Chapter 4: Model Specification, Data Description and Model Estimation

The chapter begins by specifying the economic as well as the statistical models. This specification is necessary because the economic model provides a framework for identifying the relationships investigated, and how to make use of the resulting information; whereas the statistical model is the one that was estimated. The data are then described in terms of their nature, how they were collected, the time period they cover and their limitations. The chapter ends with a description of the estimating techniques.

4.1 The Economic Model

From an examination of the theory of supply and a review of the literature on the maize industry in Kenya, the relevant variables that influence maize supply are the expected own price of maize, the expected price of wheat, the relative input costs especially the cost of fertilisers and labour, the weather especially the rainfall patterns, and the level of technology as embodied in the hybrid and synthetic seeds. The economic model can be written as:

Area equation

(4.1) $$A_t = f(Pm_{t-1}, Pw_{t-1}, P_{F_{t-1}}, W_{L_{t-1}}, R_{t-1}, R_{t-1}, A_{t-1})$$

where

A_t = area planted under maize

Pm_{t-1} = price of maize lagged one year

Pw_{t-1} = price of wheat lagged one year

$P_{F_{t-1}}$ = price of fertiliser lagged one year

$W_{L_{t-1}}$ = wage rate of the agricultural sector lagged one year

R_{t-1} = rainfall previous year

A_{t-1} = area of maize in previous year

Yield equation

$$Y_t = A_t\ g(R_t, T, P_F / Pm, A_t)$$

Where

R = rainfall current year

T = trend variable

P_F / Pm = price of fertiliser/price of maize

A_t = area of maize current year

4.1.1 The Response Variables

The supply function applies theoretically to the unobserved planned output, and as such it cannot therefore be used in the model. To measure planned output, a proxy must be used. Supply response in agriculture has been modelled either directly or indirectly. The direct method is when output is specified as the dependent variable and is then related to other relevant supply determining variables. The indirect method is where area sown is used as the dependent variable.

Following Ghatak and Ingersent (1984), total output (=Q) of the crop is given by the product of acreage (=A) and yields (=Y), thus: $Q = A * Y$. It is assumed that acreage under cultivation and yields respond to price (=P) changes. Totally differentiating

(4.2) $$\frac{\partial Q}{\partial P} = Y\frac{\partial A}{\partial P} + A\frac{\partial Y}{\partial P}....$$

Assuming constant returns to scale, and dividing equation (4.1) by Q/P the result is

(4.3) $$\frac{dQ / dP}{Q / P} = \frac{Q / A.\partial A / \partial P}{Q / P} + \frac{Q / Y.\partial Y / P}{Q / P}...$$

or

(4.4) $$\ell_{qp} = \frac{\partial A / \partial P}{A / P} + \frac{\partial Y / \partial P}{Y / P}....$$

or

(4.5) $$\ell_{qp} = \ell_{ap} + \ell_{yp}$$

where

ℓ_{ap} = the elasticity of acreage with respect to price

ℓ_{yp} = the elasticity of yield with respect to price

ℓ_{qp} = the elasticity of output with respect to price

It is generally assumed that ℓ_{yp} is non-negative. To obtain a lower bound estimate of ℓ_{qp}, it is only necessary to regress acreage on price.

There are three advantages of regressing acreage rather than quantity produced on price. The first is that since the acreage planted is under the direct control of the cultivator, it reflects how much the producer actually intended to produce, and therefore it can serve as an acceptable proxy variable for output. The second advantage is that yield uncertainty due to random factors such as unexpected bad weather or pest attack can be eliminated, because these factors affect yields and not acreage. The last advantage is that since the effects of technological change are difficult to define as well as measure, the need for a proxy to measure it is avoided as technological changes affect yields rather than area planted.

However, the inadequacies of area as an approximation of planned output was recognised by Nerlove (1958) when he wrote that 'Only if the elasticity of yield with respect to price in question is zero will the elasticities of planned output and acreage be one and the same'. There are also practical problems with using area planted as a measure, especially when farmers interplant as is common in Kenya. This means that the plants' density might not be at their maximum level and so yields will not be as they should. Then the increased use of other inputs such as fertilisers and irrigation would expand the area under the crop because areas that would otherwise not have been planted are now under cultivation. Lastly, when acreage is used instead of the quantity produced, there is a tendency to underestimate the supply elasticity as it takes no account of variations in the supply of inputs other than land per unit of harvested area (Bond 1983).

These difficulties are applicable to Kenya as maize is inter planted with other crops, while technology has made it possible to extend maize into areas where it was previously not possible to grow it. To capture both advantages, this study uses two equations, one with area and the other with yields as the dependent variables.

4.1.2 The Area equation

The explanatory variables for the area equation are the previous year's regulated price of maize, the previous year's regulated price of wheat, the previous year's costs of urea at retail level, the previous year's cost of labour, the previous year's rainfall and the area planted under maize the previous year.

(a) Price of Maize

There are difficulties in modelling expected price: when used for annual crops it is plausible to assume that the desired output level is a function of expected price. Using current market prices is not realistic as farmers do not base their decisions solely on the current market prices but look at the previous prices. The prices used have therefore extended over a time period of more than a few years. Many researchers have inserted more realistic price formulations into the supply analysis. Price series most frequently cited in the studies include the price of the crop actually received by the farmers, the ratio of the price of the crop received by farmers to some consumer index, the ratio of the price of the crop received by farmers to some index of the prices of the farmers inputs, the ratio of the price of the crop received by farmers to some index of the prices of competitive crops.

None of the above prices may be the proper one to use, especially when dealing with developing countries and a crop that is mainly grown for subsistence like maize. This is because the farmers may not be motivated by the profit motive but by an intention to increase their consumption, and thus no price variable seems pertinent. If farmers do not buy a large selection of a basket of goods, then making deflation by some consumer price index is not reasonable.

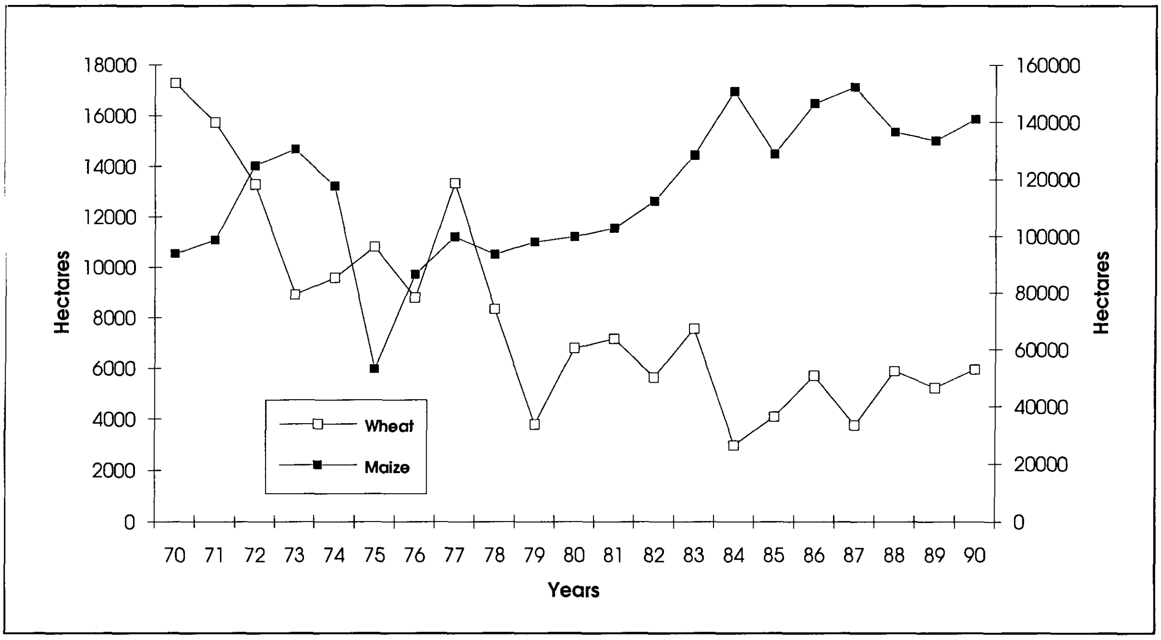
Using the relative prices of two competitive crops has the following difficulties. On the one hand, if the relative price of maize to wheat goes up a great deal in a period when other prices are constant, there might be a large increase in maize production. If on the other hand most other prices have also changed, then there might be a very different response.

Prices change over time. Using the ratio of the price of the crop received by farmers to some consumer price index may therefore not be appropriate. For example, if farmers become more prosperous, they may well buy a much wider range of consumer products. Thus even if the correct prices to use at any one time were known, a much more complicated price equation might be needed because of possible changes over time. This study adopts the hypothesis that the prices that are announced in February are the ones that producers use in formulating how much land to put under maize. Since the price was given, risk variable concerning price is not included.

(b) Wheat Prices

Wheat is a major competitor of maize especially in the zones where they can be grown together as is the case in the Central Province of Kenya. This competition is shown in Figure 4.1 which shows the area under maize decreasing as that of wheat rises and vice versa.

Figure 4.1 Area under maize and wheat in Central Kenya 1970 - 1990



Source: Plotted from data in Kenya (1992) pp 31 and 53

(c) Input Prices

Prices of inputs are important when considering net relative profitability of maize and wheat. The most important inputs for both crops are **fertilisers** and agricultural **wage rates** (see Table 2.2), those factors are therefore included in the model. Prices of fertilisers are these of urea as this is the one that has been constantly used in maize production during the study period.

The calculations of Table 2.2 were based on the assumption that farmers use machinery to prepare land, which is usually not so in small scale farms, however, so machinery costs should be seen as part of labour costs.

(d) Rainfall

In equation (3.12) a non market Z variable was included. This variable can be weather related like rainfall, humidity, drought and so on. According to Oury (1965), the explicit incorporation of a weather variable in the supply model involves some problems. To begin with, there are numerous determinants of weather and their interpretations are very complicated. Maize in Kenya is produced under rain-fed conditions, rainfall therefore contributes a great deal to the supply variations and is the variable that is included in the model as a proxy for weather. The annual rainfall figures for Trans-Nzoia District are used as this district is one of the leading producer of maize in the country.

(e) Area under Maize

Since maize is an important food crop, the current area under maize depends mainly on the previous area. The area under maize is further important as it is the coefficient attached to the previous area under maize that is used for measuring the speed of adjustment.

In its functional form, the economic model for the area equation can be re-written as:

$$(4.6) \qquad A_t^* = \alpha_0 + \alpha_1 \mathrm{P}m_{\mathrm{t-1}} + \alpha_2 \mathrm{P}w_{\mathrm{t-1}} + \alpha_3 \mathrm{P}_{\mathrm{F_{t-1}}} + \alpha_4 \mathrm{W}_{\mathrm{L_{t-1}}} + \alpha_5 R_{t-1} + \alpha_6 \mathrm{A}_{\mathrm{t-1}}$$

where

A_t^* = desired area under maize

P_m = price of maize

P_w = price of wheat

P_F = price of fertiliser

W_L = labour wages

$\mathrm{A}_{\mathrm{t-1}}$ = area under maize lagged one year

Going by equation (3.18))

$$A_t - A_{t-1} = \gamma(A_t^* - A_{t-1})$$

Solving for A_t^*

(4.8) $$\frac{A_t}{\gamma}-\frac{A_{t-1}}{\gamma}=A_t^*-A_{t-1}$$

(4.9) $$A_t^*=\frac{A_t}{\gamma}-\frac{A_{t-1}}{\gamma}-A_{t-1}$$

(4.10) $$A_t^*=\frac{A_t}{\gamma}-\left(\frac{1}{\gamma}-1\right)A_{t-1}$$

Substituting A_t^* into equation (4.6)

(4.11) $$\frac{A_t}{\gamma}-\left(\frac{1-\gamma}{\gamma}\right)A_{t-1}=\alpha_0+\alpha_1 Pm_{t-1}+\ldots\ldots\alpha_5 R_{t-1}$$

(4.12) $$A_t=\alpha_0\gamma+\alpha_1\gamma Pm_{t-1}+\alpha_3\gamma P_{F_{t-1}}+\alpha_4\gamma W_{L_{t-1}}+\alpha_5 R_{t-1}+\left(\frac{1-\gamma}{\gamma}\right)\gamma A_{t-1}$$
$$=\alpha_0\gamma+\alpha_1 Pm_{t-1}+\ldots\ldots(1-\gamma)A_{t-1}$$

4.1.3 Yield equation

Yields depend on the current area under production, the amount of rainfall in the current year, the amount of hybrid seed used, and the amount of fertiliser used. The amount of fertiliser used in production depends on how profitable it is to use fertiliser, which in turn depends on the ratio of the price of fertiliser to that of maize.

Technological change is associated with definitional and measurement problems; therefore, to capture the other factors that were not included in the model, a trend variable was considered as a proxy for technological change.

Yield risks were not considered as yields of maize have almost stabilised at about 20 bags per acre since mid 1970s (Kenya 1983). This is the yield that farmers expect.

Other factors have already been discussed in the area equation. This section therefore discusses only the trend variable.

(a) Trend Variable

Trend variable is used to measure technological change which has occurred during the study period, and therefore has contributed to the long-run shift in maize supply functions. Technological change has taken the form of high yielding hybrid varieties and drought tolerant synthetic varieties. The use of hybrid varieties has meant that more maize has been produced without changing the acreage while the synthetic varieties have expanded the area under maize, as the areas which were otherwise unsuitable for the growing of maize due to moisture scarcity are now under production.

The economic model for the yield equation is

(4.13) $$Y_t = R_t + H_s \text{ or } T + P_F / Pm + A_t$$

R_t = rainfall

H_s = hybrid seed

T = trend variable

P_F / Pm = price of fertiliser, price of maize ratio

A = current area under maize

4.4 Statistical Model

4.2.1 The Area Equation

Transforming equations (4.12) into an econometric model, the area equation becomes:

(4.13) $$A_t = b_0 + b_1 Pm_{t-1} + b_2 Pw_{t-1} + b_3 P_{F_{t-1}} + b_4 W_{L_{t-1}} + b_5 R_{t-1} + b_6 Am_{t-1} + u_t$$

where

$\beta_1 \ldots \beta_5 = \alpha_1 \gamma \ldots . \alpha_5 \gamma$

$\beta_6 = (1 - \gamma)$

u_t = disturbance term

Lim (1975) identifies six different models that can be used in the study of the supply response of annual crops. These models are: the simple Koyck distribution lag model or the simple Nerlovian expectations model, the complex Nerlovian expectation model, the

Koyck second-order lag model, the Nerlovian adjustment model, the expectations-adjustment model, and the simple model.

The choice of the model however depends on three factors which are the production and marketing characteristics of the crop, the difficulties of the estimation problems, and the availability of the statistical data. The first choice mainly involves the use of marketed surplus; however, since this study does not use marketed surplus, the choice of the model was based on the difficulties of the estimation problems and the availability of the statistical data.

As the area equation (4.13) involves lagged area, lagged prices and a disturbance term, it is evident that the partial adjustment hypothesis has been adopted. For the yield equation (4.14) the naive expectations have been adopted. The choices of the specifications are based upon practical, theoretical and statistical grounds. From a practical viewpoint, the models are to be estimated using OLS; this is a simpler method than maximum likelihood, which is used to estimate the adaptive expectations model or restricted squares, that is used for Almon polynomial lag models.

It has also been argued that maize farmers in Kenya base their decisions about how much area to devote to the crop on the price received from the previous crop. For this reason, the adaptive expectations hypothesis cannot be used. Since prices were announced before planting time, it was assumed that there were no price expectations. The rational expectations model is also not appropriate as farmers are not expected to study the market trends. Kenyan farmers are also conservative and are risk averse; they are therefore not expected to alter their farming practices considerably.

For statistical reasons, the adjustment model was chosen as it has fewer estimation problems compared to the Nerlovian expectations model (Lim 1975). It also does not suffer from any serious serial correlation as the random term v_t is not serially correlated so long as u_t is serially independent.

4.2.2 The Yield Equation

Transforming equation (4.13) into an econometric model the yield equation becomes

(4.14) $$Y_t = b_0 + b_1 R_t + b_2 T + b_3 P_F / P_m + b_4 A_m + v_t$$

where

v_t = disturbance term

4.3 The Nature and Sources of Data

The study relies on secondary sources of data. Data on the area under maize and wheat, producer prices of maize and wheat, hybrid seeds, and rainfall figures came from a collation of data by the Ministry of Planning and National Development (Kenya 1992). These in turn were compiled from data collected by the field staff of the Ministry of Agriculture, Livestock Development and Marketing. The data therefore suffer from problems normally associated with secondary data as they were collected for purposes of compiling the various annual reports of the Ministry. They were also collected using eye-ball estimates, so subjectivity in their collection cannot be ruled out. However, the data are the ones the government uses in decision making and so they can be considered as legitimate. Fertiliser prices came from various issues of FAO Fertiliser Yearbooks. The wage rates are from ILO Yearbook of Labour Statistics (various issues).

The data cover a period of 27 years, from 1963 when Kenya attained independence to 1990 when the latest statistics on fertiliser prices are available. The year 1963 was chosen as the starting year as, prior to independence, only maize from European farms was recorded. The actual data are and they are: annual hectares under maize, annual hectares under wheat, annual nominal producer prices of maize, annual nominal producer prices of wheat, annual total tonnes of maize produced, annual total tonnes of wheat produced, annual retail prices of urea, monthly permanent agricultural wages, and annual rainfall in millilitres. The unit of measurement for both maize and wheat is metric tonnes, while fertiliser is measured in one hundred kilogrammes of plant nutrient. The currency is Kenya shillings. Nominal prices are used because of the belief that they are the ones farmers base their production decisions on. The figures are in Appendix I.

4.4 Limitations of statistical analysis of supply based on time series data

Supply models based on time series data might suffer from various limitations which include: the identification problem, the *ceteris paribus* problem, the autocorrelation problem, the multicollinearity problem and the non-statinarity of the data.

4.4.1 The identification problem

All statistical analyses which seek to find relationships between prices and producer behaviour suffer from the identification problem (Lim 1975) because what is observed in the market is the price of the produce and the quantity offered. On this basis of this, it is difficult to say whether the relationship observed is a quantity-to-price one which determines demand, or a price-to-quantity one determined by supply.

The easiest way of solving the identification problem is to specify an explanatory variable that cannot identify either supply or demand. If the supply relationship is to be identified, then a variable such as rainfall should be included. This is illustrated below.

If the equations are:

(4.15) Supply equation: $S_t = \alpha + \beta P_t + u_t$

(4.16) Demand equation: $D_t = \gamma + \partial P_t + v_t$

(4.17) Market clearance: $S_t = D_t + w_t$

where

S_t = quantity supplied in period t

P_t = price in period t

u_t, v_t, w_t = error term

$a, b, \gamma,$ and ∂ = constant parameters

Combining equation (4.16) and (4.17), equation (4.18) is obtained.

(4.18) $S_t - \gamma + \partial P_t + (v_t + w_t)$

Multiplying equation (4.15) by λ and (4.16) by π, we obtain

(4.19) $\lambda S_t = \lambda x + \lambda b P_t + \lambda u_t$

(4.20) $\pi S_t = \pi\gamma + \pi\partial P_t + \pi(v_t + w_t)$

Combining equations (4.19) and (4.20)

(4.21) $S_t(\lambda + \pi) = \lambda\alpha + (\gamma\beta + \pi\partial)P_t + \lambda u_t + \pi(v_t + w_t)$

or $S_t = \dfrac{\lambda\alpha + \pi\gamma}{\lambda + \pi} + \dfrac{\lambda\beta + \pi\partial}{\lambda + \pi}P_t + \dfrac{\lambda u_t + \pi(v_t + w_t)}{\lambda + \pi}$

Equation (4.21) is a 'mongrel function' which incorporates demand and supply elements and there is no way of distinguishing it from true supply function.

If rainfall were added as an explanatory variable, equation (4.15) becomes

(4.22) $S_t = \alpha + \beta P_t + \phi R_t + u_t$

and equation (4.21)

(4.23) $S_t = \dfrac{\lambda\alpha + \pi\gamma}{\lambda + \pi} + \dfrac{\lambda\beta + \pi\partial}{\lambda + \pi}P_t + \dfrac{\lambda\phi}{\lambda + \pi}R_t + \dfrac{\lambda u_t + \pi(v_t + w_t)}{\lambda + \pi}$

Equation (4.23) cannot represent the demand equation because there is no *a priori* reason for believing that rainfall has a direct effect on demand.

It is for this reason that rainfall was included in the model to make it more realistic.

4.4.2 The *ceteris paribus assumption*

A static supply curve shows the relationship between price and quantity supplied; all other factors held constant. The dynamic model violates this assumption, so the gross relationship between quantity supplied and price is not likely to trace out the desired supply relationship.

The problem can be solved by extending the simple relationship to a multivariate one. The variables to be included depend on the various alternative economic opportunities open to producers.

4.4.3 Autocorrelation

One of the assumptions taken while using OLS to estimate the parameters is that the error term is random. If the supply equation is not well specified, there is a possibility that large systematic variables are left out in the error term. When this occurs, then the residuals suffer from autocorrelation. It is therefore necessary to test for autocorrelation using the Durbin Watson statistic. If there is autocorrelation, then this can be corrected by using a generalised least squares estimator.

4.4.4 Multicollinearity

Multicollinearity is a problem that arises when some or all of the variables in a model are so closely related to each other that it becomes difficult to isolate their separate influences and obtain a reasonably precise estimate of their relative effects. This is the reason for estimating an area and yield equation separately.

4.4.5 Non-stationarity

Non-stationarity of the data is a serious problem, as conventional estimation techniques no longer have the usual distribution. That is, t-ratios, R^2, and other measures of goodness of fit cannot be relied upon. For this study the time series data was tested for non-stationarity. The results indicated that the variables are stationary.

4.5 Estimating techniques

The maize area and maize yield equations were first estimated using OLS. Since contemporaneous correlation between the areas of maize planted and the areas of wheat were suspected, the seemingly unrelated regression (SUR) method was also considered. Joint maize and wheat yield equations were therefore estimated using SUR. This consideration was based on the fact that maize and wheat are competing crops; therefore, the disturbance terms in both equations at a given time are likely to reflect some common unmeasurable or omitted factors that could be correlated. The SUR method was used as a way of pooling information to obtain more efficient estimates than those obtained using OLS because when contemporaneous correlation exists, it may be more efficient to estimate all equations jointly rather than to estimate each one separately using OLS as long as the explanatory variables across equations are different (Judge *et al* 1988). When the equations in the system contain the same explanatory variables, there is no gain with SUR.

In econometric applications, contemporaneous correlation between the disturbances is often attributed to variables which are omitted from the equations. Examples of this could be the effects of temperatures in the yield equation and general economic indicators in the area equation. This was another reason why the SUR estimation was considered.

Chapter 5: Results and Discussion

As stated in the previous chapter, OLS and SUR regression were used to estimate the equations. The results for the coefficients of the area equations are presented in Table 5.1, and those of the yield equations in Table 5.3.

The elasticities for the area equation are shown in Table 5.2, while those of the yield equation are in Table 5.4. Results for the hypothesis tests are in section 5.2.2. A discussion and economic interpretations of the results follow in section 5.3. Section 5.4 compares the results of this study with those from Kenya and elsewhere.

5.1 Area Equations

5.1.1 Results

The equation estimated was:

(5.1) $$Am = \beta_0 + \beta_1 Pm_{t-1} + \beta_2 Pw_{t-1} + \beta_3 P_{F_{t-1}} + \beta_4 W_{L_{t-1}} + \beta_5 R_{t-1} + \beta_6 A_{t-1} + u_t$$

The results are as presented in Table 5.1. The estimated coefficients all show the expected signs. This means that the model conforms to the economic theory. It is only the intercept that shows the negative sign but since the intercept does not have any economic meaning, it can take any sign (Griffiths *et al* 1993).

The statistical values of OLS and SUR estimates are not very different meaning that the SUR estimates did not improve on the OLS estimates. The Breusch-Pagan test had a value of 2.1609, the χ^2 with 1 degree of freedom at α 0.05 is 3.84 and at α 0.1 is 2.7. Thus the hypothesis of no correlation between the maize and wheat equations cannot be rejected.

The OLS model was tested for the presence of autocorrelation. The null hypothesis of no correlation was accepted. The Durbin-H statistic -0.031726. The Durbin-H statistic was used instead of the Durbin Watson, given that the later cannot be used when the equation contains lagged dependent variables.

Table 5.1 Regression coefficient results for the OLS estimating method

Variables	Results
Intercept	-251.46
	(-1.374)
Pm_{t-1}	8.8181
	(2.332)
Pw_{t-1}	-3.5827
	(-1.078)
$P_{F_{t-1}}$	-0.11622
	(-0.6723)
$W_{L_{t-1}}$	-0.47036
	(-0.8449)
R_{t-1}	0.38091
	(2.825)
A_{t-1}	0.79733
	(6.681)
R^2	0.83

Figures in parenthesis are t-ratios.
Durbin-H = -0.031726, P-value = 0.0509

The t-ratios for all the coefficients are small except for the lagged area. This indicates that the area in the previous year does have a significant influence on the area planted in the current year, this was expected. The reported t-ratios are not significantly different from zero at the 5% level. The only significant ones are those of the price of maize, rainfall and lagged areas. This again was expected as most maize is planted without fertiliser as well as hired labour.

5.1.2 Hypothesis Testing

As stated in section 1.5, three hypotheses were tested, these were: that there are no adjustment costs, that the maize price effect is zero and that the effects of fertiliser prices are zero. In mathematical form:

(a)
$$H_0: \gamma = 1 \text{ or } \beta_6 = 0$$
$$H_1: \gamma < 1 \text{ or } \beta_6 > 0$$

(b) $H_0: \beta_1 = 0$
$H_1: \beta_1 \neq 0$

(c) $H_0: \beta_3 = 0$
$H_1: \beta_3 < 0$

From the one tail t-test results, the first and second test values were greater than the critical values, as such, the two null hypotheses were rejected. However, the third hypothesis could not be rejected as the test value was less than the critical value.

5.1.3 Elasticities

The short run elasticities of the variables were evaluated at the mean and are presented in Table 5.2. From the short elasticities, the long run elasticities were calculated.

Table 5.2 Short run and long-run elasticities for maize

Variable	Short-run	Long-run
Maize	0.67	3.30
Wheat	-0.41	-2.02
Fertiliser	-0.07	-0.34
Wages	-0.15	-0.74
Rainfall	0.30	1.48
Area	0.78	3.84

The long run elasticity is calculated by the ratio of the short run elasticity to the coefficient of adjustment, or, $\frac{\text{short run elasticity}}{1-\gamma}$, γ being the coefficient of adjustment. The short run elasticities are all inelastic, while the long run ones are elastic except for fertiliser and wages, the reason has been explained.

5.2 Yield Equations

The yield equations that were estimated jointly using SUR were:

(5.3) $$Y_m = R_t + T + P_F / P_m + A_m + u_t$$

(5.4) $$Y_w = R_t + T + P_F / P_w + A_w + v_t$$

where

$Y = Qm / Am$ and Qw / Aw respectively, and T is the Trend variable.

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5.2.1 Results

The results are as reported in Table 5.3

Table 5.3 Regression coefficient results for Maize/Wheat yield equations

Variables	OLS (Maize eq.)	SUR (Maize eq.)	SUR (Wheat eq.)
Intercept	121.24	283.45	1294.9
	(0.4089)	(1.185)	(4.221)
Rainfall	0.39680	0.43248	0.07174
	(2.110)	(2.580)	(0.4079)
P_F / Pm(Pw)	11.845	-1.3966	135.27
	(0.4165)	(-0.05927)	(2.896)
Area	-0.39183	-0.58005	-5.6685
	(-1.547)	(-3.363)	(-3.855)
Trend	77.456	83.277	22.895
	(8.253)	(11.81)	(4.642)
R^2	0.88	0.90	0.58

(Figures in parenthesis are t-ratios)

Breusch-Pagan $\chi^2 = 11.917$ for SUR linear equation.

All the signs were as expected except for the ratio of the price of fertiliser to the price of maize in the OLS maize equation. The change of sign in the P_F / Pm coefficient between OLS and SUR estimates is the most striking result in Table 5.3. This shows that the Breusch-Pagan test is highly significant indicating that the additional information in the SUR model improves the estimation. The R^2 results indicate moderate to high goodness of fit. The t-ratio for rainfall is significant for maize but not for wheat. This again is expected as the rainfall figures were for an area that is not a wheat growing area. The coefficient of the trend variable is large showing that there has been a marked increase of yields over the years. This is confirmed by Figure I, Appendix II

5.2.2 Elasticities

As with the area equations, short-run elasticities were evaluated at the sample mean. The results are presented in Table 5.4.

Table 5.4 Short run elasticities of maize yield equations

	Estimating	Methods
Variables	OLS	SUR
Rainfall	0.37	0.40
Trend	0.83	0.89
P_F / P_m	0.05	-0.006
Area	-0.33	-0.495

The yield elasticities with respect to the variables under consideration show the expected signs. That of the trend variable stands out showing that yields increased with time.

The coefficients of area are negative. This means that the planting of marginal land to maize has a negative influence on average yields.

The price of fertiliser/price of maize coefficients is almost negligible for maize in both equations. However, it shows the expected sign for SUR estimate thus improving it over the OLS estimate. This may be explained by the fact that most farmers do not use fertilisers for this crop.

5.3 Economic Interpretations of the Results

SUR model did not improve on OLS model except for the yield equation when it changed the sign for the fertiliser price/price of maize coefficient. The following section interprets the results giving them the economic meanings.

5.3.1 Area Equations

(a) Response to adjustment lag

From the results in Table 5.1, the coefficient of adjustment for maize in the OLS estimate is 0.797. Since the speed of adjustment is calculated by (1-γ), this comes out to be 0.20. Maize farmers therefore adjust about 20% of their area in the short run keeping other factors constant. This figure is reasonable given that the area under cultivation has almost been exhausted from the mid 1970s and maize is a traditional crop.

The short-run elasticity is 0.78 This means that a 10% change in area cultivated in the previous year contributes to 7.8% change in area in the current year.

(b) Response to the lagged price of maize

The coefficient attached to maize prices is positive as was expected. As when the price of maize of the previous year is high, then the area under cultivation in the current year should increase, all other factors held constant. This indicates that despite maize being mainly a subsistence crop, maize farmers still respond to prices. The elasticities calculated in Table 5.2 help to provide an objective measure of maize response to the price changes. In the short-run, a 10% change in the price of maize in the previous year makes farmers adjust the maize area in the current year by 6.7%, all other factors held constant. These elasticities are rather large for a major staple food in a poor country, as Timmer, Falcon and Pearson (1983) suggest a rule of the thumb elasticity of between 0.2 and 0.3.

(c) Response to the lagged price of wheat

The coefficients attached to the price of wheat are negative as was expected. When the price of wheat in the previous year was good, then the area devoted to maize goes down and vice versa as farmers who can do so switch to a more profitable alternative. Looking at the cross price elasticities in Table 5.2, a 10% increase in the price of wheat makes the area under maize to decrease by about 4%. This is lower than the 6.7 increase of own price elasticity of maize, and again, is realistic given that maize yields on average 3.42 t/ha as compared to 1.7 t/ha of wheat in high potential areas (Hassan *et al* 1993).

(d) Response to lagged price of fertiliser

The response is negative as was expected. This is because as the price of fertiliser increases in the previous year more than that of maize, less land will be planted this season using fertiliser. The response is however negligible. A 10% increase in the price ratio is responsible for only 0.7% decrease of the area planted, all other factors held constant. This again was expected given that most farmers do not apply fertilisers to their maize.

(e) Response to lagged wages

The sign is negative as was expected; as wages rise, it becomes more expensive to cultivate more land and so less is put under maize. Looking at the elasticities, a 10% increase in agricultural wages in the previous year results in a decrease of 1.5 of land under maize in the current year, all other factors held constant. The magnitude is not prominent as most maize is produced by family labour and therefore wage rates do not affect maize production significantly.

(e) Response to lagged rainfall

The area response to lagged rainfall is positive as was expected. This expectation is based on the fact that if rainfall was good the previous year, then farmers expect the same to continue in the current season. They will therefore expand their maize crop at the expense of wheat as maize does better in high rainfall areas.

The elasticity of supply of maize is 0.30 respectively. This means that a 10% increase in last seasons rainfall will make farmers increase their area under maize by 3%, all other factors held constant.

The long run elasticities are also presented, but they are not particularly relevant for an annual crop like maize whose prices were determined each year. Therefore, farmers had no time to fully adjust to price increases.

5.3.2 Yield Equations

In the yield equation, current figures were used as opposed to lagged figures as yields respond most to the current figures.

(a) Response to rainfall

The response to current rainfall is positive as was expected. It is also not different from that of the Area equation; this again was expected as the rainfall figures are from a station that does not experience a wide variation of rainfall. The effects of rainfall in the area and yield equations is the same. Even the elasticity is almost the same in that an increase of rain by 10% makes yields of maize go up by 3.7% and 4% for OLS and SUR respectively, all other factors held constant.

(b) Response to the trend variable

The trend variable was used to capture all other factors that were not included in the model of the yield equation. Looking at the trend elasticity of yield, a 10% change in trend resulted in a change in yields of 8.3 for OLS estimates and 8.9% for SUR estimates, all other factors held constant. This response was expected given that there was a rapid change in yields in the 1970s due to increased used of hybrid seeds.

(c) Response to price of fertiliser/price of maize

As in the area equation, this response was negligible. The elasticity was positive for the OLS estimate, which was unexpected, and negative for the SUR estimate, which was expected. The SUR elasticity showed that a 10% increase in the ratio was responsible for 0.6% decrease in yields, all other factors held constant. The reasons for this negligible response have been explained. The OLS result is unrealistic, but this has been commented on earlier.

(d) Response to area

Yield response to area under cultivation was negative as was expected. The more yields farmers expect to get per area planted, the less area they devote to maize. The area elasticity of yields for the SUR and OLS estimation methods, shows that a 10% decrease in area planted (due to expected increase in yields) results to an increase in yields of 4.95% and 3.3% respectively, all other factors held constant. This is reasonable given the opportunity cost principle which states that units of the input are allocated to each enterprise in such a way that the profit earned by the input is a maximum. The other reason for the negative sign is that small scale farmers are risk averse and therefore, to minimise risks, they plant many other crops. If high maize yields are assured, then the area devoted to it is reduced and other crops planted instead.

Comparing the area response for the acreage equation and the yield equation, the results conform to those of other studies as yield responses tend to have lower ranges (Scandizzo and Bruce 1980).

5.4 Comparison of elasticities with those of other studies

Table 5.6 shows the results of similar studies have been done on the supply response for maize in most countries, including Kenya. The studies are rather dated but there seem to have been no recent studies on supply response on maize. This may be due to lack of interest on this subject in the 1980s. Some of the elasticities in the table shows the perverse supply response which was thought to be one of the characteristics of developing countries' agriculture. This may be due to poor estimation techniques as reported in Askari and Cummings (1976).

Other studies done in Kenya in early 1980s show that the short run supply response elasticities range from 0.15 to 0.95 (Pinckney). Booker International's (1983) study came up with a short run elasticity of 0.4. The results for this study are within the range of the previous studies.

The following chapter discusses the policy implications of the results.

Table 5.6 Price elasticity of supply of maize in LDCs

Country	Response	Period	Short run	Long run
Kenya	Area	1950-69	0.95	2.43
Egypt	Area	1920-40	0.03	.04
Egypt	Area	1953-72	-0.18	-0.13
Syria	Area	1947-60	0.51	0.69
Syria	Area	1961-72	2.27	2.16
Jordan	Area	1955-66	-0.21	-0.25
Lebanon	Area	1953-72	0.13	0.29
Sudan	Yield	1951-65	0.23	0.56
Lebanon	Yield	1953-72	-0.06	-0.38
Syria	Yield	1947-60	-0.49	-0.61
Jordan	Yield	1955-66	6.13	6.40
Syria	Yield	1961-72	-0.65	-0.73
Egypt	Yield	1920-40	-0.16	-0.25
Egypt	Yield	1953-72	0.04	0.09

Source: Scandizzo, P.L. and Bruce, C. 1980, p.74

Chapter 6: Policy Implications

6.1 Introduction

Maize control has been seen by the government of Kenya as the best way of balancing its agricultural development. This may explain the six month ban on maize importation that was instituted in August 1994 even after market liberalisation in December 1993. Though the ban was lifted after only three weeks, it shows that the government is not in favour of complete maize price liberalisation. Consequently, the government still plans to support maize production through the following strategies:

- putting in place a short term input subsidy programme covering fertilisers;
- offering farmers minimum producer prices;
- ensuring increased and timely availability of key agricultural inputs procured through a cost reduction mechanism;
- improvement of research and extension services; and
- levying of import taxes to protect the producer.

This section analyses various policies that have been put in place since 1992 when Kenya became seriously committed to maize trade liberalisation. The policies are evaluated using economic theory, the analytical tools of demand and supply, and the results of this study.

6.2 Subsidies

Inputs can be subsidised to make them affordable, thus lowering production costs. Subsidised inputs can also increase production, especially where producers do not use optimal amounts, as is the case with fertiliser in Kenya. This section is mainly concerned with evaluating the 5% subsidy on fertiliser and how it may affect maize yields.

The bulk of the evidence on input prices relating to fertilisers has emphasised the importance of the output-to-fertiliser price ratio as the key measure of economic incentives in agriculture. Most of the very large differences in yields across countries are explained by the large differences in the ratio of output prices to fertiliser prices

(Timmer and Falcon 1975). The argument is that raising output prices or, equivalently, reducing fertiliser prices will bring about rapid agricultural development. Raising output prices for a staple like maize has political implications (Krishna 1976). The Kenya government has therefore opted for fertiliser subsidy and duty on fertiliser imports have been abolished since August 1994.

The elasticities for the fertiliser price/maize price for this study were -0.07 for the area equation. As for yield equation they were 0.05 for OLS and -0.006 for SUR. These results indicate that, in order to improve the response of maize production to fertiliser subsidies, the structure of the supply equation needs to be changed by encouraging farmers to apply more fertiliser. This can be done by promoting fertiliser use through the extension service and providing credit, as recent studies have shown that fertiliser application is primarily influenced by producer prices, fertiliser prices and credit availability (Kimuyu *et al* 1991). Ongaro (1990) claims that credit availability and extension contacts had positive and significant relationships to maize yields.

Due to the inconclusive results from this study, empirical estimates for studies done elsewhere are used to analyse the effects of fertiliser subsidy on supply. David (1975) showed that a 10% increase in fertiliser application would increase rice production by 1.43% when all environmental and technological factors have adjusted upwards. The *ceteris paribus* response rate is 0.7%.

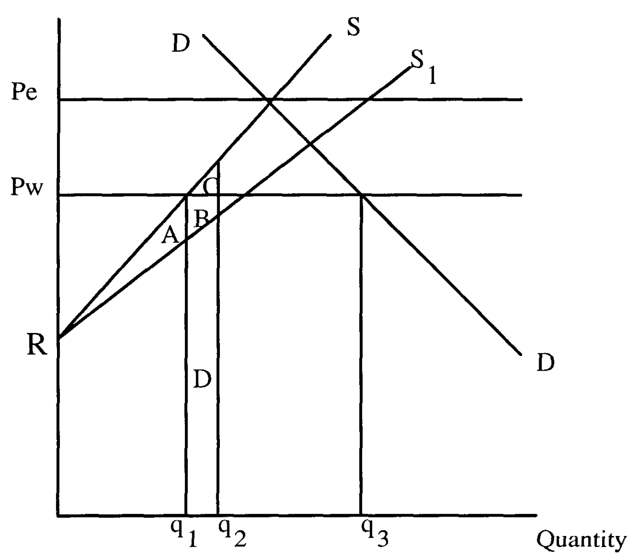
Timmer (1976) reported a decline in fertiliser use for a 10% price rise ranging from 3.4% in the short-run to 66.3% in the long run, the average being about 20%. Rao (1989) interpreted these results by considering a 10% subsidy on the price of fertiliser. This leads to a 20% increase in fertiliser use and a 2.86% increase in supply. Therefore, a 5% subsidy will lead to a 1.43% increase in supply. However, the long-run elasticity for fertiliser is a composite of the effects of prices and of changes in various environmental factors. They fail to measure the efficacy of a fertiliser subsidy taken alone.

In her subsequent study, David (1976) systematically allowed for fertiliser demand differences due to non-price factors. The long-run fertiliser demand elasticity was stable at about -0.9. In the short-run, the elasticity drops to -0.3, thus only about one-third of the long-run fertiliser response can be explained by price changes alone. The other finding was that the pure price-response of fertiliser was greater in countries with larger levels of fertiliser consumption. This finding makes it more difficult to justify exclusive reliance on fertiliser subsidies in poorer countries to raise the level of supply.

The effects of a fertiliser subsidy can also be analysed diagrammatically using the demand and supply model, as shown in Figure 6.1. The domestic supply curve without subsidy is RS, the domestic demand DD, and world supply is the horizontal line Pw. At price Pe the domestic supply and demand are at equilibrium. At world price Pw, domestic supply (without subsidy) would be q_1 and demand q_3. Thus the difference $q_3 - q_1$ will have to be met by imports.

Introducing a fertiliser subsidy reduces the marginal cost of production causing the supply curve to shift downwards and to the right to RS_1. Demand however remains the same while supply increases to q_2. The cost of the subsidy is equivalent to area $A+B+C$. Producer surplus increases by $A+B$. C, however, is not a contribution to surplus; it is an element of resource cost required to expand output from q_1 to q_2. It therefore represents a loss of production efficiency arising from a competitive misallocation of resources.

Figure 6.1 Effects of fertiliser subsidy



Source: Adapted from Colman, D. and Young, T. 1989 p. 274.

As a result of the subsidy policy, additional resources $A+B+C$ are drawn into production. The consequences are that outputs expand, imports decline by the same amount and there are foreign exchange savings of $B+D$. Thus additional resources worth $B+C+D$ have been employed to achieve foreign exchange savings of imports worth only B + D. Again, this represents a misallocation of resources equivalent to value C.

The effects of the fertiliser subsidy would have been better analysed in this study if an appropriate production function for the yield equation had been known. This is an area for further investigation.

Input subsidies are therefore inferior to output subsidies, because input subsidies distort the mix of inputs used when raising production. However, they are preferred because of their political appeal: they indicate that the government is doing something to help producers cut their cost of production. It is also important on budgetary grounds because only farmers using fertilisers benefit, as opposed to output subsidies that benefit a large number of producers.

The policy may also have long term benefits. This is when it induces new farmers to adopt the use of inorganic fertiliser. Since most maize farmers do not use fertilisers, it is unlikely that a 5 per cent drop in prices will induce them to do so. Hence the subsidy may benefit large scale producers only.

6.3 Improved Technology

Improved technology has the same effects as a producer subsidy. However, the social costs calculations are different because a dollar spent on research yields more than a dollar on cost reduction (Gardner 1987). The sum of producers' and consumers' gains outweighs the government costs. Instead of a triangular deadweight loss, there is net social gain. Supporting research on maize production will therefore be more beneficial as consumers gain as a result of reduced costs of the produce.

6.4 Price Support and Ceiling Price

6.4.1 Price support

This is when the government sets a 'fair' price that is usually above the equilibrium point in order to benefit the producers. Price support is therefore only possible when prices are regulated. By setting prices, supply is also determined, because for any given predetermined price, there is a unique corresponding supply which the producers find profitable to produce and sell. However, there is no guarantee that this quantity will coincide with the quantity the buyers will willingly purchase at that predetermined price. Price support therefore gives rise to extra production that the authorities must buy and stock pile if prices are to be maintained at that level. The main problem with support prices comes about when the authorities are not able to purchase all the produce offered. This leads to prices which are neither stable nor predictable.

Other problems with support schemes are high costs associated with handling and storage which can go up to 15 to 20 per cent (Tomek and Robinson 1992); prices must therefore rise by at least this percentage each year the commodity is held in storage if losses are to be avoided. Costs however depend on the elasticities of demand and supply curves: the more elastic the demand and supply curves are, the higher will be the costs of maintaining a given level of support.

Price support schemes are against the consumers as they are forced to pay more while in reality they should have paid less under free market conditions. They are also a source of political tension as any attempt to reduce the stock-pile leads to an accusation of dumping. To stop or minimise dumping, Kenya recently introduced an anti-dumping tax on cereals and sugar (Daily Nation, 8 Sept. 1994).

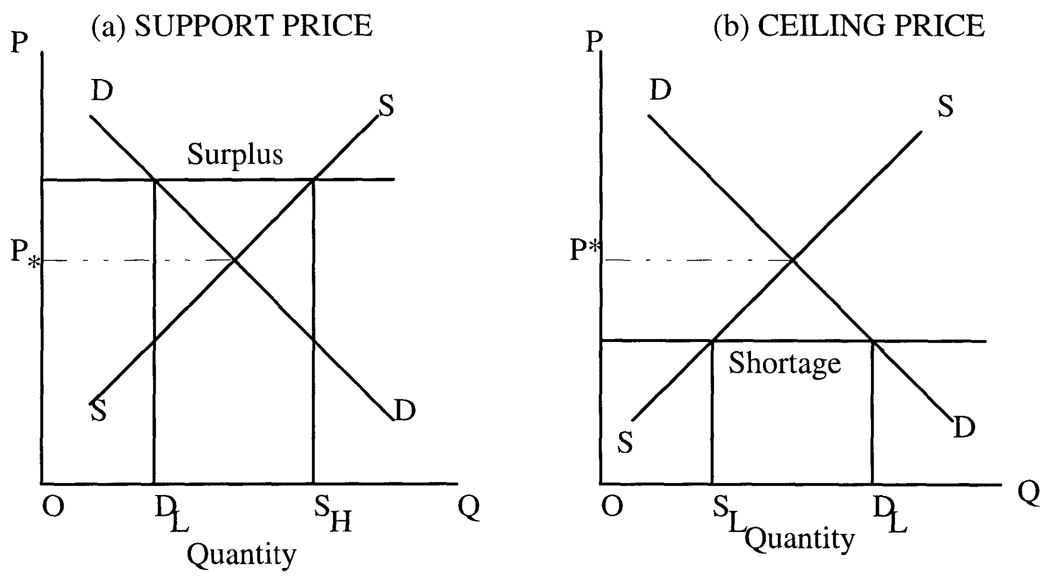
An example of how such a scheme did not work is the situation in the 1970s and 1980s, where the South Australian government set a prices for grapes that were higher than the equilibrium point to "improve farm profits". Many growers could not find buyers and the grapes withered on the vines (Samuelson, *et al.* 1992).

6.4.2 Ceiling price

This occurs where the maximum prices for products are legislated. The aim is to benefit the consumers as the prices are set below the equilibrium point. This practice was common in countries such as Tanzania, the former USSR, Cambodia, China and Burma which professed socialist ideologies. Setting maximum prices results in stagnant supply. When this practice was relaxed during the 1980s in China and Tanzania, production boomed. However, the practice was not exclusive to the socialist countries but was also tried in France. From 1914 to 1948, rents were set below the equilibrium point to protect the tenants. No houses were built during this period as it was not economical to do so. When ceiling prices are effected, commodities will be in short supply and the available supply is rationed through other means such as queues and the black market. These examples illustrate how the equilibrium point in demand and supply is important for setting of prices. Any attempt to tamper with it distorts either demand or supply.

The mechanisms of how support and ceiling prices encourage excess and shortages in supply are illustrated in Figure 6.2. In (a) the set price can only be sustained if the excess supply is purchased by authorities. In (b) an imposed ceiling price deters supply and leads to shortages.

Figure 6.2 Minimum and maximum prices giving rise to surpluses or restricted supply



Source: Samuelson *et al* p. 104.

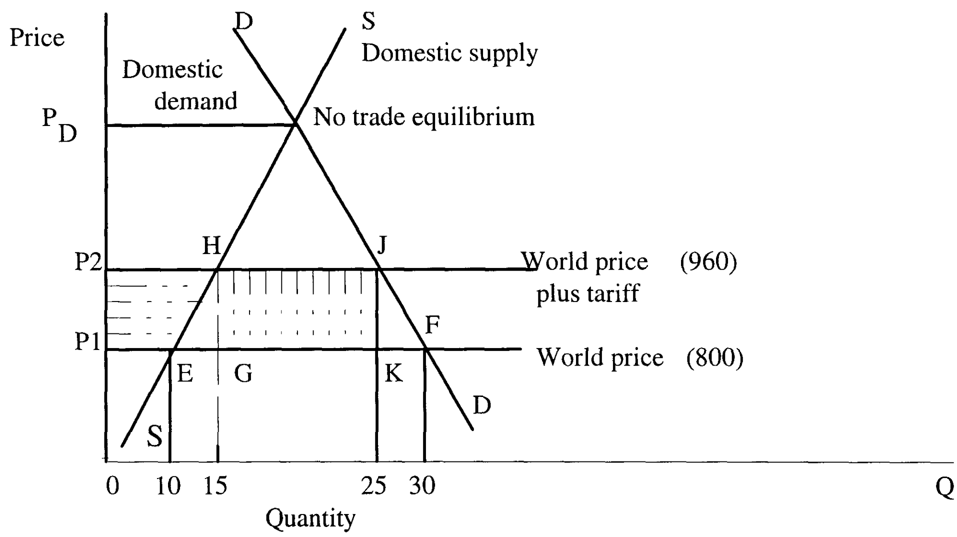
Floor and ceiling prices operate under two main constraints. First the domestic market must be separated from international markets either by imposing tariffs or by subsiding inputs and/or outputs. Otherwise the commodity will be imported or exported illegally depending on which mechanism is being used. The effects of tariffs and subsidies are discussed in section 6.5 under policy implications. Price controls also require tight administrative control, otherwise smuggling will thrive.

6.5 Restriction of Imports through Tariffs and Variable Levies

6.5.1 Tariffs

The economic loss to consumers as a result of tariffs exceeds the revenue gained by the government plus the extra profits earned by producers. The net result is that tariffs create economic inefficiency. This is demonstrated in Figure 6.3.

Figure 6.3 Economic cost of tariff



Source: Adapted from Samuelson *et al* (1992) p. 65.

In the absence of a tariff and with a free import market, domestic producers would supply 10 units, domestic consumers would demand 30 units, and the difference would be met by imports. When a tariff of 20 per cent is introduced, the price is increased to 960. At this price, producers supply 15 units and consumers demand 25 units, thus reducing imports to 10 units. Relative gains and losses can be measured by reference to labelled areas.

The effect of a tariff is represented by the area of quadrilateral P_1P_2JF, which is $(160*25)+(\frac{1}{2}*5*160)=400+175=4400$. This consists of the redistribution effect, the consumption effect and the protection effect. Producer surplus or the redistribution effect of the tariff is area $EP_1P_2H=(10*160)+(\frac{1}{2}*160*5)=2000$. The revenue effect, or the amount gained from tariff by the government is area GHJK which is equal to $10*160=1600$

The society loses by $(4400-3600)=800$. This is the area equivalent to the two triangles EGH and KJF. Area EGH represents the efficiency loss due to the use of marginal land as a result of a tariff. This is because a tariff induces producers to cultivate land whose marginal costs for producing are between 800 and 960 per unit. Bringing in these high marginal-cost lands is inefficient as the crop produced could be imported at a cost of 800. The total loss is $(\frac{1}{2}*5*160)=400$. Area KJF, which is equivalent to EGH, is the consumption effect, the loss of consumer surplus from the high price brought about by the tariff. This area is also known as the protection effect.

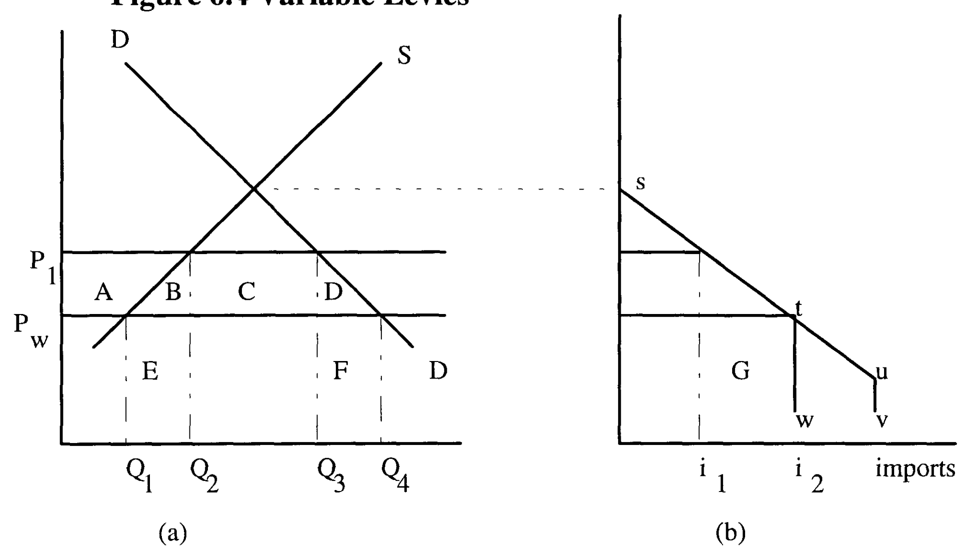
The degrees to which internal production and consumption are affected by tariffs depend on the elasticities of the demand and supply curves. The more elastic these relations are in the importing nation, the greater will be the impact.

To protect the domestic market from imports from neighbouring countries, an import levy on maize was introduced for the first time in 1992. Its effect is difficult to gauge because most of this maize was imported either illegally and in small quantities, or through the Board. Because the short-run supply and demand elasticities for the staple are relatively inelastic, this import levy apparently did not work in protecting the producers from imports. This may explain why maize and wheat importation were banned for a period of six months in August 1994 even when the levy was in force. However the ban was lifted after three weeks and replaced by variable levies (Daily Nation 8 Sept. 1994).

6.5.2 Variable Levies

With a fixed tariff rate on imports of agricultural commodities, exporting countries can maintain the existing volume of sales by reducing their own exports. If this occurs, the internal price may not increase or will rise less than the amount of the tariff. With variable levies, this is not possible. Therefore variable levies are more effective in protecting domestic producers in that they are adjusted up and down to compensate for any change in export prices. This type of protection has been adopted by the European Union to protect grain and livestock products. Variable levies affect both supply and demand. This is shown in Figure 6.4.

Figure 6.4 Variable Levies



Source: Colman, D. and Young, T. 1989 p. 280.

When variable levies are imposed, domestic supply increases from Q_1 to Q_2 and demand declines from Q_4 to Q_3. Thus the welfares of producers and consumers are affected positively and negatively respectively. Imports are also reduced from i_2 to i_1.

The levy causes excess demand to fall from *stuv* to *stw*, thus becoming completely inelastic at prices below P_1. This is due to the fact that the price in the domestic market will not fall below P_1 irrespective of what changes occur in the world prices. Below P_1, the domestic supply and demand will therefore be unresponsive to world prices.

An import tax therefore has the following economic effects.

Consumer surplus loss = $A+B+C+D$.
Producer surplus gain = A
Tax revenue gain = C
Deadweight economic loss = $B+D$.

Deadweight social loss is equivalent to consumer surplus loss minus both the producer surplus gain and the tax revenue gains.

This levy also generates foreign exchange savings of $E+F=G$. This is achieved at a resource cost of $E+B$ and a loss of consumption value under the demand level of $F+D$.

Given the wide margin between the international price (which is US $153 per tonne) and domestic ones (which is officially set at US $230 at the exchange rate of US $1 to K shs 40), it is unlikely that this levy alone will discourage importation of maize. It is therefore not surprising that there were 760 000 tonnes of maize imported in 1994 as opposed to 600 000 tonnes in 1993 (Daily Nation, 9 Feb. 1995).

Up to now, the agricultural policies that the government of Kenya has put in place to accompany maize liberalisation do not seem to be effective in protecting the producer from cheap imports. The alternative is to invest more in research so that Kenyan maize can be competitive. The problem is that the response may be too great and the problem of disposal may arise.

Chapter 7: Summary, Conclusions and Recommendations

7.1 Summary

The objective of the study was to assess the supply response of maize to the agricultural policies that have been in force in Kenya since Independence in 1963. These policies were where the Board was used to fix prices at all levels of production and marketing. The problems with fixing prices were discussed, together with those which have affected the maize marketing boards in Kenya.

Theoretical supply analysis was discussed, followed by the methodology of the study. Time series data, and the Nerlovian adjustment model was used for the study. Two different aspects of supply were analysed: area planted and yield. The explanatory variables in the area equation were lagged price of maize, lagged price of wheat, lagged price of fertilisers, lagged price of agricultural labour, lagged rainfall, and lagged area under maize. For the yield equations, yield of maize was regressed against current rainfall, time trend, fertiliser price/price of maize ratio, and the area of maize.

Yield equations were estimated by both the OLS and the SUR methods, whereas the area equation was estimated using OLS only. In the yield equation the SUR produced a considerable improvement in the values and signs of the coefficients.

Three hypotheses were tested. These were: whether there were adjustment costs, whether supply responded to controlled prices, and whether there was any effect on the fertiliser price/price of maize ratio.

The findings were as follows:

- That farmers adjust about 20% of their area in one year, thus there are adjustment costs.
- That there was supply response to price: a 10% change in prices made the area under cultivation to be adjusted by 6.7%.
- That the supply response to the price of fertiliser/price of maize was negligible.
- That response to changes in wages was also low, as a 10% increase in wages showed a response of only 1.5% in the area under cultivation.

- That the trend variable for the yield equation stood out, meaning that other factors that were not included in the model, especially technology, were more important to the yields rather than price of maize.
- That the short-run elasticities for both area and yields were inelastic, while the long-run were elastic except for fertiliser and wages.

Most of the signs were as expected. The SUR results were outstanding only in changing the sign of the fertiliser price/price of maize ratio to the expected one in the yield equation. From these results, and using theory and the work of others, an analysis of policy implications was attempted

7.2 Conclusions and Recommendations

A major conclusion that can be drawn is that the supply of maize in Kenya responds to prices. Therefore, the Board's pricing policies appear to have been effective. The theory of the backward sloping supply curve is therefore not confirmed. It should be noted that price is not the only factor responsible for the supply; other factors such as the introduction of new technology in the form of hybrid seeds were much more important than the price incentive. Extending maize into drier areas reduced its yields, while the response of yield to fertiliser price was negligible. This suggests that a production function approach to the yield equation might be a better tool to estimate the possible effects of the extension programme on maize supply.

It can therefore be recommended that:

- The drier areas be left to those crops which can do well there and maize production be limited to high potential areas.
- The fertiliser subsidy of 5% is not substantial enough to encourage other farmers to start using fertiliser; thus, the subsidy may benefit only those who are already using it. Credit facilities should therefore be expanded to make those who are not using fertilisers because of costs do so.
- As shown earlier, production increases as a result of new technology seem to have been exhausted; there should therefore be investment in research to produce crops that are economical to plant.
- The Board may have had its problems, especially those connected with administration. However, since supply responded to the Board's price, the policies seem to have been appropriate. The Board should therefore improve its

administration and should not be disbanded as has been suggested. This is because maize is an important crop that should not be left to the market forces alone.

The steps the government has taken in protecting maize from imports appear to be in the right direction given that the supply of this staple is not constant in the world market. The problem is complicated by trade agreements such as the Common Market for Eastern and Southern Africa (COMESA), which advocates free trade within the member countries. As such maize from COMESA countries will find its way to Kenya if the producer prices in Kenya are higher, so with these trade agreements, it would be less costly for Kenya to liberalise the agricultural sector.

Jaffee (1993) studied the horticultural industry in Kenya and concluded that, even in a liberal market environment, the technical characteristics of many crops, their production and their processing, may lead to centralised procurement and marketing arrangements. Hence, market liberalisation may involve a simple shift from centralised public control to some form of centralised private control. This study is important as the horticultural industry is one of the few industries where government control has been minimal. Total internal liberalisation of trade within Kenya and the COMESA region is in order. However, freeing trade to external competition may not make good political sense.

This study recommends maize trade liberalisation, but even after liberalisation, farmers will still have to be assisted because of the peculiar nature of agriculture. Apart from New Zealand, world experience has shown that no country has abandoned the farmers. However, internal competition is healthy as this will encourage farmers to find ways of reducing costs and thus becoming competitive. The marketing boards need not be disbanded but they should be restructured so that they compete with other traders. This will make them more efficient.

7.3 Limitations of the study and areas of future research

The study had the following limitations:

- There was not enough available time series data to enable the study to come up with concrete recommendations,
- The demand equation could not be identified as maize is not exported,
- The study covered a period when maize prices were controlled. Therefore, the structure of the supply equation may change under free market conditions.

Because of the above limitations, further research is needed when enough data is available for proper statistical analysis. The demand equation is also necessary as the implications of a particular policy can be studied only if the elasticities of supply and demand for the commodity in question are known. The response of farmers to increased price risk might be an important factor that may drive supply change; therefore, this would be an important area of research in a few years when additional data are available. This study therefore acts only as a pointer to what might happen given the theoretical analysis.

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Appendix

APPENDIX I: Time series data used in the study

Year	Area	Pland.	Prod	Price	Total	Prodn.	Seed	Urea	Wages	R'fall
	(ha)		Ksh/	90 kg	'000	tonnes	Kshs/	Kshs/	Kshs/m	cm/m
	Maize	Wheat	Maize	Wheat	Maize	Wheat	'000kg	100kg		
1963	701.1	116.7	29.6	47.9	229.50	128.9	00000	182	92.0	100.1
1964	454.0	119.7	32.6	47.4	187.70	143.0	00000	200	99.0	120.1
1965	436.0	129.8	32.0	46.8	295.65	132.2	00000	213	104.0	84.93
1966	447.7	136.2	36.1	48.7	403.20	179.1	00000	213	110.0	134.5
1967	829.3	150.9	31.7	50.7	511.20	238.9	1972.8	213	115	43.77
1968	939.4	167.3	27.7	50.6	619.20	222.6	2331.4	213	118.8	115.2
1969	943.4	164.3	27.7	46.5	727.20	215.5	3207.8	213	123.0	111.4
1970	974.4	128.1	30.0	40.6	835.20	176.9	4790.8	116	129.2	130.7
1971	1043.0	115.1	35.0	45.0	943.2	170.3	6221.1	110	140.0	122.6
1972	1211.6	104.4	35.5	45.5	1051.2	149.6	7145.0	123	180.6	116.3
1973	1151.3	107.4	41.8	51.0	1159.2	137.9	7447.4	169.28	181.2	104.5
1974	1161.8	105.1	62.8	72.3	1267.2	157.8	9047.2	274	196.6	105.1
1975	1190.9	117.3	68.9	94.2	1375.2	161.9	10700	274	233.4	117.5
1976	1215.8	119.7	80.0	108.3	1597.1	180.7	12224	368	312.9	97.36
1977	1246.7	137.8	69.7	120.0	1671.4	165.9	10922	458	326.9	174.0
1978	1282.1	119.0	69.7	120.0	1620.0	157.5	9192.5	466.6	376.9	158.3
1979	1332.7	87.2	80.0	129.3	1606.5	155.1	13073	521.7	411.5	136.08
1980	1364.9	99.9	85.8	147.5	1888.3	188.8	12197	489	434.5	98.22
1981	1120.0	99.7	90.0	150.0	2560.0	225.7	13482	625	483.0	144.53
1982	1208.0	118.8	96.3	160.7	2450.1	243.6	13010	966.1	539.1	168.88
1983	1236.0	120.0	138.6	195.0	2214.8	251.3	1554.2	987.6	539.1	122.23
1984	1230.0	110.3	157.5	225.5	1500.0	144.4	20290	794.9	585.0	88.6
1985	1370.0	118.1	168.3	242.0	2440.3	201.1	""	1047.5	633.7	133.56
1986	1430.0	136.5	178.2	269.4	2609.4	252.0	""	1088.7	720.5	88.13
1987	1440.0	145.1	188.1	286.0	2732.1	207.0	""	927.6	794.3	117.3
1988	1420.0	148.2	192.8	286.0	3140.0	234.0	""	891.3	933.9	121.93
1989	1460.0	153.4	201.0	302.0	3030.0	244.2	""	1100.0	990.8	128.82
1990	1300.0	138.2	235.5	418.0	2890.0	190.1	""	1061.1	1084.9	133.5

N.B. For Fertiliser 00000 means no fertiliser was there

"" "" means figures were not available

APPENDIX II: Figure showing Area and yields of maize in Kenya (1963 - 1990)