereals are both competitive and complimentary in production. Moreover, the current supply elasticities for grain cereals in Kenya were found to be broadly consistent with those reported in previous studies undertaken in Kenya and also compare favourably with recent estimates undertaken in Eastern and Southern Africa.

At the intermediate level, intuitively appealing elasticities were estimated. The own-price derived elasticities of demand for maize, wheat, rice and sorghum at the farm level were estimated at -0.43, -0.28, -0.18 and -0.28 in the short-run while their long-run counterparts were -1.41, -0.78, -0.32 and -0.30 respectively. Moreover, the elasticities of demand for maize, wheat, rice and sorghum at the wholesale level were -1.00, -2.22, -1.26 and -1.72 in the short-run and -2.34, -2.82, -1.72 and -1.73 respectively in the long-run. These derived elasticity estimates offer an intuitive mechanism for linking the three market levels.

On the demand side, the ADF test results suggested the existence of nonstationarity series. In demand systems, Johansen's approach violates the restrictions implied by theory and was not used to test for cointegration. Static and dynamic cointegration tests were used instead. The results indicated the presence of long-run equilibrium relationships. Moreover, the data used in the ECM supported homogeneity and symmetry. These theoretical tests illustrated the robustness of the estimated model and thus, the elasticity estimates were considered valid for policy analysis.

All estimated consumer demand elasticities possessed the expected negative signs both in the short-run and in the long-run. The own-price Marshallian elasticities for maize, wheat, rice and sorghum were -0.53, -0.26, -0.66 and -0.79 in the short-run while their long-run counterparts were -0.80, -0.35, -0.92 and -0.86 respectively. The negative own-price elasticities suggest that the corresponding demand curves are downward sloping and thus satisfy the law of demand. In addition, the estimated expenditure elasticities were found to be positive and income inelastic implying that grain cereals are necessary goods in Kenya.

The Hicksian elasticities of demand for maize, wheat, rice and sorghum were estimated at -0.20, -0.12, -0.64 and -0.58 respectively in the short-run and were -0.44, -0.20, -0.61 and -0.90 in the long-run. Since all own-price Hicksian elasticities were negative, the underlying slutsky matrix was negative semi-definite, satisfying the concavity of the underlying cost function. The cross-price Hickisian effects were in agreement with their Marshallian counterparts. These finding confirmed the actual grain consumption pattern in Kenya where maize acts as a net substitute for sorghum but is a net compliment for rice and wheat.

A more interesting finding from the demand analysis was that the estimated short-run elasticities were all smaller in absolute terms than their long-run counterparts. This finding implied that the *LeChatelier principle* was upheld with regard to price and expenditure elasticities. Overall, the current elasticities of demand for grain cereals in Kenya are consistent with other studies in the region. Unlike the previous elasticities, the current estimates provide valuable information on the short-run dynamics of demand and expand the alternatives available for policy analysis.

Some of the most interesting findings in this study came from the trade policy analysis. In general, domestic maize prices fell after the implementation of market reforms in Kenya. The declining prices caused an increase in consumption and a general decline in domestic production. However, the declining prices were accompanied by an increase in price variability, which might have eroded any welfare gains. These trends in outputs indicate that the decline in prices did not elicit the desired production responses but had positive influences on maize consumption.

With regard to Kenya's URAA market access commitments, it was found that a 24 percent tariff cut would result in a four percentage decline in wholesale prices relative to the base solution value. Similarly, prices at the farm and retail levels fell by two percent. The declining prices cause a slight consumption increase of about a one percent, but caused a two percent decline in domestic production. Furthermore, the 24 percent tariff reduction results in a 0.72 percentage increase in consumer surplus, but yields a six percentage decline in producer surplus. Overall, the 24 percent tariff cut leads to a 1.47 percent loss in total social surplus.

A complete removal of tariffs was found to further reduce maize prices across the three market levels relative to the base solution value. At the wholesale level, prices decline by 16 percent while they decline by six and nine percent at the retail and farm levels respectively. Subsequently, maize consumption increases by five percent while domestic production decreases by 20 percent. The elimination of tariffs was found to increase consumer surplus by only three percent, but reduce producer surplus by 25 percent and decrease intermediate surplus by seven percent. Overall, a complete removal of maize import tariffs in Kenya leads to a six percent loss in social surplus.

The welfare impacts of trade policy reform Kenya's maize sector have generally been negative. While consumers appear to be the major beneficiaries from trade liberalization, domestic producers were hurt by the trade reforms. In addition, the government losses a large sum of tariff revenue. The loss in producer surplus would by far outweigh the gain to consumers and yields a loss in social surplus. In general, the gain in consumer surplus would not compensate the loss in producer surplus. Thus, Kenya's implementation of the Uruguay Round market access commitments without compensating producers would leave the maize sector worse off.

8.3. Policy Implications

The analysis undertaken in this study has several policy implications for Kenya's maize industry. One of the most important finding on the demand side was that cereal consumers have price and income inelastic responses, which implied that income and price oriented policies have equal potential for improving cereal consumption. These implications are further validated by the large budget share of maize (54 percent of the cereals budget) in a country where cereals accounts for over a third of the total food expenditure and food accounts for 46 percent of household total expenditures.

Given the high budget share and the inelastic own-price elasticity of demand for maize, any price decreases would benefit a majority of the households. This is true when considering that over two thirds of Kenyan rural households are both producers and net purchasers of maize. Thus, one viable option to benefit consumers in the short-run is by offering incentives that improve domestic maize production. In the long-run, consumption could be improved by investments in research that could diversify the uses of domestically produced cereals.

An interesting finding from the supply side is that cereal producers in Kenya respond rationally to price incentives. Given the high price responsiveness there is need for incentives that can boost domestic production. The literature on agricultural supply response in developing countries proposes a number of complimentary policies to facilitate farmer's responsiveness. These include improving farmer's access to inputs, new technologie and credit. In addition, producer incentives can be improved by investing in infrastructure, institutions, market information services and agricultural research and extension.

Some of the most interesting implications for the Kenyan maize sector can be drawn from the trade policy simulations. The finding that the implementation of the URAA market access commitments hurts maize producers more than it benefits consumers questions some of the hypothetical gains from trade liberalization in the context of the Kenya's maize sector. Overall, the gain to consumers is not large enough to offset the loss to producers implying that trade liberalization as a policy has no compensating potential in Kenya's maize industry. Thus, further trade liberalization without compensating the losers cannot be considered a viable policy in Kenya's maize sector.

Given the fact that Kenya is a developing country with limited revenue generating sources, compensating losers from trade liberalization in the maize sector might not be an option in the short-run. One viable option for the sector might be to undertake complimentary reforms that are necessary to transmit world prices to consumers and attempt simultaneously to improve the ability of producers to respond to incentives and price shocks. These complimentary reforms belong to the green box support measures under the WTO.

8.4. Contribution to Knowledge

This thesis makes four broad contributions to the existing stock of knowledge. Theoretically, the study develops a simple graphical model of crop portfolio choice under risk. This model can be used to show the effects of price risk on *ex-post* consumption decisions of three household types; purely subsistent, net-sellers and net-buyers. Analytically, the study develops a partial equilibrium model of trade that can be applied for policy analysis in other developing countries.

Empirically, this thesis makes three major contributions. It generates theoretically consistent elasticities of supply and demand for cereals in Kenya that are reliable for policy analysis. Specifically, this is the first study in Kenya that estimated the elasticities of demand for wheat, rice and sorghum. Similarly, it is the first study that estimates acreage elasticities for rice and sorghum. To the best of my knowledge, this thesis is the first study in the Kenyan context that estimates farm derived elasticities and wholesale elasticities for maize, wheat, rice and sorghum. Finally, it is also the first study which employs cointegration analysis and an ECM to estimate the demand system and systems of acreage functions for maize in Kenya.

The PEM generates consistent welfare measures that are used to draw policy implications for Kenya's maize sector. Perhaps the most important finding from this study is that Kenya's implementation of the market access commitments made at the Uruguay Round of the multilateral trade negotiations without compensating producers would leave the maize sector worse off. Thus, complimentary reforms are necessary to transmit world prices to consumers and at the same time improve the ability of producers to respond to price incentives.

8.4. Limitations of the Study

While this study makes a number of contributions to knowledge, the model used in this analysis has some limitations that need to be highlighted. The model is partial in nature and, thus does not take into account the interlinkages between the cereals sector in Kenya and other sectors within agriculture or other sectors in the economy. Thus, it might not capture the shifting of resource across different sectors of the economy following the policy reforms. A general equilibrium model may offer a mechanism for accommodating such economy wide interlinkages.

It is widely acknowledged that simulation models are sensitive to the elasticity values used. Thus, any variations in their magnitudes could either lead to an over estimation or an underestimation of welfare. However, the base parameter values used in this simulation are estimated using theoretically consistent approaches and compare reasonably with those reported in literature. Moreover, the Monte Carlo experiment illustrates the robustness of the base solutions and shows that even though the welfare measures take different numerical values, their direction of changes remain unaltered by the change in parameter values.

The simulated welfare results might also be compromised by the type of data used in this analysis. As witnessed in most developing countries, the reliability of secondary data is often questionable. This can be attributed to resources constraints that limit the collection, compilation and distribution of reliable data. However, the reliability of such data can be enhanced by comparing different data sources. In this study the reliability of the data used was ascertained by comparing data from two different sources; statistics from a Kenyan data pool and the FAOSTAT source.

8.6. Direction for Future Research

One of the key areas for future research that can substantially improve the knowledge base with regard to Kenya's maize sector is related to a good understanding of producer risk preferences. Even though this study appropriately measured producer's risk perceptions in terms of output price variability, it made no attempts to analyze risk preferences due to data limitations. Thus, a systematic investigation of the type of risk aversion exhibited by maize farmers in Kenya can greatly enrich future agricultural policy and trade policy analysis.

The supply side estimates used in this study are derived from an aggregate data base of all cereal producers in Kenya. While the use of aggregate data was unavoidable, it might conceal the variations in price responses by different types of producers. Given the dual production pattern of maize in Kenya, future studies should estimate the responses of commercial producers separately from those of small-scale farmers. It should also be noted that such exercises in the context of Kenya's maize industry cannot utilize time-series data and have to resort to survey data.

Even though this study takes cognisance of the need to demonstrate the distributional impacts of the gains from trade liberalization, it was not possible to undertake this to the fullest extent possible in this research. This was hampered by the lack of data differentiated by household type such as small and large producers and rural as well urban consumers. Unlike the current time series exercise such an effort would require the use of survey data. Thus, a more in-depth research should be undertaken in future to analyze the distributional effects of trade liberalization for different socioeconomic groups in Kenya and especially its effects on food security and poverty.

9.0. References

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Annex 1. Impacts of Trade Reforms in Developing Countries

Author	Title	Approach	Major Findings	Remarks
Krueger *et al*, 1988	Agricultural Incentives in Developing Countries	Simulation – Compared direct and indirect effects	Economywide effects dominate sectoral effects	Shows the negative policy bias against agriculture
Sadoulet and de Janvry, 1992	Agricultural Trade Liberalization And Low Income Countries	Simulation - Multi-market CGE model	Rising food import bills and exchange rate depreciation	Result interpretation is complicated by aggregation
Brandao *et al*, 1993	Implications Of Agricultural Trade Liberalization For Developing nations	Simulation – compared PE and CGE model estimates	Some poor countries do not benefit from free trade	PE and CGE models yield comparable results.
Barrett, 1997	Liberalization And Food Price Distributions: ARCH-M Evidence From Madagascar	Econometric - ARCH-M model	Short run effects of free trade on the mean and variance of food prices vary substantially by commodity, region and season	There is no well articulated theory of how stochastic food prices respond to economic liberalization measures
Mwanaumo *et al*, 1997	A Spatial Analysis Of Maize Marketing Policy Reforms In Zambia	Simulation - Spatial PE model	Welfare gains from liberalization are larger than commonly thought	Failed to analyze distributional effects of the gains from trade
Sumner *et al*, 1999	Implications Of Trade Reforms For Agricultural Markets In Northeast Asia: A Korean Example	Simulation - Equilibrium Displacement Model (EDM)	The study demonstrates the importance of cross-substitution between rice and horticulture	The study highlights a concept that is often ignored by analysts
Blake *et al*, 2001	The Impact On Uganda Of Agricultural Trade Liberalization.	Simulation - Contrasted CGE & PE models	Reported slight positive pro-poor impacts on low-income countries.	Use of PE and CGE models yields results that are not significantly different
Reimer, 2002	Estimating The Poverty Impacts Of Trade Liberalization	Econometric and simulation approaches	Trade/poverty analysis needs to be informed by both bottom-up and top-down perspectives	Various approaches yield comparable results
Karim and Kirschke, 2003	The Implications Of World Trade Liberalization On Agricultural Trade And Food Security	Simulation approach Multi-market PE model, Sudan	Free trade would lead to increases in food production, trade	Use of PE model is inappropriate given agricultures large contribution to GDP.
Hertel *et al*, 2003a	Short Versus Long-Run Implications Of Trade Liberalization For Poverty In Three Developing Countries	Micro-Simulation model	Reported substantial differences between short and long-run implications of global trade liberalization	Underscores the need to draw case specific results
Hertel *et al*, 2003b	Trade Liberalization And The Structure Of Poverty In Developing Countries	Simulation - CGE – GTAP model	Differing short run poverty impacts across countries, strata and within strata	High level of aggregation obscures the interpretation of results

Annex 1. (Continued) Impacts of Trade Reforms in Developing Countries

Author	Title	Approach	Major Findings	Remarks
Fabiosa *et al*, 2003	Agricultural Market Liberalization And The Doha Round	Simulation - Multimarket PE model – FAPRI	Net food exporters expand exports but net food importers are penalized by higher prices	Demonstrates the varying impacts of free trade on different countries
Boussard *et al*, 2004	May The Pro-Poor Impacts Of Trade Liberalization Vanish Because Of Imperfect Information?	Simulation - CGE – GTAP model	Gains from free trade disappear in the face of risk	The data used in this study is highly aggregated
Bautista *et al*, 2001	Policy Bias and Agriculture: Partial and General Equilibrium Measures	Simulation – compared PE and CGE model estimates	PE measures miss much of the action operating via indirect product and factor market linkages	PE measures overstate the direct (sectoral) effects
Weerahewa, 2004	Impacts Of Trade Liberalization And Market Reforms On The Paddy Sector In Sri-Lanka	Simulation - PE model	Trade liberalization increases demand for rice but lowers paddy prices	Did not quantify the welfare gains
Winters *et al*, 2004	Trade Liberalization And Poverty: The Evidence So Far	Simulation - CGE model for developing countries	There is no simple general conclusion about the relationship between free trade and poverty	Highly aggregated data sets
Valenzuela *et al*, 2004	Evaluating Poverty Impacts Of Globalization And Trade Policy Changes On Agricultural producers	Simulation – CGE model in 8 developing countries	Significant cross country differences between short run and long run effects	Cross country differences pose a challenge to analysts
Hertel *et al*, 2004	The Earning Effects Of Multilateral Trade Liberalization: Implications For Poverty	Simulation - CGE – GTAP model in Indonesia	Aggregate reduction in the national poverty headcount following trade liberalization masks a more complex set of impacts across groups	Problems of aggregation are highlighted
Ravallion *et al*, 2004	Gainers And Losers From Trade Reform In Morocco	Simulation - CGE model	The rural poor are worse off after liberalization	There are winners and losers from free trade
Chitiga, 2004	Trade Policies And Poverty In Zimbabwe	Micro-Simulation CGE Model	Trade liberalization reduces poverty but increases inequality	Highly aggregated data sets
Seshan, 2005	The Impact Of Trade Liberalization On Household Welfare In Vietnam	Simulation - PE model	Agricultural trade reforms did not improve overall household welfare or poverty reduction in Vietnam	Free trade does not improve welfare in all cases

Annex 2. Impacts of Market Reforms in Kenya's Maize Sector

Author	Title	Approach	Major Findings	Remarks
Argwings-Kodhek *et al*, 1993	The Impacts of Maize Market Liberalization in Kenya	Descriptive Statistics	The potential benefits from maize market reform are great	No attempt was made to formally estimate the benefits.
Jayne and Kodhek, 1997	Consumers Response to Maize Market Reform in Urban Kenya	Descriptive Methods	Maize market reform has conferred major benefits to urban consumers	No attempt was made to analyze the effect on rural maize producers and consumers
Nyangito and Ndirangu (1997)	Farmers Response to Reforms in Marketing of Maize in Kenya	Descriptive methods	The reform impacts were mixed with no conclusive evidence on farmers response	Failed to empirically model acreage response
Karingi and Siriwardana 2001	Structural Adjustment Policies and the Kenyan Economy: A CGE Model Analysis	Simulation – CGE model (KENGEM)	The economy stands to benefit from agricultural trade liberalization	The estimated effects are blurred by high levels of aggregation
Karingi and Siriwardana 2003	A CGE Model Analysis of Effects of Adjustment to Terms of Trade Shocks on Agriculture and Income Distribution in Kenya	Simulation – CGE model (KENGEM)	High import tariffs and indirect taxes reduce the positive impacts of trade reform policies	Demonstrates the policy bias against agriculture and advocates for the reduction of tariff and indirect taxes
Nyangito and Ndirangu (2002)	Impact of Institutional and Regulatory Frameworks on the Food Crops Sector in Kenya	Descriptive methods – trend analysis and (Structure-Conduct-Performance) S-C-P analysis	A decline in real producer prices and domestic production after price decontrol in 1995	Fails to empirically estimate the impacts
Nyangito *et al*, 2004	Impact Of Agricultural Trade And Related Policy Reforms On Food Security In Kenya	Descriptive Methods – trend analysis and food security indices	Agricultural prices have declined post-reforms	Fails to estimate the welfare impacts of free trade
Jayne *et al*, 2005	The Effects of Government Maize Marketing and Trading Policies on Maize Market Prices in Kenya	Econometric – VAR model	NCPB operations raise wholesale market prices while the import tariff only has modest impacts on prices	VAR approach is not as informative as structural econometric analysis
Wangia *et al*, 2001	Review of Maize Marketing in Kenya:	Literature review	There is an easy flow of maize in the market	Findings are not based on any empirical analysis
Nyoro *et al*, 1999	Evolution of Kenya's Maize Marketing System in the Post Liberalized period	Descriptive methods – S-C-P analysis	Liberalization has led to a decline in maize prices and milling margins	While urban consumers gain, rural producers may be hurt by trade liberalization