AN ECONOMIC ANALYSIS OF PRODUCERS' INCOME INSTABILITY IN KENYA'S AGRICULTURAL SECTOR: THE CASE OF SELECTED MARKETED COMMODITIES

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INTRODUCTION

Problematic Situation

Kenya is a democratic republic on the east coast of Africa (Figure 1). The country was a British colony until gaining its independence in 1963. It has a parliamentary system of government, with a president as head. Normally, elections are held every five years. Suffrage is universal over the age of 21. Since independence, the country has had remarkably stable political and economic continuity, at least relative to other African countries.

With a land area of 582,646 square kilometers, Kenya's physical and climatic differences are caused mainly by variations in altitude. Elevation ranges from zero at sea level to over 5,000 meters above sea level. The daily mean temperature on the coast is 27 degrees centigrade while at 1,500 meters, the temperature varies between 21 and 26 degrees centigrade. Annual rainfall varies from a high of 250 centimeters around Mt. Kenya to less than 25 centimeters in the north and northeast. Most of the country experiences two rainy seasons. The seasons vary from region to region. The country is divided into ecological zones depicted in Figure 2. A World Bank report (1975) described the zones and their agricultural potential. These are briefly described below.

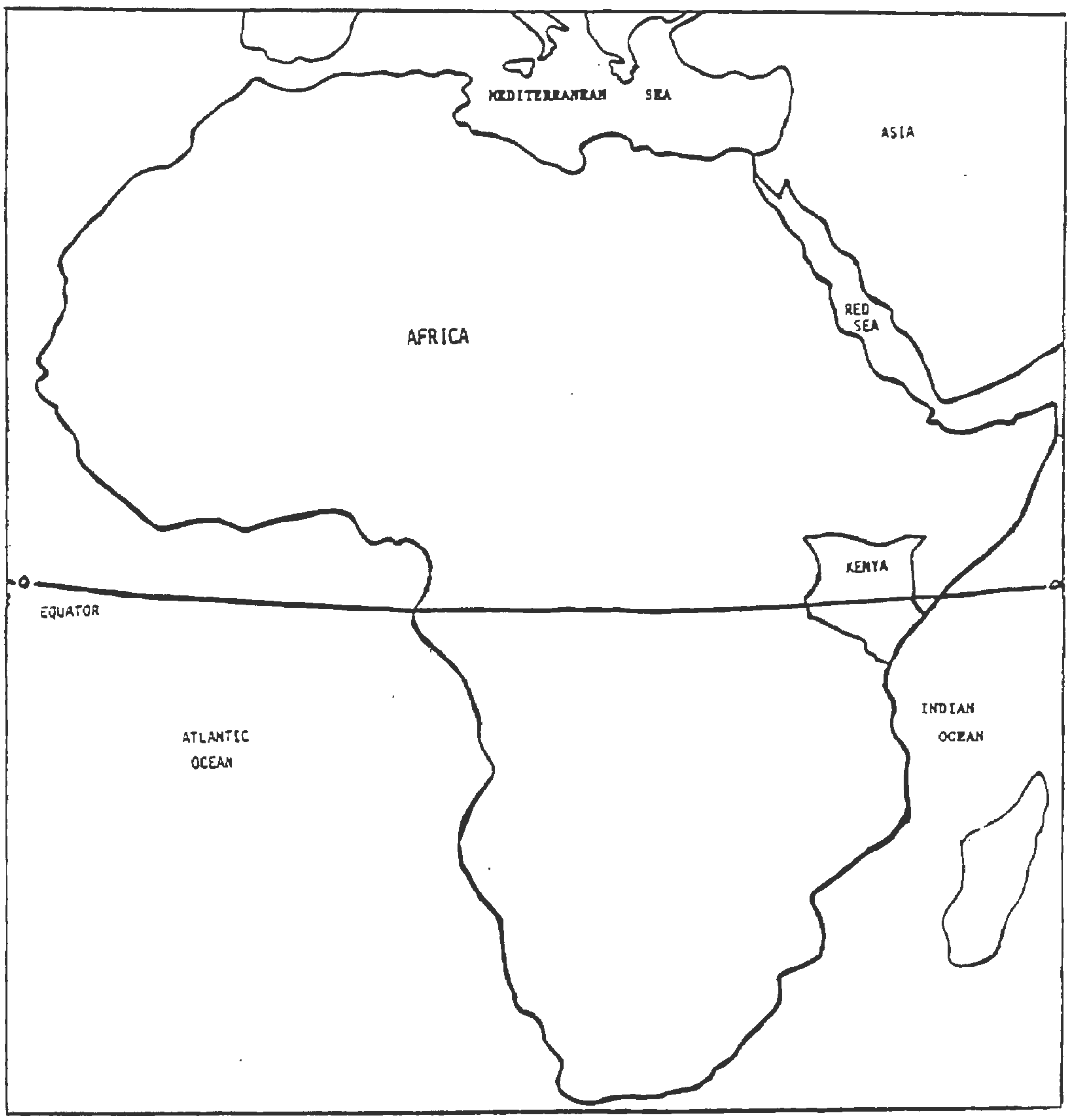


Figure 1. Geographical Location of Kenya

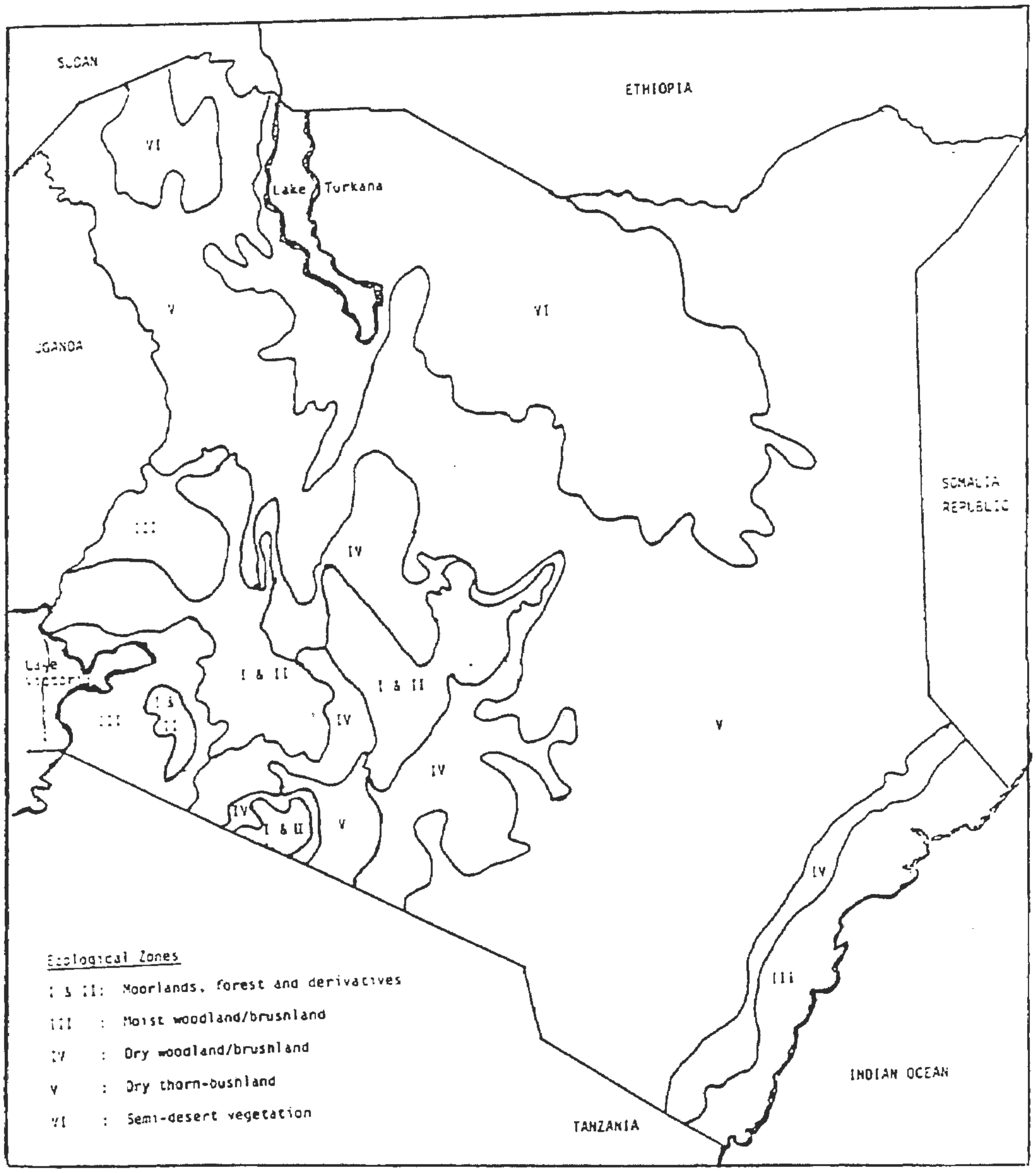


Figure 2. Major Ecological Zones of Kenya

Zone I: This covers about 800 square kilometers. Land is limited to water catchment.

Zone II: This extends some 53,000 square kilometers. It has high agricultural potential. Tea, coffee and livestock are the major commercial activities.

Zone III: It covers about 53,000 square kilometers. Large scale commercial wheat, maize and barley are grown in the zone. Maize production is dominant in small scale farms. Intensive livestock activities are possible.

Zone IV: Having roughly the same area as Zone III, the zone has limited agricultural potential. Cotton, pulses, sisal and oilseeds are the main cash crops. Some commercial ranching is practiced.

Zone V: The zone covers some 300,000 square kilometers. It has moderate rangeland development potential. Wildlife is important.

Zone VI: This zone covers about 112,000 square kilometers. Rainfall is erratic. Nomadic pastoralism is the main activity.

Thus, Zones II and III, forming less than 20 percent of the country, could be classified as having high to medium agricultural potential. The rest is either marginal or low potential under existing ecological conditions.

The Kenya Economic Survey (1985) estimated Kenya's population at 18.8 million in 1983 and growing at about 4 percent per annum. The estimated per capita gross national product for 1980 was equivalent to $420 U.S. (IBRD/World Bank, 1983). This declined to $310 U.S. in 1984

(World Bank, 1986). The high population growth rate is an important development problem for the country. Based on the 1979 census, about 60 percent of the population was less than 20 years old. Approximately 80 percent of the population depends on agriculture. The youthful nature of the population raises dependency problems. The IBRD/World Bank (1983) reported that in 1976, a square kilometer of agricultural land in Kenya supported a population density of 231, making it one of the highest in Sub-Saharan Africa.

Essentially, Kenya has a "mixed" economic system. Diverse forms of economic organizations and incentives exist. Private enterprise is encouraged. However, the Government also advises and participates directly or indirectly through state-owned or parastatal corporations. Cooperatives, especially in the agricultural sector, have been central to economic development. For the period 1964 to 1973, the average annual growth rate of total GDP was 6.6 percent, with agriculture and manufacturing growing annually at 4.7 and 8.4 percent, respectively (IBRD/World Bank, 1983). Performance has been erratic in the later part of the 1970's and early 1980's. The average growth rate in GDP in 1983 was 3.5 percent (Kenya, Economic Survey, 1985). Although the agricultural sector contributes about 30 percent of GDP, Kenya is still an agriculturally dependent country.

Kenya's agriculture is dichotomous in many ways. There are land areas with high and low agricultural potential, large and small scale farms, crop and animal production systems, as well as subsistence and commercial agricultural production. De Wilde (1984) estimates that the share of market oriented agricultural GDP has risen from 42 percent of the total agricultural GDP in 1964 to about 50 percent in

1977. Thus, commercial agriculture plays an important role in the country's market oriented economy. It is this subsector which provides much of the stimulus for overall expansion of the economy. Instability in the subsector can have negative repercussions throughout the economy. Dualism exists in the subsector too. There are export oriented production activities as well as those directed toward the domestic market.

In 1980, it was estimated that 74 percent of Kenya's net foreign exchange earnings were from agricultural sources (Schulter, 1984). Coffee, tea and sisal are the major exports. Major food commodities which enter the domestic marketing system are maize, wheat and liquid milk. These six commodities form the backbone of Kenya's commercial agriculture. At the macroeconomic level, the commodities are complementary in nature. The export commodities provide foreign exchange which is used to import fertilizers, energy and machinery. Occasionally, export earnings are necessary to pay for food imports. At the farm level, some of these commodities compete for producers' land and labor resources. Typical examples include the competition between cash and food crops for land in small scale production systems in the Central Province. At the national level, the subsector is viewed as the major source of employment for the expanding labor force given the limited employment opportunities in the non-agricultural sector.

During 1960-70, the average annual growth rate in agricultural production was 3.3 percent. This rate declined to 2.7 during the 1970-82 period (IBRD/World Bank, 1984). Between 1972 and 1978, the commercial subsector grew at the rate of 2.6 percent (IBRD/World Bank, 1983). A study by Josling (1984) revealed the average annual growth rate in agricultural export earnings for the period 1970-79 was 17.8 percent. However, the rate of growth of purchasing power was 1.9 percent. Thus, the growth rate of export earnings was not favorable when compared with costs of imports. In 1961, the commodity concentration index, defined as the share of total exports from the three principal exports, was 34.2 percent while the average for the 1976-78 period was 52.5 percent (IBRD/World Bank, 1981). Hence, Kenya has become increasingly dependent on fewer commodities. The average price fluctuation indices for coffee and tea during the period 1955-81 were 17.7 percent and 7.7 percent, respectively (Singh, 1981). Market concentration is declining although the traditional industrialized nations still account for over 50 percent of total purchases (Kenya, Statistical Abstract, 1984). These levels of concentration make Kenya more vulnerable to the economic fortunes of the fewer trading partners.

Accompanying the above imbalances has been the devaluation of the Kenya currency against the United State's dollar by about 47 percent between 1970 and 1983. A recent World Bank study on Kenya (IBRD/World Bank, 1984) indicates that during the period 1970-82, the annual growth rate in terms of trade against its trading partners was -0.4 percent. Furthermore, debt-service as a percentage of exports rose from 5.4 percent in 1970 to 20.3 percent in 1982. The economic shock of 1973-74, that arose from an increase in oil prices, led to a decline of 12 percent in terms of trade resulting in an approximate 5 percent loss in income in real gross domestic product (IBRD/World Bank, 1983).

Concerning Kenya's geographical factors, Wolgin (1975) noted that climatic and ecological conditions vary widely across space and time in Kenya. Variation in space gives rise to well-defined agroecological zones. Often there is a predominant activity in each zone but diversification is also common especially among small-scale producers. Variation across time contributes to annual or seasonal irregularities in agricultural production. Whereas Kenya, being a small and open economy in many respects, has limited or no control on international markets and climatic factors, it may be able to alleviate inconsistencies in the domestic markets by choosing relevant weights on appropriate policy instruments.

Most current policies associated with food production in Kenya are embedded within goals of Kenya's National Food Policy (Kenya, 1981). Broadly, the major policy goals include: (1) self-sufficiency in the basic foodstuffs with the surplus being exported profitably; (2) a reasonable degree of food security in the country; and, (3) increased availability of nutritionally balanced diets for all citizens. Inherent in these goals is the stabilization of domestic food prices. Past policy has promoted production through the provision of price incentives to producers and improvements in the marketing system.

Kenya has been marginally self-sufficient in the basic foodstuffs. Assuming an annual population growth rate of 3.5 percent and a growth rate of per capita income of 2.5 percent, projections for the period 1977-2000 estimate food consumption will grow by 4 percent per annum (IBRD/World Bank, 1983). Kenya must expand its food supply and distribution network if it is to meet increased food requirements. Otherwise, the rapidly growing population and its changing spatial distributions could destabilize producers' income through strained marketing channels.

The major commercial farm commodities are marketed through or regulated by government controlled agencies. These agencies are commodity based and are responsible for advising the government on policies regarding their respective individual commodities. As such, national commodity production risks and benefits are assumed by agencies. A breakdown in coordination among agencies may result in a Cournot-like decision making process, especially concerning production. An agency would set the price for the commodity in which it is responsible assuming that the other agencies would not change their positions. This approach ignores the possibility of commodity substitution at the farm level. Some observed production distortions and disincentives accrue from lax coordination among these agencies. The government controls producer and consumer prices for the principal food commodities. Despite the fixing of producer prices, non price factors reduce the effective net farmgate prices. For example, delays in payments by the agencies have negative temporal effects on farm operations. Coupled with environmental vagaries, a producer's marketed supply response may be based on the expectations of average revenues instead of fixed prices as is commonly stipulated (Scandizzo et al., 1984).

There is ample evidence to suggest that the major constraints to achieving desired goals in the agricultural commercial subsector are economic and political rather than technical or biological (IBRD/World Bank, 1983). Most agricultural commodities have the potential of entering the commercial subsector. In recognition of this potential, the government of Kenya has been developing guidelines for agricultural marketing and pricing policy. In general, the objective has been to promote efficiency of the marketing system and spur agricultural production through increased "competition." In designing policies for the commercial subsector, price rather than quantity or average revenue instruments are commonly used. Accordingly, producer prices are set with consideration of border prices, production costs, supply trends, effects on consumers and the promotion of specific crop or animal activities. These are reviewed regularly as part of the Ministry of Agriculture's Annual Price Review. Thus, domestic prices are, implicitly, the result of a form of welfare optimization. Policy has been formulated under unstable domestic and external environments resulting in possibly unnecessary shifts in resource use and ensuing production and income instabilities.

The Problem

The preceding description suggests that commercial agriculture in Kenya faces three potential sources of instability: demand, supply, and government. Demand instability may arise from variability in consumers' tastes and preferences, incomes, and prices of other commodities. Also, exchange rate effects arising from domestic fiscal and monetary policies and import trade restrictions of its trading partners contribute to demand instabilities.

Changes in production conditions, prices of inputs, and technical change are the common sources of supply instability. Government may contribute to variability through its responses to market fluctuations and regulations which affect supply and demand situations. Conversely, well conceived and implemented government policies may decrease variability associated with unregulated supply and demand. The relative importance of each source in the subsector varies across time, form, and space.

Instability in agriculture has been the subject of many studies. Following the pioneering work of Waugh (1944), Oi (1961) asserted that producers rather than consumers stand to benefit from price instability if the instability is the result of random fluctuations in selling prices. In a similar Marshallian framework, Massell (1969) demonstrated that instability benefits neither consumers nor producers when jointly considered. The crucial element, in the formulation of appropriate policies on stabilization, is availability of information on price elasticities of supply and demand.

In developing countries, the authenticity of the estimated elasticities is as questionable as Bateman's (1965) observation on the long run influence of prices in producers' decision making process. Chenery (1983) makes the point that the decision to use price or quantity as a policy instrument should be made by balancing the advantages and disadvantages of each variable. With effects risky, governmental policies may lead to long term or short term allocative inefficiencies in production and consumption. Turnovsky (1976) argued that stabilization could be harmful or beneficial to either consumers or producers depending on the source of instability.

Producers' income instability in Kenya's commercial agricultural sub-sector can be traced to economic conditions prevailing in both international and domestic environments. Brodsky (1983) demonstrated that the measurement of export instability is highly sensitive to the numeraire currency. This casts some doubt on the validity of the many studies on this subject, at least for weak "currency" countries. Attempts to insulate producer prices, in a small country like Kenya, from unstable world market situations are often futile.

Studies on the correlation between growth of exports and the gross national income have been inconclusive. As noted by Myint (1984) a positive or negative statistical association between growth of exports and gross national income may imply that export expansion is the cause of economic development, economic development is the cause of increased exports, or other factors cause changes in both. However, for Kenya, especially in the 1970's, international events have had ripple effects on the performance of its economy. Recognizing the presence of linkages between export earning and commercial agriculture, it may not be wise to make a second-best policy for export trade restrictions to reduce income instability (Corden, 1974).

Empirical findings elsewhere indicate that government stabilization programs can lead to net welfare gains (Gardner et al., 1984). The success of individual programs depend upon the nature of the policies implemented in response to the unstable environment. Agricultural production and trade policies may have long run and/or short term effects on producers' income. Usually, instability is the focus of short term policy responses. Thus, one prerequisite for sound Kenyan policy formulation is the measurement of instability, the identification of its sources, and the evaluation of alternative means of stabilizing income in the commercial subsector given the prevailing risky and uncertain environment. This needed empirical analysis has not been done.

Objectives

The general objective of this study is to determine the sources, magnitude, and policy implications of producers' income instability in the commercial agricultural sub-sector of Kenya. Specific objectives include:

1) to review appropriate statistics for measuring export earnings instability;
2) to quantify producer earnings instability from the export of selected commodities;
3) to examine producer income instability from selected domestically marketed commodities;
4) to evaluate the following domestic policy instruments under selected economic scenarios:
   i) no government intervention;
   ii) minimum price support policy;
   iii) guaranteed minimum income policy; and,
5) to develop policy recommendations which incorporate producer income stability as a goal.

Hypotheses

This study is organized around the working hypothesis that information on producer income instability in the commercial agriculture sub-sector will be useful to Kenyan policymakers in formulating domestic agricultural, agricultural trade, and general policy. Specific hypotheses to be tested include:

1) export instability may be appropriately measured in terms of Kenya's currency;

2) impacts on producer income instability are greater from commodities exported than from commodities marketed domestically;

3) certain domestic policy instruments could be effective in stabilizing the incomes of agricultural producers; and,

4) policies can be developed which increase the stability of producer incomes as measured by coefficients of variation.

Procedure

This study employs the coefficient of variation as a measure of instability. The measure has been used by many authors in empirical studies pertaining to instability. These include Labys and Thomas (1975), Labys and Perrin (1976), Newbery and Stiglitz (1981), Schmitz and Koester (1984), and Bigman (1985). This section gives a general overview of the procedure used in this study. Further details are given in the chapter on methodology.

Objectives one and two will be achieved by using a variant of the approach used by Brodsky (1983). The main export crops are valued using major international currencies and the national currency. A basket currency, represented by the Special Drawing Rights (SDR) is also used. SDR has been defined since 1970 but figures have been calculated for years prior to 1970. Export earnings instability is calculated for each numeraire currency using the general approach of Cuddy and Della Valle (1978). To determine the effects of using the different numeraire currencies, the correlation coefficients between the various indices, as derived above, are calculated. The coefficients will be tested to see if they statistically differ from one.

Objectives three, four, and five will be achieved by using the results of an econometric simulation model similar to that developed by Bigman (1985). The model has three components:

1. An econometric model consisting of supply and demand functions. Since the interest is on production and trade, consumers are aggregated into a single group. Log-linear demand and supply functions are used.
2. The stochastic process reflects variation in agricultural production in the subsector and in domestic and world prices.
3. A set of domestic policy instruments which can be used to describe government reaction to specified contingencies.

Domestic policy simulation is carried out within a partial equilibrium framework.

Organization of Study

The rest of the thesis is organized as follows: A review of literature is presented in Chapter II. In Chapter III, methodological and theoretical issues are discussed. Measures and sources of Kenyan income instability are presented in Chapter IV. The effects of government stabilization programs are presented in Chapter V. The summary and the conclusions of the study are presented in Chapter VI.

Policy implications and suggested directions for future research are also discussed in this final chapter.

CHAPTER II

REVIEW OF LITERATURE

Introduction

It is generally acknowledged that instability in agricultural commodity markets has significant repercussions on the welfare of a country. To this end, instability has attracted a large body of research. Economists have sought to identify and analyze its sources, effects, and means of control. This phenomenon has had neither a precise definition nor a unifying principle underlying its quantification (Gelb, 1979). The purpose of this chapter is not to present a comprehensive review of the theoretical and methodological research on the subject. Rather, the focus is on contributions relevant to the analysis of income instability in the agricultural sector of a developing economy. This chapter is thus divided into two main sections. The first section examines common methods of measuring instability of one or more variables. The literature on market models of instability is described in the second section.

Measuring Instability

The array of past measures of instability can be categorized according to their purpose. Two categories are readily identifiable. First, are those that attempt to capture the degrees of instability among single variables. Second, for functionally related variables, are those that endeavor to apportion variability among their components using statistical identities. In both cases, the degree of instability has been measured without any explicit assumption about the underlying structural relationships.

Single Variable Indices of Instability

According to Gelb (1979), at least 16 different indices of instability have been reported in development literature. Some of these indices are listed in Appendix D. The major concern is that using similar time series data, but employing different indices, often results in widely differing conclusions. This has serious policy implications. Glezakos (1970) presents a statistical verification of some indices that have been used in export instability studies. Some of these indicators are discussed by Knudsen and Parnes (1975) and a recent review of the measures is presented by Offutt and Blandford (1983). Disparity among the measures arises primarily from methods used to eliminate trend and to weight the deviations from the trend. Indices derived from variance and mean absolute deviations are discussed below.

One of the earliest indices of instability, a logarithm-variance type, was developed by Coppock (1962). The index, Ic, is defined as:

$$Ic = \text{antilog of } \left[\frac{1}{n-1} \sum_{t=1}^{n-1} \left[\log \left(\frac{X_{t+1}}{X_t} - M \right)^2 \right] \right]^{\frac{1}{2}} \qquad (2.1)$$

where

X_t = the logarithmic first difference of the variable

t = time

n = the number of observations

$$M = 1/n-1 \sum_{t=1}^{n-1} \log X_{t+1}/X_t$$

An example of its application is given in Appendix E.

Two advantages of the index are apparent. First, by taking the first difference, much of the linear trend is removed. Secondly, influences of peripheral observations are abated by taking logarithms of the data. The major drawback is that the formation of expectations depends on the first and the last points of the data set. As shown by Knudsen and Parnes (1975), the trend eliminating term is a function of the two points. From equation (2.1), M can be rewritten as:

$$M = 1/n-1 \ (\log X_2 - \log X_1 + \log X_3 - \log X_2 + \ldots + \log X_n - \log X_{n-1})$$

$$= 1/n-1 \ (\log X_n - \log X_1) \qquad (2.2)$$

Equation (2.2) demonstrates that the formation of the expectations revolves around X_1 and X_n, the first and the last observations, respectively. Thus, intermediate observations are excluded in the process. This raises conceptual problems. There is no reason to assume only X_1 and X_n as the basis for forming expectations. Furthermore, the exclusion makes the index sensitive to the period selected. However, it has been used in a number of studies related to export trade instability. Recent examples include Leith (1970), and Rangarajan and Sundarajan (1976).

Instability among single variables can be compared by coefficients of variation (CV), which express the standard deviation for each variable as a percent of the arithmetic mean of its observations. The index is frequently used and easily interpretable. For a set of observations, the index is defined as

$$I_{CV} = \frac{100}{\bar{X}} \left[\frac{\sum_{t=1}^{n} (X_t - \bar{X})^2}{n-1} \right]^{\frac{1}{2}} \tag{2.3}$$

where

X_t is the value of the variable in time t, t = 1 . . . n.

$\bar{X}$ is the arithmetic mean of X.

As defined in (2.3), the I_{CV} index is independent of the length of the series of the data. Unlike Coppock's index, all the data are considered in its development. However, most of the time series data in agriculture exhibit some form of trend. Hence, it is necessary to separate the long run trend component from the short run variations about the trend. Cuddy and Della Valle (1978) indicated that I_{CV} would overestimate the degree of instability if the trend is statistically significant. Nevertheless, the World Bank (1975), Labys and Thomas (1975), and Labys and Perrin (1976) have used the untrended CV (I_{CV}) index.

The importance of trend removal cannot be overemphasized. Massell (1970) stated that the type of trend fitted to time series data determines the index of instability obtained. He postulated that countries tend to plan in terms of growth rates rather than in terms of absolute increments. Consequently, using an exponential rather than a linear form is justified. Although he used the linear form, he observed that, empirically, the former function provided a better fit than the latter for the sample of countries considered. The fitting of a logarithmic function presumes an exponential relationship between the deterministic part of the dependent variable and time. Depending on the properties required of the estimate, the random component can be either independent of time or autocorrelated. Yotopoulus and Nugent (1976, p. 331) assumed the exponential relation in detrending their data.

By fitting a linear form to remove trend, the exact part of the dependent variable is proportional to time. In using this form, Hazell (1982) stated that it does not assume a deterministic component for any relationship between the variance of the dependent variable and time. Hazell (1984, 1985) used quadratic forms because of the above assertions and the ease with which unbiased and efficient estimates of the variances and covariances are obtained from the resulting variance-covariance matrix.

The basic procedure uses ordinary least squares to fit the desired functional form. The linear form:

$$X_t = a + bt + e \qquad (2.4)$$

where

X_t denotes the value of the variable in time t, t = 1, 2,...n.

e_t is the error term.

Using the linearly detrended data, Massell (1970) arrived at his index, I_{Me}, as follows:

$$I_{Me} = \frac{1}{\bar{X}} \left[\frac{\sum_{t=1}^{n} (X_t - \hat{X})^2}{n} \right]^{\frac{1}{2}} \tag{2.5}$$

where

I_{Me} denotes Massell's index.

$\hat{X}$ is the fitted value of X, estimated as per equation (2.4).

The variant of Massell's index used by Yotopoulus and Nugent (1976) is defined as

$$I_{My} = \frac{1}{\log\bar{X}} \left[\frac{\sum_{t=1}^{n} (\log X_t - \log\hat{X})^2}{n} \right]^{\frac{1}{2}} \tag{2.6}$$

where

I_{My} refers to the index used by the above authors.

$\hat{X}$ is the fitted value of X, estimated using the transformation where

$$\text{Log } (X_t) = a + bt + e \tag{2.7}$$

Cuddy and Della Valle (1978) noted the statistical bias in I_{Me} and I_{Ml}. In their derivation, the divisor, n, was used instead of the generally accepted n-2, the degrees of freedom in equations (2.4) and (2.7). Also there is a debate as to whether to use linear or exponential functions when detrending the data. To alleviate the problem, the authors developed a general approach. The starting point is R^2, the coefficient of multiple determination from a multiple regression model:

$$R^2 = 1 - \frac{\sum_{t=1}^{n} (X_t - \hat{X})^2}{\sum_{t=1}^{n} (X_t - \bar{X})^2} \tag{2.8}$$

The relationship in (2.8) can be expressed as

$$\Sigma(X_t - \hat{X})^2 = (1-R^2) \sum_{t=1}^{n} (X_t - \bar{X})^2$$

$$= (n-k)(1-R^2)\left(\frac{n-1}{n-k}\right)\left(\frac{\sum_{t=1}^{n} (X_t - \bar{X})^2}{n-1}\right) \tag{2.9}$$

where k is the number of independent variables. Note that the square of the standard error (SEE) of the regression and the standard deviation of X can be derived from (2.9). Using the definition of the coefficient of variation, and the relationship given in (2.9), an index, I_{Ga}, can be derived as

$$I_G = 100 \frac{SEE}{\bar{X}} = CV\ (1-R^2)\ \frac{n-1}{n-k} \tag{2.10a}$$

Recognizing that [·] above is equal to one minus the adjusted coefficient of multiple regression, $\bar{R}^2$, equation (2.10a) can be simplified as

$$I_G = CV[(1-\bar{R}^2)]^{\frac{1}{2}}\ ,\ \bar{R}^2 \geq 0 \tag{2.10b}$$

The above general approach has the following advantages:

(1) The index can be compared across several types of trend relations

(2) The index is bounded by the lower and upper limits of the CV of the data. Thus, given that $\bar{R}^2 = 1$, then $I_G = 0$ implying the observations show no deviation from the estimated regression line. If $\bar{R}^2 = 0$, then $I_G = CV$ suggesting that no additional information to that in CV accrues from the regression model.

The main disadvantage is that $\bar{R}^2$ assumes only positive real numbers for I_G to be useful.

The Cuddy-Della Valle approach was also used by Schmitz and Koester (1984) in a study on the sugar market policy of the European Economic Community (EC).

The mean absolute percentage deviation (MAPD) is an alternative index of instability to those derived directly from the variance. Defined as

$$\text{MAPD} = I_{AD} = 100/n \sum_{t=1}^{n} \left| \frac{X_t - \bar{X}}{\bar{X}} \right| \qquad (2.11)$$

Newbery and Stiglitz (1981) showed that it can be converted to CV if certain assumptions about the distribution of X are made. For a normally distributed series about $\bar{X}$, with CV as σ,

$$\sigma = I_{AD} \left| \frac{\pi}{2} \right| \qquad (2.12)$$

$$\doteq 1.25 I_{AD}$$

A log-normally distributed series would enhance the approximation to the index.

On export trade, Brodsky (1983) showed that the indices are highly sensitive to the units in which the exports are measured. Thus, the use of a strong currency such as the U.S. dollar as the numeraire currency when developing export earnings instability for a developing economy may yield invalid conclusions. He suggested that an export weighted measure or a proxy, calculated as a basket currency may be a relevant numeraire currency.

Gelb (1979) asserted that instability should be treated as a variation measure on a filtered stochastic process. Using spectral analysis procedures, time series data could be decomposed into Fourier components. The sum or the integral of the variances of the components yields the variance of the series. Gelb classified the components into frequency groups with very high frequency components being associated with a duration of one year. A duration of over 5 years was associated with low frequency components. He concluded that:

1. The common indices of instability do not explicitly indicate which components are being considered.
2. Using short time series data (10 to 15 years) worsens the situation.
3. At least on costs of buffering the export earnings instability, research and policy emphasis should be toward the lower frequency components.

Based on Gelb's findings, Newbery and Stiglitz (1981) pointed out that very short duration components could be easily taken care of by the agricultural producers. Also, very long period components could be accommodated gradually. Therefore, the main concern is on the medium period fluctuations. The common indicators of instability described above measure the components imprecisely because short time series data are commonly used. The authors' study suggests that, for a nonstochastic case, an adequate measure for price instability can be obtained if:

1. The time series data cover a period of twenty-five years.
2. An exponential form is used to remove the trend.
3. The deviations about a centered five-year moving average are then used.
4. The prices are real.

So far, certainty with respect to the values of the variable has been assumed. This is not always true. Newbery and Stiglitz (1981) argued that forecast errors are better measures of instability that could be alleviated through intervention by the policy makers. These could be defined as the standard deviation of the residuals found by regressing the current values of the variables on those lagged one period.

Identity Functions

Some random variables are identity functions of other random variables. There are additive and multiplicative identities. Additive identities are used to partition the total variance of an aggregate into that attributable to its components. Multiplicative identities are used to apportion variances of products into those attributable to their elements.

The decomposition procedure is as follows: Let $X_1, \ldots, X_n$ be a random vector having multivariate distribution with variances $\sigma_1^2, \ldots, \sigma_n^2$. For aggregate identities, the aggregate value, $S_n = \sum_{i=1}^{n} X_i$ and the variance of S_n is given by

$$Var(S_n) = \sum_{k=1}^{n} \sigma_k^2 + 2 \sum_{j,k} Cov\ (X_j,\ X_k) \tag{2.13}$$

The last term extending over each of the (n/2) pairs of (X_j, X_k) with $j < k$. Dividing both sides by $var(S_n)$ yields

$$1 = \frac{\sum_{k=1}^{n} \sigma_k^2}{var(S_n)} + \frac{2 \sum_{j,k}^{n} Cov(X_j,\ X_k)}{var(S_n)} \tag{2.14}$$

The first term on the right hand side may be considered as the variability that is associated with the individual components. The second set of terms indicates the contribution of the interaction between X_j and X_k. Thus equation (2.14) can be used to identify sources of instability. This assumes that variance is an appropriate measure of instability.

Rourke (1970) applied the above formulation in a study of world coffee variability. He demonstrated that Brazil contributed 86.13 percent of the total variability. The interaction between Brazil and other countries contributed only 13.87 percent. Rourke extended the study to the contribution of individual states in Brazil. His conclusions were that in terms of world instability, the focus should be on Brazil. Within Brazil, the attention should be on Parana and São Paulo. Nevertheless, the procedure does not provide an explanation as to the causes of instability. Offutt and Blandford (1983) suggested that more information could be obtained by decomposing the mutliplicative relationship between area and yield.

Decomposition of multiplicative identities has drawn substantial interest in agricultural production because of policy implications. Early studies include the works of Foote, Klein and Clough (1952) and Meinken (1955). They calculated annual changes in yield and acreage as a percentage of the sum of average annual changes as a percentage of acreage. Sackrin (1957) criticized the approach because it does not strictly equate the changes in production with changes in acreage and yield. He proposed taking the natural logarithm of the identity and thus obtaining an additive relation in terms of logarithms. Production is then regressed on acreage and yield independently. The sum of the coefficients is equal to unity, implying that total change in output is explained.

The primary criticism offered by Burt and Finley (1968) is that Sackrin's model does not account for the interaction of the two variables. In consequence, Burt and Finley developed an alternative procedure similar to Goodman's (1960). The approach rests on a Taylor series expansion. Thus, given the function $y = x_1 x_2$, the Taylor's series expansion is

$$y = \bar{x}_1\bar{x}_2 + (x_1-\bar{x}_1)\bar{x}_2 + (x_2-\bar{x}_2)\bar{x}_1 + (x_1-\bar{x}_1)(x_2-\bar{x}_2) \qquad (2.15)$$

where x_1 and x_2 are jointly distributed random variables with $\bar{x}_1$ and $\bar{x}_2$, their arithmetic means. The mean of y can be obtained by taking the first moment of y such that

$$E[y] = \bar{x}_1\bar{x}_2 + Cov(x_1, x_2) \quad (2.16)$$

The variance of y is defined as

$$\begin{aligned} Var(y) &= E[y-E(y)]^2 \\ &= E[(x_1-\bar{x}_1)\bar{x}_2+(x_2-\bar{x}_2)\bar{x}_1+(x_1-\bar{x})(x_2-\bar{x}_2) - \\ &\quad Cov(x_1,x_2)]^2 \\ &= \bar{X}_2Var(x_1)+\bar{X}_1Var(x_2)+2\bar{x}_1\bar{x}_2Cov(x_1,x_2) + \\ &\quad E[(x_1-\bar{x}_1)(x_2-\bar{x}_2) - Cov(x_1,x_2)]^2 + \\ &\quad 2\bar{x}_1E(x_1-\bar{x}_1)(x_2-\bar{x}_2)^2 + 2\bar{x}_2E(x_1-\bar{x}_1)(x_2-\bar{x}_2) \end{aligned} \quad (2.17)$$

Given two products of jointly distributed random variables, the exact expression for their covariance is given by Bornstedt and Goldberger (1969).

In equation (2.17), the first two terms are the direct contribution of x_1 and x_2 to total variance. The third term is the first order interaction effect. The last two terms involve higher order cross moments than the covariance terms. Burt and Finley (1968) and Hazell (1982) stated that in most cases, the last two terms are relatively unimportant and their sum can be treated as residual. Assuming the fourth term neutral, then the first three terms could be used to make asymptotic approximations of the total variance.

Offutt and Blandford (1983) applied the Burt and Finley method to actual farmers revenue data for ten U.S. field crops. In the study, revenue is the product of price and output and the two variables are not independent. The result of the decomposition indicated that price was the most important source of revenue instability for eight of ten commodities. Also the results suggested that higher order terms were often too large to be ignored. However, the higher order terms are not easily interpretable in an economic sense.

Burt and Finley (1970) noted an improvement in the approximation when linear trended data were used. Offutt and Blandford observed that the improvement is outweighed by the loss of identity of the original data upon which the Taylor's series expansion is based. The basic flaw of the Burt and Finley procedure is its inability to provide information on structural relationships.

Hazell (1982) developed a procedure for identifying sources of change in instability between two periods through the decomposition of multiplicative identities. The technique assumes that changes in variances is a measure of changes in instability of the variables being studied. From equation (2.17), the following relationship can be used to express total variance:

$$Var(y)=\bar{x}_2 Var(x_1)+\bar{x}_1^2 Var(x_2)+2\bar{x}_1\bar{x}_2 Cov(x_1x_2)-Cov(x_1x_2)^2+R \quad (2.18)$$

where R is the residual term. Equation (2.18) shows that means of the variables are involved. Therefore, their changes affect the change in total variance. Similarly, the expectation of y given in equation (2.16) is influenced by changes in covariance between x_1 and x_2. Starting with equation (2.16) and taking period 1 as the base, Hazell derived the changes as follows:

$$E\left[y_1\right] = \bar{x}_{11}\bar{x}_{21} + Cov(x_{11},x_{21}) \quad (2.19)$$

In a similar way, the relationship for period 2 can be written as:

$$E\left[y_2\right] = \bar{x}_{12}\bar{x}_{22} + Cov(x_{11},x_{22}) \quad (2.20)$$

This can be rewritten as:

$$E\left[y_2\right] = (\bar{x}_{11}+\Delta x_1)(\bar{x}_2+\Delta x_2)+Cov(x_{11},x_{21})+\Delta Cov(x_1,x_2) \qquad (2.21)$$

where Δ denotes change in the respective variable, that is, the value in period 2 less that in period 1. Changes in the mean of y over the two periods is given by:

$$\begin{aligned} \Delta E[y] &= E(y_2) - E(y_1) \\ &= x_1\Delta x_2+x_2\Delta x_1+\Delta x_1\Delta x_2+\Delta Cov(x_1,x_2) \qquad (2.22) \end{aligned}$$

The first two terms in equation (2.22) are the direct effects. The third and the last terms refer to interaction and changes in variability of x_1 and x_2, respectively. Following a similar procedure, the variance of y, Var(y), can be obtained.

Hazell (1982), using the above methodology, analyzed instability in Indian food production. He examined the following propositions:

1. The development of less risky technologies is a direct way of alleviating production instability in India; and
2. Instability can be reduced through stabilization of year-to-year adjustments in crop cereals sown.

The results indicated large increases in yield and area-yield correlations between crops. Consequently, the first proposition would be a useful target for farm or microlevel stabilization policies. The presence of high intercrop and interstate correlation would reduce the effectiveness of the second proposition when the whole of India is considered. These observations suggest that instability could be reduced by taking advantage of the covariance to allocate production in a more risk-efficient way.

In a comparative study between the instability in Indian and United States' cereal production, Hazell (1984) attributed the increase in yield covariances in India to increased adoption of improved production technologies. Other sources of variability include increases in price variability, unpredictable rainfall patterns and unstable supplies of inputs. For the U.S., the increase in total cereal production was dominated by increases in means and variances of yields. The increases in interstate yield correlation were restricted to corn. This could be attributed to the narrowing of the crop's genetic base.

Hazell (1985) applied the same procedure in an attempt to identify sources of instability in world cereal production. The most important sources of total production instability were increases in yield variances, interregional yield correlations for the same crop and different crops, and a decline in yield-area correlation. As in the earlier two studies, the author suggested a more detailed study to identify fully the sources of these changes. Again, Hazell's model does not present any information on underlying cereal production.

Piggott (1978) outlined an alternative method of decomposition. It involves apportioning total variance of gross revenue into components that are attributable to demand and supply variability and the variability of the interaction between demand and supply. The model assumes linearity in the demand and supply functions. Constant slopes over time and additive disturbances as shifters are also assumed. Demand and supply functions are estimated and equilibrium values are determined from which gross revenue, expressed as product of equilibrium price and quantity, is derived. The analysis yields similar results as the Burt and Finley approach for price elastic demand and perfectly price inelastic supply.

Piggott's procedure cannot be used to identify composition of the shifters. Moreover, the assumptions are too restrictive to be usefully applied to agricultural production and marketing studies.

Murray (1978) applied the decomposition of identities procedure to identify the source of export earnings instability for several countries. Assuming that the variables were normally distributed in logarithms, the variation in export earnings (E) were decomposed into price and quantity components from the identity:

$$\mathrm{Var}(\log E) = \mathrm{Var}(\log P)+\mathrm{Var}(\log Q)+2\mathrm{Cov}(\log P,\log Q) \quad (2.23)$$

The sign of the covariance term, positive or negative, indicates whether the variations in supply or demand, respectively, have been the main source of instability. The results indicated that supply was the primary source of instability. Furthermore, earnings instability was relatively unimportant where price volatility was the dominant factor. Similar analysis based on individual commodities supported the above results (Riedel, 1983).

Corden (1974) stated that in a situation where supply instability is general to the economy, not limited strictly to export commodities, and the authorities have no foresight, second-best policies designed to stabilize the economy, such as an export tax, may not be appropriate. The models reviewed thus far are analytically silent on this issue.

Market Models of Instability

Market models of instability have appeared in two basic categories: Partial or Marshallian framework and the general equilibrium approach. Most of the studies on commodity price stabilization fall into the former category. The complexity of modeling instability in a general equilibrium framework is reflected by the few studies that started with the work of Brainard and Cooper (1968). Recently, Jabara and Thompson (1980) specified and empirically tested a general equilibrium model of agricultural trade for Senegal. The present study centers on the commercial subsector of the Kenyan economy. Thus, this review of literature concentrates on partial rather than general equilibrium.

The Waugh-Oi-Massell Framework

The early theoretical framework for analyzing price stabilization within a partial-equilibrium framework was advanced by Waugh (1944), Oi (1961), and Massell (1969, 1970). Waugh used the concept of consumer surplus to examine the effects of price instability on consumers of agricultural products. Assuming that consumers purchased more at low prices and less at high prices, Waugh concluded that, for a given unstable demand and supply situation, consumers would benefit from instability. Oi arrived at similar conclusions for producers using the producer surplus concept. The model presumes that producers respond instantaneously to price changes. Schmitz (1984) stated that similar results could be obtained by assuming that the expected prices and quantities are realized.

Both Waugh and Oi models consider consumers and producers of agricultural products separately. Massell (1969) demonstrated that instability is not beneficial to either group if they are jointly considered and the supply and demand curves are not perfectly inelastic. Linear supply and demand curves and additive disturbances are assumed. A complete costless price stabilization scheme is optimal to society as a whole. However, this is not usually achievable. Consequently, the effects of partial price stabilization strategies have been studied. In this context, Massell (1970) and Just, Schmitz and Turnovsky (1979) utilized buffer stock as a policy action and assumed a linear adjustment rule in their studies. The presence of asymmetric market conditions understates the validity of the rule.

Extensions of the Waugh-Oi-Massell Approach

In a graphical exposition, Schmitz (1984) explained the effects of a nonlinear demand curve with supply as the source of instability. The results indicate that for a sufficiently nonlinear demand curve, consumers would gain from stability while producers would lose from it. These contradict the findings of Massell (1969). Also, converse effects are obtained for the case of a sufficiently nonlinear supply curve when the demand is the source of instability. Nevertheless, the net effect is positive when both groups are considered jointly. The policy implications of a non-linear demand curve are expressed in Hillman, Johnson and Gray (1975) and supported by the findings of Just et al. (1978). In this context, a steeply sloping demand curve at higher prices while shallowly sloping at lower prices, would lead to a change in storage policies from those favoring producers to those which are beneficial to consumers.

Turnovsky (1976) extended Massell's approach to include nonlinear demand and supply and multiplicative disturbances. The results indicated that, unlike the additive case, the need to stabilize prices depend upon the deterministic component of supply and demand curves rather than the source of instability.

Hueth and Schmitz (1972) extended the basic Waugh-Oi-Massell framework to international trade where external markets are unstable and internal supply reacts instantaneously to price changes. The study did not consider the effects of price uncertainty or the cyclical behavior of prices. Their findings suggested that consumers and producers prefer instability when its source is external to the country. However, countries taken together prefer price stability. Just et al. (1978) found that, for nonlinear demand and supply functions, importing countries were likely to gain more from price stabilization than exporting countries.

The free trade assumption of the Hueth-Schmitz model was relaxed by Bieri and Schmitz (1973) through the institution of trade restrictions. Specifically, the study looked at tariffs and the use of marketing boards that introduce less than perfectly competitive marketing conditions. The intriguing results were:

1. If trade is restricted by tariffs, and the source of price instability is abroad, the importing country benefits from price stability.
2. If trade is restricted by marketing boards and the source of instability remains external, the importing country loses

from price stabilization.

Implicitly, the latter proposition provides an approach to alleviating producer risks in an exporting country through the use of marketing boards.

Just et al. (1978) modified the Hueth-Schmitz model to include distorted trade situations with nonlinearity and alternative forms of stochastic disturbances. Policies leading to this form of imperfect trading conditions, commonly practiced in western Europe, imply that domestic commodity prices are insulated and instability is transferred to the trading partners. Thus, consumers in importing countries lose from instability while producers in exporting countries gain. Various government intervention policies on price instability were studied by Bale and Lutz (1979). Their main conclusion was that governments are primarily interested in domestic rather than global stability.

The welfare effects of storage under a production cartel have been analyzed by Young and Schmitz (1984). With reference to the U.S. milk industry, the imperfect market situation is generated by presence of large producer cooperatives and marketing orders. In this case, price stabilization through the use of buffer stock is curtailed. Results suggest that the government should allow storage and institute pan-territorial pricing, that is, a uniform price country-wide. But, the sensitivity of the conclusions to the assumptions about the demand function necessitates empirical analysis as a basis for determining the relevant assumptions.

Konandreas and Schmitz (1978) applied the Hueth-Schmitz model to study the welfare implications of grain price stabilization in the U.S. The findings indicated that price stability of the feed grain sector benefits both consumers and producers in the aggregate. However, for the wheat sector, the results were not conclusive although they tended to suggest that price instability in the wheat sector is desirable.

Zwart and Meilke (1979) compared effects of changing domestic policies and buffer stocks on price stability of the world wheat industry. They concluded domestic pricing policies have more effects on instability than policies based on buffer stocks. On a similar issue, Sarris and Freebairn (1984) demonstrated the aggregate impact of domestic intervention on rice trade. On average, they lead to artificial increases in world price and an increase in instability, a conclusion arrived at by Bigman (1979). Furthermore, major rice producing countries have the most leverage on world rice prices. Small producers, although large in terms of rice exports, have a lesser influence on price.

Subotnik and Houck (1976) analyzed welfare implications of stabilized consumption and production. They demonstrated stabilized consumption is the least beneficial in terms of welfare.

The basic assumption of the Waugh-Oi-Massell framework is that producers and consumers are risk-neutral. The model captures transfer gains but not risk-response. Just (1975) found that with the exception of strongly regulated crops, risk is an important factor in explaining producer supply response. Just and Hallam (1978), on the same issue, concluded that a price stabilization policy should depend on the identification of important risk preferences. Recently, Quiggin (1983) studied the effects of different sources of risk in wool prices on the risk borne by users. He concluded that the long-run effects of price stabilization is to decrease risk faced by wool producers and increase that faced by users if the major sources of risk are fluctuations in final demand or exchange rates.

Studies on exchange rate volatility have been inconclusive. Akhtar and Hilton (1984), in a study of international trade in manufactured goods for West Germany and the U.S., concluded that uncertainty in the nominal exchange rate had a statistically significant impact on trade. Gotur (1985) extended this model to include more countries. He demonstrated that Akhtar and Hilton's results were not universal. Schuh (1974) argued that an overvalued exchange rate can influence the need for government intervention policies. McCalla and Josling (1985) succinctly show the importance of the exchange rate in international trade and development.

Van Kooten and Schmitz (1985) incorporated producer price uncertainty into the basic Waugh-Oi-Massell framework. As stated earlier, this approach considers only price instability. The following results were found:

1. The Waugh-Massell case always overestimates the true gain to society from price stabilization.
2. The Oi-Massell case suggests that price stabilization is Pareto-optimal.

Regarding food-grain consumption in developing countries, Reutlinger (1982) concluded that unstable domestic consumption is attributable to internal and not external price or supply instability. Bigman and Reutlinger (1979) and Bigman (1982) studied the impact of trade policy on food insecurity. They showed that more trade liberalization alleviates food insecurity than does protectionism.

Valdés (1982) supported Reutlinger's (1977) argument that the instability problem for less developed countries (LDC's) stems from fluctuations in real income within the LDC. Valdés argued that the availability of foreign exchange to import food when required is important for the stability of food consumption. Concerning food aid, Reutlinger (1976) observed that within limits, additional economic benefits from storage without food aid are sufficient to change a net loss to a net gain for society. In this case, storage reduces the cost of food aid.

The Newbery-Stiglitz Approach

Newbery and Stiglitz (1981) provided a systematic procedure for assessing the desirability of price stabilization through the use of buffer stocks. They asserted that the relevance of policy analysis depends on the identification of the variables to be measured. On specific price stabilization proposals based on the Waugh-Oi-Massell approach, their contention is that such policies have less benefits in situations where risk plays an important role as in the case of most developing economies. Specifically, their study centers on the following aspects:

1. effects of risk and uncertainty on consumption and productions; and
2. the structure of policies that are implemented by decision-makers in response to the unstable environment.

Newbery and Stiglitz showed that under certain situations, price stabilization leads to income instability and if a price stabilization policy is to be effective, it has to reduce producers' risk. Among other issues, the authors argued that producers are basically concerned with the costs associated with commodity instability. These costs "are better measured by income variability, which will also depend on supply variability. Moreover, the impact of stabilization schemes depends quite sensitively on the location of the source of the instability, which may vary from place to place" (p. 289). Consequently, the problem of what to stabilize is empirical and location specific.

Bigman (1985) developed a simulation model for analyzing food prices under instability. Noting the effects of producer income instability in rural areas, and without referring to any country, Bigman analyzed the impacts of alternative producer price support and stabilization programs. For a closed economy scenario with risk neutral producers, minimum price supports, government procurement programs, guaranteed income and buffer stock policies effectively eliminate producer income risk. Under similar production assumptions, but in an open economy, the policies are also effective at reducing income risk. With risk-averse producers in a closed economy, the policies contributed to greater output and decreased mean prices. However, in this case, producers' income depended on the price elasticity of demand for the commodity.

For internationally traded commodities, Bigman reconsidered the issue, first raised and analyzed by Newbery and Stiglitz, that with risk-averse producers and incomplete risk markets, free trade may be Pareto-inferior to no trade. His simulation analysis showed the above conclusion applies to price elasticity of demand values that are above 0.6. At lower values, autarky is Pareto-inferior (to farmers) to free trade. Nevertheless, if substitution is possible, the production stability of the substitute and its price elasticity of demand would be important determinants of optimality. Like Newbery and Stiglitz, Bigman (1985) concluded that the issue is essentially empirical.

Producers' Expectations

The above literature assumes producers have perfect foresight on prices and quantities. But, agriculture abounds with cases where there is no such ex ante information. Concerning formation of price expectations, Turnovsky (1974) considered two formulations: adaptive and rational.

In the adaptive expectation mechanism, producers supply decisions are based on anticipated prices as follows:

$$S(P_t^*) = \alpha_0 + \alpha_1 P_t^* + v_t \qquad (2.24)$$

where P_t^* is the anticipated price at time t, v denotes error term. The hypothesis about the formation of expectations is defined as

$$P_t^* - P_{t-1}^* = \gamma(P_{t-1} - P_{t-1}^*), \quad 0 \leq \gamma \leq 1 \qquad (2.25)$$

where γ denotes the coefficient of expectation. Equation (2.25) postulates that expectations are revised each period by a fraction of the forecast error of the previous period.

Turnovsky's study demonstrated that conclusions arrived at by Oi on the effects of price stabilization do not hold universally. The conclusions depend on the relative slopes of the demand and supply curves, the length of the lag in the formation of expectations, and the autoregressive properties of the error term. The Waugh results, based on consumer surplus, still held. Nevertheless, price stabilization leads to an overall welfare gain despite the loss by one group.

In the rational expectation hypothesis, price formulation can be defined as

$$P_t^* = E_{t-1}(P_t) \tag{2.26}$$

where E_{t-1} defines conditional expectations at the time t-1. Accordingly, producers are rational if their predicted prices for period t are equal to that predicted conditional on all information at the time of forecasting. This approach eliminates the ad hoc nature of the extrapolation existing in the adaptive expectation hypothesis (Bigman, 1985). Rational expectations, in the sense of Muth (1961) assume that producers behave as utility- and profit-maximizing agents, operating in a perfectly competitive world.

Based on rational price expectations, Turnovsky (1974) demonstrated that:

1. There was an overall positive gain in welfare.
2. If the source of instability is random shifts in the supply curve, consumers lose from price stabilization policies.
3. If the source of instability is the random shifts in demand, producers lose from price stabilization. This is true whenever the random disturbances are not autocorrelated.

Thus, whether the Oi framework is applicable to this group of decision-makers or not depends on the way expectations are formulated.

Hazell and Scandizzo (1975, 1977) argue and demonstrate that in risky production environments, where output variations are multiplicative and output decisions are based on price expectations, competitive markets are socially inefficient. If decisions are based on expected unit revenues rather than price, the inefficiency is eliminated. Revenue expectations account for the joint distribution of price and output. The authors found that if production is undertaken in risky conditions, revenue expectations lead to less output than price expectations. Consequently, optimal policy formulations should be based on empirical studies based on the nature of production risks and the formulations of expectations by producers.

In line with the arguments put forward by Hazell and Scandizzo, Bigman (1985) asserted that a producer equates his marginal cost, which is deterministic, to the expected price less the risk premium. The risk premium is assumed to be proportional to the variability of the unit revenues and price formations follow the adaptive expectation hypothesis.

Chapter Summary

A review of major contributions in instability studies has been presented. The first section described the methodologies that have been put forward in an attempt to measure the degree of instability in time series data. In the second part, specific market models of instability and their extensions were surveyed.

It was shown that the problem of measuring instability is yet to be resolved despite the large number of indices that have been developed. The basic problem concerns what instability reflects. Gelb (1979) states that it should be treated as a measure on a filtered stochastic process. Newbery and Stiglitz assert that common indicators could be relevant if they could measure medium period fluctuations.

Where random variables are identity functions of other variables, statistical decomposition provides a means for identifying sources and the degree of instability of their components. The identities may be additive or multiplicative. The decomposition of multiplicative identities has drawn a lot of interest because of policy implications. Goodman (1960) developed the procedure for decomposing identities. This was popularized among agricultural economists by Burt and Finley (1968). Decomposition of identities is undertaken without any explicit assumption of the underlying structural relationships. Piggott (1978) outlined an alternative method that considers the structural relationship but it involves restrictive assumptions that limit its application in agricultural studies.

Waugh (1944), Oi (1961), and Massell (1969, 1970) advanced the basic risk-neutral theoretical framework for sectoral analysis of the effects of instability. The concept of consumer and producer surplus is the basis for the analysis. With producer price uncertainty coupled with instability, the Waugh-Oi-Massell production mode does not hold. In an alternative framework, Newbery and Stiglitz (1981) argue that producers are basically concerned with costs associated with commodity instability. Thus, stabilization measures are location specific and therefore what to stabilize is an empirical problem. This proposition is supported by Bigman (1985).

Studies on expectations, in the context of instability, have revolved around adaptive and rational price expectations. However, under risky production conditions, socially efficient markets are obtained when the expectations are based on unit revenues rather than price. Hence, information on producer's production conditions and his formation of expectations are essential for optimal policy formulation (Hazell and Scandizzo, 1975, 1977).

The stock of literature on instability emphasizes empirical findings as bases for appropriate policies on stabilization. There is an empirically determined information gap on income instability where:

1. agricultural producers are risk-averse;
2. government intervention is prevalent;
3. producers face both open and closed economic situations depending on the commodity they produce; and
4. commodities are functionally related in terms of their resource requirements so that income instability affects all commodities in one way or another.

These are common phenomena in Kenya and most countries.

CHAPTER III

METHODOLOGY

Introduction

In this chapter, an analytical framework for studying income instability in Kenya's agricultural sector is presented. In developing the framework, key components relevant to the analysis of income instability are identified. Theoretical issues pertaining to these components are discussed. The problems associated with empirical analysis are then addressed.

The first section of this chapter provides a theoretical basis for the analysis of demand, supply and government intervention in markets for agricultural commodities. Empirical models are specified in the second section. A model for determining an appropriate measure of earnings instability of agricultural exports is presented. The chapter closes with specification of an econometric simulation model. The components of Bigman's (1985) simulation model are outlined and given limited theoretical treatment. Relevant variables to be included in the present study are specified. This simulation model will be used to evaluate the impacts of predetermined policy instruments on producers' income instability.

Analytical Framework

This section describes three components of agricultural production and trade that have a strong impact on income of agricultural producers. Supply, demand and government intervention components are not mutually exclusive. However, they are described independently for ease of exposition. The focus is on how the components work to create instability from farmers' perspectives.

The Supply System

The supply system considered in this study is composed of agricultural commodities that are produced for either the domestic or export market. Crop production for the domestic market is mainly a seasonal activity. Export crops are perennial and usually involve long term investment in land. However, even perennial crops have high short run supply elasticities as producers have considerable flexibility to change variable inputs and thus the related output.

Kenyan agricultural producers are faced with risky production and, to a lesser extent, prices. It follows, therefore, that incomes derived from agricultural commodities are also risky. The weather, in particular rainfall, is a major determinant of output in Kenya. Prices of most domestically marketed agricultural commodities, especially food crops and milk, are set by the government at the beginning of the season. Nevertheless, the presence of non-price factors such as delays in payments and collection costs represent uncertain effects on the announced prices. This creates deviation between announced and realized prices. Most export crops face a free market situation. Specifically, producer prices for coffee and tea reflect world prices.

Producers may be less concerned with price stabilization than income stability. Price stabilization does not necessarily lead to income stability because of yield variation. Fixed prices prevent producers from compensating for poor harvests by higher prices. Confronted with uncertain production and subsequent income instability, risk-averse farmers commit resources based on expectations about future income streams.

Supply analysis centers on how Kenyan farmers formulate income expectations given stochastic yields and prices when government preannounced prices are subject to random shocks. It is commonly believed that previous experience plays important roles in the formation of expectations. In general, producers wish to earn more income if the increased income can be obtained with a tolerable level of risk. The level of tolerance varies with the individual producer. In their quest for higher incomes, producers attempt to avoid the possibility of occasional high losses (Perrin, et al., 1976). In other words, producers exhibit the usual rational behavior that more is preferred to less but with the restriction that income instability is minimized. Occasional losses accrue from fluctuations in yields and prices.

Scandizzo et al. (1984) suggested that farmers facing risky production conditions may be making decisions based on expected revenues rather than expected prices. This approach adds realism from explicit recognition of the joint probability distribution between output and prices. Where producers have prior information about price, P_t, of a commodity, the major source of income instability becomes its yield.

To demonstrate the effects of the above assumptions, consider a single product market in which demand is deterministically related to the product price as

$$D_t = f\ (P_t) \qquad (3.1)$$

where D_t and P_t denote demand and price, respectively, during period t. Producers are confronted with a production function with multiplicative disturbance terms of the form

$$Q_t = h\ (Q_t^*, \varepsilon_t) \qquad (3.2)$$

where Q_t denotes the quantity produced. Q_t^* is the producers' planned marketed surplus, that is, total output less self-consumption, and ε_t is the realized stochastic yield. Given previous knowledge about the distribution of yield under normal circumstances, the anticipated yield may be specified as $\varepsilon_t^* = E\ [\varepsilon]$. If the random variable P_t^* represents expected returns, which is consistent with utility maximizing criteria of producers, then the planned marketed surplus Q_t^* becomes a nonstochastic function of P_t^*.

Domestic supply of commercial foodcrops and livestock products depends on the marketed surplus. In Kenya, the surplus may be viewed in two ways. It could be considered as product in excess of the producers' domestic needs which is sold to the relevant marketing agency. Alternatively, it could be viewed as excess resources set aside by the producer for the production of the marketed commodity, after meeting requirements for domestic needs. The former definition is commonly employed in literature. In any case, Q_t^*, the planned supply to the market is a function of the anticipated price, P_t^*, other things equal.

Sandmo's (1971) work on the theory of the firm under risk suggests that farmers equate their certain marginal costs to expected marginal revenue. Following Scandizzo et al., the aggregate supply function can be defined as:

$$S_t = \varepsilon_t A_t$$

$$= \varepsilon_t g(P_t^*) \qquad (3.3)$$

where S_t is the actual quantity supplied at P_t^*, A_t is the area allocated to the production of the commodity while the deterministic component of the supply is given by $A_t = g(P_t^*)$. As indicated in Chapter I, the availability of arable land under existing technology is a major constraint to spatial expansion of production in Kenya. Hence, one could assume that planned output is directly related to anticipated price, P_t^*. Assume normally distributed random variables so that $E(\varepsilon_t) = \mu$, $Var(\varepsilon_t) = \sigma^2$, $Cov(\varepsilon_t, \varepsilon_{t-1}) = 0$, and $Cov(P_t^*, \varepsilon_t) = 0$. S_t can be evaluated at its means to yield the anticipated supply

$$S_t^* = \mu g(P_t^*) \qquad (3.4)$$

Assuming producers equate marginal costs to expected marginal revenue in formulating supply, then differentiating total revenue, given as $P_t S_t$, with respect to anticipated output yields

$$\delta (P_t S_t)/\delta S_t^* = P_t \delta S_t / \delta S_t^* \qquad (3.5)$$

Using equations (3.3) and (3.5), it can be shown that

$$\delta(P_tS_t)/\delta S_t^* = P_t\delta[\varepsilon_t g(P_t^*)/\delta[g(P_t^*)] \quad (3.6)$$

Since P_t does not vary directly with S_t^*, that is,

$$\delta P_t/\delta S_t^* = \delta P_t/\delta Q_t^* = 0 \quad (3.7)$$

then expected marginal revenue is

$$E[\delta(P_tS_t)/\delta S_t^*] = E[P_t]E[\delta S_t/\delta S_t^*] + Cov[P_t, \delta S_t/\delta S_t^*]$$

Equation (3.8) can be simplified further by noting that

$$\delta[\varepsilon_t g(P_t^*)]/\delta[\mu g(P_t^*)] = (\varepsilon_t/\mu)[\delta g(P^*)]/[\delta g(P^*)]$$

$$= \varepsilon_t/\mu \quad (3.9)$$

The simplified form is thus

$$E[\delta P_tS_t/\delta S_t^*] = E[P_t] + Cov[P_t, \varepsilon_t/\mu]$$

$$= E[P_t\varepsilon_t]/\mu \quad (3.10)$$

Earlier, ε_t was defined as realized stochastic yield and P_t as actual price. Therefore, the expectation of unit revenue, R_t, standardized by mean yield μ is represented by $E[P_t\varepsilon_t]/\mu$. Since $E[\varepsilon_t/\mu]=1$, then it is obvious that

$$P_t^* = E[R_t] \quad (3.11)$$

and thus producers formulate their expectations based on unit revenue, that is, price times yield divided by mean yield. With an assumed downward sloping demand curve, yield and realized price are inversely related. Therefore, the covariance term in equation (3.10) is negative, implying that $P_t^* < E[P_t]$. Hence, anticipated prices are less than the expected price.

The above analysis suggests that revenue measured as the product of output and price, plays an important role in the assumed market situation. Using equation (3.11), Bigman (1985) showed that the higher the variability of output, the higher the price, P_t^*, and the smaller the area set aside for production.

The findings of Sandmo (1971) and Ishii (1977) indicate that a risk-averse decision maker determines his or her optimal output by equating the marginal costs to a price lower than the mean price. The difference in price represents the risk premium. Risk premium can be represented by the coefficient of variation of producers income (Bigman, 1985). Risk premium at time t is derived as follows:

$$RP_t = (1 + \sigma_y / y) \qquad (3.12)$$

where σ is the standard error of y. The variance, σ^2, of y is given by

$$\sigma_y^2 = \frac{1}{n} \sum_{i=1}^{n} (y_t - \bar{y}_t)^2$$

$$y_t = \frac{1}{n+1} \sum_{j=0}^{n} y_{t-j} \qquad (3.13)$$

and y_t is the producers' income at time t.

The Demand System

The demand system facing the six commodities being considered in the study can be divided into two categories: domestic and foreign. Domestic demand could be further divided into income groups since price elasticities will often change with changes in income. In Kenya, the basic foodstuffs, maize, wheat and liquid milk, are generally consumed by all income groups. This study focuses on agricultural production and trade. All marketing transactions concerning the commodities are controlled by the government through its marketing agencies. The marketed surplus is purchased at a pre-announced price. Thus, the producers face a perfectly elastic demand at that price.

Retail prices for the major staple food commodities are under government control. Marketing boards transport the commodities within the country so as to stabilize their supply. In times of shortage, the board supplements domestic supply with imports. Consumer prices are set so as to reflect producer prices plus processing and distribution costs. The government's policy has been to adjust domestic stocks and imports to maintain pre-announced consumer and producer prices.

Recently, Barnum and Squire (1979) and Ahn et al. (1981) argued that in a semi-commercial agriculture commonly found in developing countries, the two components are interdependent. To capture this relationship, modeling procedures should integrate both production and consumption within a single theory of household behavior. Ahn et al., using an integrated approach found that, for a given output response, increased prices reduce marketed surplus response because the demand for self-consumption of farm output increases.

Standard textbook consumer theory suggests that household consumption of a normal good decreases with a rise in its price. But, in a semi-commercial agriculture an increase in price leads to a rise in income levels for producers. The rise in income is attributable to the increase in value of the marketed surplus. The change in income levels affects households' consumption and expenditure patterns. That is, a shift in the budget curve occurs in addition to the usual changes in its slope as suggested by theory. Lipton (1970) reports that price stabilization of major foodcrops may destabilize the revenue of farmers with marketed surplus. Thus, the problem of what to stabilize remains essentially unresolved. However, policy objectives provide a guide as to the most appropriate policy instrument.

In Kenya, producers of agricultural surplus for domestic consumption form a significant proportion of consumers. From the above observations, one could postulate that to increase the supply of marketed surplus, the government needs lower consumer prices. The approach leads to government subsidies to maintain high producer prices and low consumer prices simultaneously. The domestic demand system induces instability in producers' income, given the stochastic nature of yields and rational government behavior which attempts to minimize the government subsidy.

The demand for coffee, tea and sisal is basically external, with domestic demand insignificant. Since Kenya has no control over the international market, producers face an infinitely elastic foreign demand at the world price. Prices received by Kenyan farmers reflect world supply and demand scenarios. The decision to grow the export crop depends on expectations about yields and world prices.

Traditional economic theory indicates that free trade works to stabilize prices. The Marshallian framework of Waugh, Oi and Massell described in Chapter II, supports the notion that free trade is Pareto-optimal. However, as Newbery and Stiglitz (1981) demonstrate, the situation may be reversed where producers in a competitive economy face risky production conditions.

In a closed competitive economy, where prices are inversely related to marketed surplus and price elasticities of demand are unitary, farmers' incomes are always stable since price increases are offset by a decrease in quantity marketed. If the economy is opened to international trade, prices are stabilized so that any variation in domestic output leads to instability in producers' income. If income instability from the commodity exceeds the tolerable limits, farmers shift resources to less risky commodities in spite of unchanged mean income. If excess domestic demand is offset by imports, then the shift would not raise the average price of the commodity. Hence, free trade makes them worse than no trade.

Government Intervention

Most governments formulate and implement domestic economic stabilization policies with little explicit consideration on global economic integration. Policy instruments appear in several forms. Tariffs, levies and manipulation of exchange rates are commonly used in international trade. For large trading countries or blocks of countries, such as the U.S. or the European Economic Community (E.C.), the effects of such policies may have significant negative impacts on the welfare of smaller trading nations, particularly the developing non-oil exporting countries.

Consider the impact of an appreciation in the domestic currency, the Kenya Shilling (KSh.), depicted in Figure 3. D and S denote domestic supply and demand, respectively. For a given commodity, foreign demand and supply schedules are indicated by D_f and S_f. With no trade, domestic equilibrium price is P_k while the equilibrium price in a foreign market is P_f. As prices increase above P_k, domestic production would exceed domestic consumption. The excess supply function (S_e) illustrated is the supply function of exports to the world market. In the rest of the world, a fall in prices below P_f causes consumption to exceed production. An excess demand function, D_e, is depicted. D_e is the demand function from the world market.

With trade between Kenya and the rest of the world and abstracting from trade barriers and transportation costs, the equilibrium price for Kenya and the rest of the world is P_e. Q_e^* is the equilibrium level of Kenya's exports. This is the same volume as the imports by the foreign importer. With an appreciation of the KSh., the export demand schedule rotates to the left. Hence, for a stated amount of Kenyan goods, foreign importers must sell more goods in their currency to buy the same amount in Kenya currency. The new equilibrium, P_e', results in lower exports in Kenyan goods (Q_e^*) and Kenyan prices represented by P'. The price of Kenyan exports in foreign currency is given by P_e'. The higher foreign market price

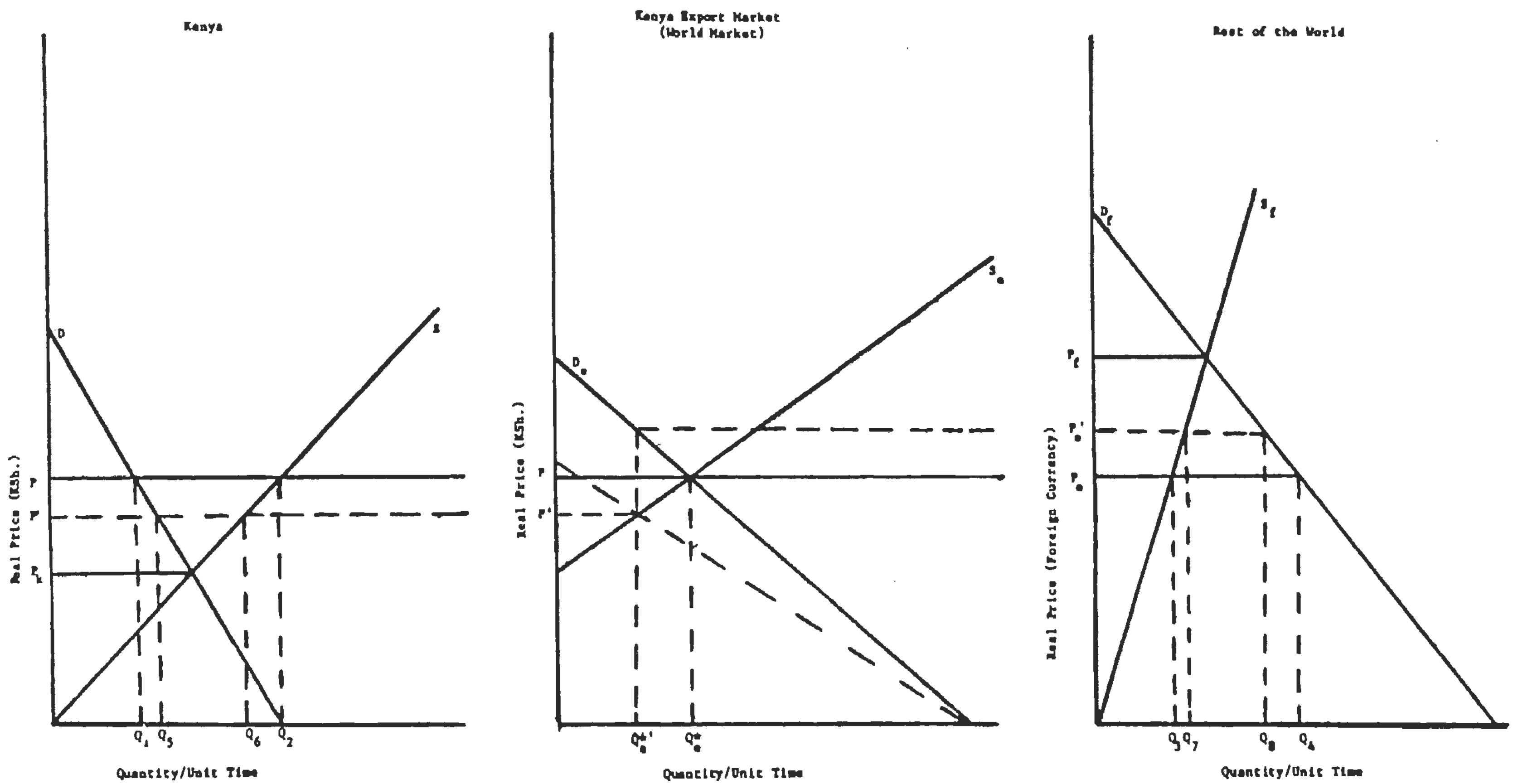


Figure 3. Impact of an Appreciation in Kenya Shilling (KSh.) on Export Trade of Agricultural Commodities

decreases demand and increases supply in the domestic market of the foreign country leading to a decline in imports by the rest of the world. A reduction in the volume of trade lowers the domestic price in Kenya. This enhances domestic consumption but by less than the decline in exports. If changes in the exchange rate are transmitted to both producers and consumers, then the quantity traded would be altered. Where domestic demand is insignificant, volatility in exchange rates enhances producers' income instability.

As for domestic sales, the Kenya government intervenes directly through price supports and marketing controls. The basic objectives are to maintain a broad self-sufficiency position in foodstuffs, a reasonable degree of security in food supply and equitable distribution of foodstuffs. Notwithstanding the need to safeguard the interests of farmers, the government recognizes the importance of trade in major export crops. Exports play an indispensable role in foreign exchange earnings that provide the nation with import capabilities. In this way, variability in export earnings has an impact on consumer demand, either directly through food imports or indirectly via imports of inputs necessary for domestic food production, the bottom line being socio-economic and political stability.

Anderson et al. (1977) stated that economic theory is ambiguous on the need for price stabilization schemes. One argument is that uncertainty is undesirable if followed by market failure. In this case, correcting the failure is preferred to the removal of uncertainty. However, Samuelson (1972) argued that an economy in a Pareto equilibrium without uncertainty cannot improve itself by generating uncertainty. Hence stabilization policies should attempt to eliminate the source of risk. Price stabilization is adopted for lack of an alternative practical approach. It is not necessarily the best alternative because price variability is a manifestation of structural sources of instability that include uncertainties in supply and exchange rates in export trade.

Abbott (1979) developed an econometric model that was used to show the need to endogenize the role of government in international trade. McKinnon (1982) argued that domestic stabilization policies that manipulate money supply and exchange rates enhance global instability. Chambers and Just (1979) presented a theoretical and empirical critique of agricultural trade. Their analysis led them to suggest that exchange rates are important determinants of agricultural trade flows. The presence of money and exchange rates disguise exchange in real goods. The situation is exacerbated by a government's interference with the market determination of exchange rates.

Developing countries, in general, peg their exchange rates to convertible currency or baskets of currencies. Presently, the major hard currencies have floating exchange rates in the sense that the market forces of demand and supply determine their values. McCalla and Josling (1985) note that the impact on the domestic economy of a change in the exchange rate of hard currency is variable and sometimes ambiguous. Depreciation of hard currencies does not necessarily help the developing economies because they are basically exporters of primary commodities and importers of manufactured and capital goods (McCalla, 1982). As the foreign currency depreciates relative to the domestic currency, international prices in terms of domestic currency rise but the quantity of imports may not adjust accordingly. Absence of quantity adjustments may not be offset by gains in foreign exchange resulting from more competitive exports.

Gulhati et al. (1985) state that many post-independence African governments did not consider the exchange rate as a possible policy instrument. Three factors are identified as causes for aversion to the use of the instrument. African governments believe that devaluation of their exchange rates would increase domestic inflation, increase budgetary deficits and generate few benefits from international trade. If exports have low elasticities of demand in international markets, then changes in real exchange rates may have little influence on the quantity exported and subsequent income to producers. Moreover, in many African countries, fiscal resources are derived from the agriculture sector. Inflation and declining demand for export commodities increase taxation of the sector with deleterious consequences on the domestic agriculturally-based economy.

Instability in foreign exchange rates has drawn the attention of policy-makers because of the possible repercussions on domestic-currency value of internationally traded commodities. There is general agreement that exchange rates changes affect prices, supplies, and quantities demanded. Currently, there is no strong theoretical consensus as to the most relevant forms of fluctuations (Bank of England, 1984). The choice of exchange rate standard does not affect external terms of trade. Rather, the concern is its effects on internal trade, income distribution and domestic allocation of resources (Lipschitz, 1978). Nevertheless, Lanyi and Suss (1982) found that choice of the exchange arrangement affects exchange rate instability. Their study suggested that minimizing the instability of nominal effective exchange rates also minimizes that of the real effective exchange rate and vice versa. Since 1973, some countries have had exposure to flexible exchange rates and have chosen exchange rate regimes that attempt to minimize costs associated with exchange rate instability.

Often, unit value of an export commodity is fixed for the contract period in terms of an easily convertible foreign currency. If domestic currency fluctuates against the currency, exporter's earnings would vary accordingly. The inability of the exporter to control variability represents a cost to him. So long as the exporter is risk-averse, his/her interest would be to minimize the deviation between expected and actual values in terms of domestic currency. Individual transactors are interested in the exchange rate for the hard currency in which export earnings are denominated. Therefore, the export instability facing an individual is appropriately calculated using the relevant transaction currency.

Brodsky (1983) tested the validity of the notion that measured export instability is independent of the transaction currency used. Exports of each country considered were valued using seven different numeraire currencies. The standard error from the least squares exponential trend regression equation was used as the instability measure.

Model Specification

Export Instability Measure for Kenyan Data

Several measures of instability were described in Chapter II. In this section, one of the procedures for deriving instability measures is restated in the form used for calculating producers' income instability in Kenya.

Assume that the coefficient of variation, (CV), uncorrected or corrected for the trend, is an appropriate index of instability. Also, treat income from marketed commodities as a single random variable. In reality, income is the product of price, nominal in this case, and quantity sold. For non-trended time series data, the index, I_{cv}, is derived as follows:

$$I_{cv} = \frac{100}{\overline{P_{it}Q_{xt}}} \left[\frac{\sum_{t=1}^{N} (P_{it}Q_{xt} - \overline{P_{it}Q_{xt}})}{N-1} \right]^{\frac{1}{2}} \qquad (3.14)$$

where P_{it} is the numeraire currency i during period t, t=1,...N. Q_{xt} represents the quantity marketed of commodity x during period t. $P_{it}Q_{xt}$ is, therefore, the value of the marketed commodity in terms of currency i.

Economic theory suggests that there is a tendency for countries to plan in terms of growth rates rather than absolute increments. Empirical findings (Massell, 1970) demonstrate that exponential trend provides a better fit for most data. Consequently, Massell recommended detrending the data using an exponential relation of the form

$$\log(P_{it}Q_{xt}) = a_i + b_i t + e_{it} \tag{3.15}$$

where t denotes the time in years and e is the random term. Following Cuddy and Della Valle, R^2 can be derived as follows:

$$R^2 = 1 - \frac{\sum_{t=1}^{N} (P_{it}Q_{xt} - \widehat{P_{it}Q_{xt}})^2}{\sum_{t=1}^{N} (P_{it}Q_{xt} - \overline{P_{it}Q_{xt}})^2} \tag{3.16}$$

Equation (3.16) can be rewritten as

$$\sum_{t=1}^{N} (P_{it}Q_{xt} - \widehat{P_{it}Q_{xt}})^2 = (1-R^2) \sum_{t=1}^{N} (P_{it}Q_{xt} - \overline{P_{it}Q_{xt}})^2 .$$

$$= (N-K)(1-R^2)\left(\frac{N-1}{N-K}\right) \left(\frac{\sum_{t=1}^{N} (P_{it}Q_{xt} - \overline{P_{it}Q_{xt}})^2}{N-1}\right)$$

where K is the number of independent variables including the intercept. The above equation can be expressed as

$$SEE = SD \left[(1-R^2)\left(\frac{N-1}{N-K}\right)\right]^{\frac{1}{2}} \tag{3.18}$$

where SEE is the standard error of the regression estimates derived by dividing (3.17) by the degrees of freedom. SD is the standard deviation of the observations.

The general index developed by Cuddy and Della Valle is given by

$$I_G = 100.SEE/\overline{P_{it}Q_{xt}}$$

$$= CV\left[(1-R^2)\left(\frac{N-1}{N-K}\right)\right]^{\frac{1}{2}} \quad (3.19)$$

Since the adjusted coefficient of multiple determination can be written as

$$\bar{R}^2 = 1 - \left[(1-R^2)\left(\frac{N-1}{N-K}\right)\right] \quad (3.20)$$

then,

$$I_G = CV\ (1-\bar{R}^2)^{\frac{1}{2}} \quad , \qquad \bar{R}^2 \geq 0 \quad (3.21)$$

I_G is the "corrected" coefficient of variation.

In this study, I_G is either derived from linearly or log-linearly detrended data. The above authors suggest a selection criterion as follows:

(1) Choose I_{CV} if the detrended regression equations are not significant at the 1 percent level.

(2) Select the I_G from the equation having significant R^2 value at 1 percent if the alternative equation is not significant at the same level.

(3) If R^2 from both equations are significant at the 1 percent level, then choose I_G from the equation with the highest $\bar{R}^2$.

The index in equation (3.21) is derived for the selected commodities using the vehicle currencies selected. The selection rules given by Cuddy and Della Valle are used to select the appropriate index for each commodity.

Given producers' gross income is the product of quantity and price, the identity

$$I_i = P_i Q_x \tag{3.22}$$

where I denotes gross income from commodity x, x=1,...3, P_i is its price in terms of the appropriate transaction currency and Q_x is the quantity marketed, then

$$\ln I_i = \ln P_i + \ln O_x \tag{3.23}$$

and the variance of log I is given by the relationship

$$Var(\ln I_i) = Var(\ln P_i)+Var(\ln Q_x)+2Cov(\ln P_i, \ln Q_x) \tag{3.24}$$

The variance and the covariance are measured around a semi-logarithmic trend of the form given in equation (3.15). The variables are assumed to be normally distributed in natural logarithms. Variance, as a measure of instability, is commonly used (Bale and Lutz, 1979). However, it can be a misleading criterion of instability where the variables being compared have different means. In this case, CV would be a better measure.

The sign of the covariance of price and quantity is often taken as an indicator of the source of income instability. If the covariance is positive or negative, then the source is demand or supply, respectively. Following Murray (1979), further manipulation of equation (3.24) could provide more useful information. Dividing

Var(lnP) and Var(lnQ) by the sum of the variances and multiplying by 100 yields:

$$PC = 100Var(lnP_i)/[Var(lnP_i) + Var(lnQ_x) + 2Cov(lnP_i, lnQ_x)] \quad (3.25a)$$

$$PQ = 100Var(lnQ_x)/[Var(lnP_i) + Var(lnQ_x) + 2Cov(lnP_i, lnQ_x)] \quad (3.25b)$$

where PC and PQ are proportions of price and quantity contribution to total instability, respectively.

Proponents of the theory of underdevelopment emphasize that lags in food production in the Third World arise from their dependence on a global economic system. The development of a dichotomous agriculture that has generally favored export over domestic market oriented production has caused this dependency. While Kenya's agricultural sector exhibits this dichotomy, it is believed that economic complementarity exists between commodities produced for the export market and domestic food crops.

Concerning producers' income instability, it is worthwhile noting the commodity combinations that minimize total income instability. Assuming that, in terms of gross receipts; coffee, tea, maize, wheat and milk production are the most important commodities, the procedure in Schmitz and Koester (1984) is adapted to determine the proportion of income from exports that minimizes total income instability. Bautista (1986) has followed a similar procedure.

Consider the following additive identity:

$$I = I_e + I_d \quad (3.26)$$

where I is total income, I_e and I_d denote income from exports and domestic marketings, respectively. Exports are coffee and tea while the domestic marketings are maize, wheat and milk. The variance of I is given by

$$Var(I) = Var(I_e) + Var(I_d) + 2Cov(I_e, I_d) \qquad (3.27)$$

The coefficient of variation (CV) and the variance of income have the following relationship

$$Var(I) = CV_I^2\bar{I}^2 \qquad (3.28)$$

In terms of CV's, equation 3.28 can be written as

$$CV_I^2 I^2 = CV_{Ie}^2\bar{I}_e^2 + CV_{Id}^2\bar{I}_d^2 + 2r\bar{I}_e\bar{I}_d CV_{Ie}CV_{Id} \qquad (3.29)$$

In the above equation, r is the correlation coefficient between $\bar{I}_e$ and $\bar{I}_d$. The share of income attributable to the respective market can be derived by dividing both sides of (3.29) by $\bar{I}^2$ to yield

$$CV_I^2 = S_e^2 CV_{Ie}^2 + S_d^2 CV_{Id}^2 + 2S_e S_d r CV_{Ie} CV_{Id} \qquad (3.30)$$

S_e denotes the share of income attributable to export market while S_d is that from the domestic market.

Given the CV's and , then total income instability is determined by the contribution of each category. Assuming that the Kenyan variables remain unchanged, then total differentiation of equation and rearranging (3.30) gives

$$dCV_I = \frac{CV_{Ie}^2 S_e dS_e}{CV_I} + \frac{CV_{Ie}^2 S_d dS_d}{CV_I} + \frac{S_d rCV_{Ie} CV_{Id} dS_e}{CV_I}$$

$$+ \frac{S_e rCV_{Id} CV_{Ie} dS_d}{CV_I} \qquad (3.31)$$

Noting that $S_e + S_d = 1$ and $dS_e = -dS_d$, equation (3.31) can be rearranged thus:

$$\frac{dCV_I}{dS_e} = \frac{-CV_{Ie}^2 - rCV_{Ie}CV_{Id}}{CV_I} + \frac{[CV_{Ie}^2 + CV_{Id}^2 - 2rCV_{Ie}CV_{Id}]}{CV_I} S_e \qquad (3.32)$$

Following Bautista, if

$$S_e > \frac{CV_{Id}^2 - rCV_{Id}CV_{Ie}}{CV_{Id}^2 + CV_{Ie}^2 - 2rCV_{Id}CV_{Ie}} \equiv S_e^* \qquad (3.33)$$

then greater total income variability ensues from a rise in the share of export earnings. Assuming that $\bar{I}_e$ and $\bar{I}_d$ are independent, that is, $r = 0$, then

$$S_e > \frac{CV_{Id}^2}{CV_{Id}^2 + CV_{Ie}^2} \equiv S_e^* \qquad (3.34)$$

Minimum conditions are achieved when second order conditions are met. Rearranging (3.34) yields

$$S_e > \frac{1}{1 + CV_{Ie}^2/CV_{Id}^2} \equiv S_e^* \qquad (3.35)$$

Thus, the ratio of CV_{Id}^2 to CV_{Ie}^2 determines the export crop share that minimizes income instability. If the ratio is unity so that

$S_e^*=0.5$, then minimum total income variability arises from equal proportions of income from exports and domestically marketed commodities.

Simulation Model: Description

The Kenyan government has supported the agricultural sector directly through its financial institutions. Private financial institutions have been encouraged to support the sector through concessionary monetary policies. A number of agricultural credit schemes have been used with mixed results. The Guaranteed Minimum Returns (GMR) scheme had an element of commodity insurance in it. Most of the existing schemes do not have complete commodity insurance. Absence of complete commodity insurance programs coupled with risk-averse producers have destabilized short term supply of marketed surplus. To producers, the consequence of fluctuating sales constitutes income instability.

This study uses a modified version of Bigman's (1985) econometric simulation model to evaluate the effects of three alternative policies on producers' income instability. Simulation provides a controlled environment for evaluating alternative policies under varied conditions. Also, it provides a unique opportunity to observe directly the dynamic behavior of the interaction processes. A number of simplifying assumptions are made to facilitate deeper understanding of consequences. The basic assumption is that the government's policy decision in one period is a function of the actual weather conditions during that period. The model thus consists of an econometric component that describes demand and supply scenarios, a stochastic process that describes random weather component changes, and a set of policy rules that specify government response to different contingencies.

The simulation model as developed by Bigman (1985) describes a discrete dynamic process of an economic system. The structure of the analysis is composed of: (1) initial state variables at time t-1; (2) random events at time t; (3) decision variables (policy actions) at time t; and, (4) decision rules at time t. These factors combine to determine the state of the system at time t. The decision process is accomplished as follows. Let S_{t-1} represent a vector of state variables at the end of season t-1, which is also the initial state of the farming system at the beginning of period t, the current season. During period t, the random event with a known probability distribution described by vector RE occurs. According to a certain set of rules D, the vector RE_t and S_{t-1} determine the decision variables (policy actions) described by the vector X_t. The relationship can be written as

$$X_t = D(S_{t-1}, RE_t) \qquad (3.36)$$

Depending on the values of the initial state of the system, S_{t-1}, the decision variables X_t, and the random event RE_t, the state of the system during period t can be determined. Thus, the state of the system in the current season can be defined as

$$\begin{aligned} S_t &= F_t\,[S_{t-1}, RE_t, X_t] \\ &= F_t\,[S_{t-1}, RE_t, D(S_{t-1}, RE_t)] \qquad (3.37) \end{aligned}$$

F_t is a deterministic and known relation that is assumed to exist between the current state of the system S_t and the preceding state variables, the current random event RE_t, and the current policy actions X_t. The function F_t may include historical time-dependent processes such as population growth. The initial state of the system at the beginning of season S_{t+1} is given by values of S_t.

The recurrent nature of equation (3.37) implies that the state variables in any season t may be written as functions of initial conditions S_o, the set of decision rules D, and the sequence of random events $RE_1, \ldots, RE_T$. For an objective function that depends on the entire sequence of state variables, the problem consists of finding a set of decision rules that for a given initial condition S_o, and a given set of random events $RE_1, \ldots, RE_T$, will yield the highest ranking outcome attainable as defined by the ordering criterion. Given S_o, the objective function, G, is defined as follows:

$$G = g(S_o, S_1, \ldots, S_T) \qquad (3.38)$$

G may be a vector consisting of several objectives, for example net economic gains and effects of price support policy on the level and variability of producers' income and food supply. Maximizing the expected value of each of the decision rules yields the optimal solution.

To illustrate, let W be a vector representing the weather. Assume that the events are normally distributed. Draw sequences of random numbers, $W_1, \ldots, W_T$, from the distribution. If S_o and D are known, then using equation (3.37), $S_o, \ldots, S_T$ can be computed.

Using equation (3.38), the value of the objective function can be calculated. The frequency distribution of the outcomes of several repetitions yield the value of the objective function for the set of decision rules.

The solution procedure is recursive rather than simultaneous. Each production period has the following special features:

1. initial conditions that are specified by a set of exogenous parameters that usually include demand and supply elasticities and parameters describing stochastic processes and endogenous variables that have been generated in the previous period, for example, past prices;
2. planned production levels that are based on (1). The supply response being a function of area, expected returns per hectare and price elasticity of competing activities;
3. actual supply is a function of the resources allocated and the random variables (weather);
4. reference solution results from the interaction of the actual supply and prevailing demand schedules;
5. free market solution is the set of prices and quantities obtained by equating prices in (4) to costs of insurance and freight (CIF) and free on board (FOB) prices, then deciding whether to import or export;
6. government interventions result from equating (5) to "trigger" prices that initiate the actions of the government where the trigger price acts as a rule of behavior that predicts the nature of the policy actions; and the

7. final solution for the period is the set of quantities that is obtained after all the interventions.

Performance measures are derived from (7). The initial conditions for the second period are the final solution data adjusted for the expected prices and time dependent changes. The dynamic process continues until a predetermined end period is attained. In all cases, sets of random events constitute the disturbance terms. These are derived from Monte Carlo simulations. The random processes are assumed to be normally distributed. A schematic description of the simulation model is represented in Figure 4.

Econometric Components. The supply function, after transformation, takes a log-linear-constant elasticity form as:

$$\ln QS_{it} = \alpha + \beta_i \ln P^*_{it} + \sum_{i=1}^{n} \gamma_i \ln X_{it} + u_t \qquad (3.39)$$

where QS_t refers to planned marketed surplus of commodity i during period t, P^*_{it} is the anticipated unit revenue at the beginning of the season for time t, as described earlier. X refers to other independent variables. Here, the disturbances represented by u_t are attributable to weather changes. Following the arguments of Scandizzo et al. (1984), P^*_t is explicitlv used in this study to represent expected unit revenues.

Domestic market equilibrium is achieved when quantity demanded equals that supplied by the marketing agency at the preannounced prices. As stated earlier, the government arranges for market clearances by engaging in external trade through marketing boards. Hence, producers' income for the commodities are independent of

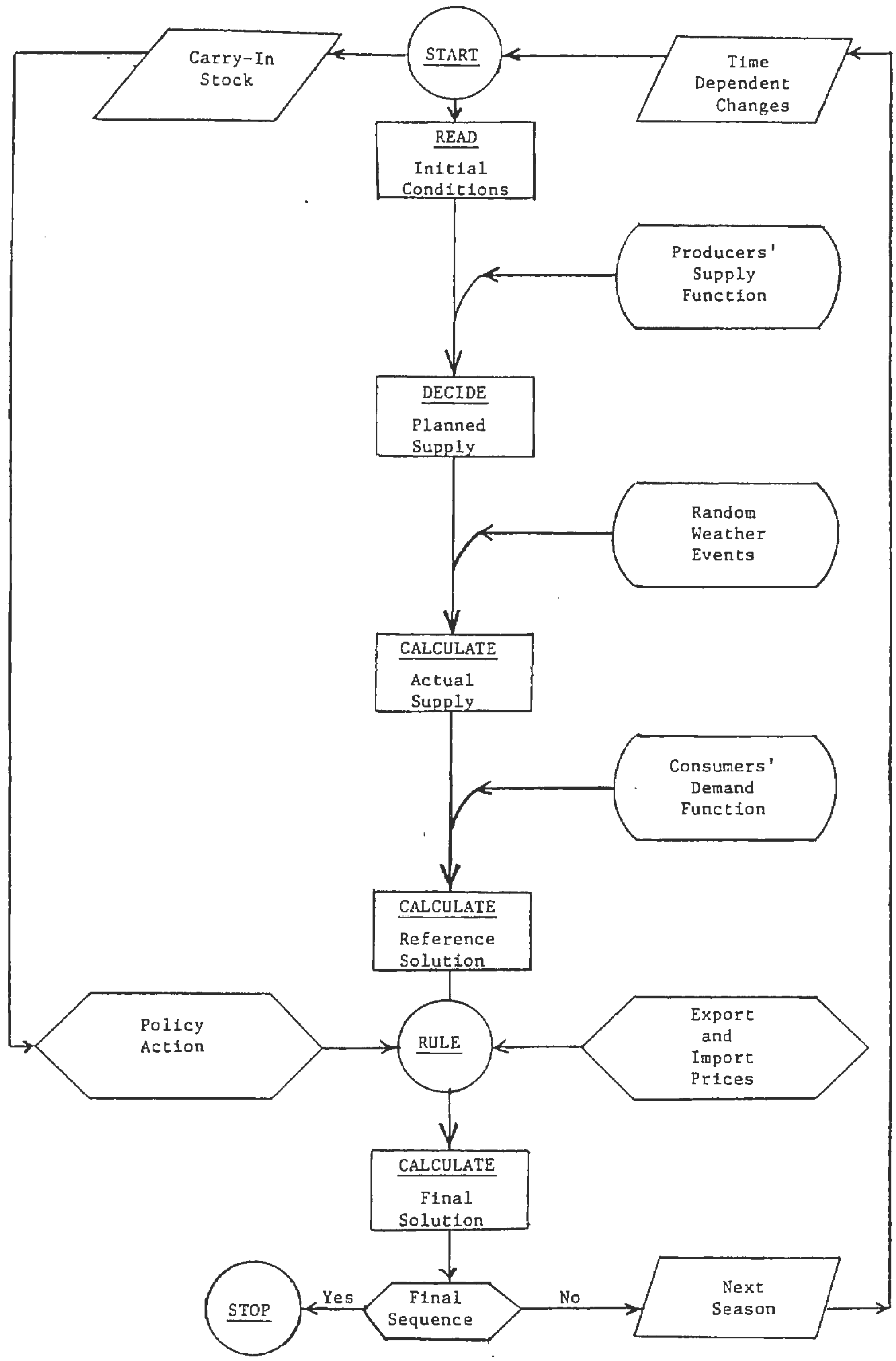


Figure 4. Flow Diagram for Solution Procedure of Simulation Model (Adapted from Bigman, 1985)

consumer demand, at least in the short run.

Simulation Model: Application with Kenya Data

The basic structure of the simulation model developed by Bigman is adopted in this study. A stochastic simulation model of domestic marketed supply in Kenya is used to simulate a base scenario and changes resulting from alternative stabilization schemes. Closed and open economy situations are examined.

This study focuses on instability of income from marketed agricultural commodities. Ideally, behavioral equations in such a model are described by demand and supply relationships. However, in the Kenya model, it is assumed, as described earlier, that the domestic market clears at the preannounced prices. Initially, the parameters of the supply equation are estimated from historical data using log-linear equations described earlier. Subsequently, the parameters associated with this equation and the stochastic process are prespecified. Elements of the vector of state variables, S_{t-1}, are the values assumed by the quantities and prices of marketed commodities and the different supply and demand parameters. Random events are attributable to changes in weather. Therefore, data requirements are very demanding. Given this situation, national aggregates would suffice.

In the context of this study, a closed economy is defined as one that does not respond to external price signals. Hence, domestic prices have no relationship to the level of world commodity prices. An open economy is one whose domestic producer prices vary with world prices. However, consumer prices remain as in a closed economy. This is in consonance with the commonly reported feature of consumer protection in developing countries. The decision criteria are the alternative government stabilization schemes considered in the study. The second case is where there is limited government participation. Producers face prices prevailing in a competitive open economy. The revenue support scheme takes the form of deficiency payments. In principle, the deficiency payments approach allows producers to sell in a market as described in the second case above. If the average realized price is less than a guaranteed level, the producer receives a supplementary payment from the government. The guaranteed minimum income presents the least interference in the market mechanism. A floor is set under which income fluctuates for the product. There is no ceiling. Guaranteed minimum returns scheme comes into operation whenever producers income falls below a prespecified percentage level of their income under normal circumstances.

A number of simulation runs will be made. The assumptions underlying each run are stated below.

1. Base run - assumes a continuation of the present policies:
    a) Prices paid to farmers are fixed by the government at the beginning of the season;
    b) All the marketed surplus is purchased by the government;
    c) The government fixes retail prices; and
    d) The domestic market clears at fixed prices through import and export trade to maintain the prices.
2. Limited government intervention: all the assumptions in (1) hold except that producers face world prices. This is the case of an "open" economy.

3. Price support: the situation is as described in (1) except that producer prices are not fixed. The government guarantees to purchase the produce at a predetermined floor price whenever the free market price falls below the floor price during the season.
4. Guaranteed minimum income: a three season average income is set as a floor under which it fluctuates. If the producer income falls to 80 percent of the average, then the government augments producers' income. The rest of the assumptions are similar to the base run.

Performance measures will be derived from the respective simulation runs. These include output, prices and the degree of income instability for each of the commodities under consideration.

Chapter Summary

The first part of this chapter dealt with theoretical issues pertaining to the components of agricultural production and marketing that influences producers' income instability. It was shown that in cases where producers consumed part of farm output, the supply function referred to marketed surplus and not total production. It was indicated that government could cause income instability through its policies.

Two analytical procedures were developed. The first approach was developed to examine export earnings instability. The second procedure was described as a dynamic-stochastic simulation model. The model will provide more detailed impacts of specified government policies that affect income instability. The advantages of this approach were also described.

In the next chapter, sources of the data and empirical findings from the models will be discussed. The results will be used to evaluate the specific hypotheses described in Chapter I.

CHAPTER IV

MEASURES AND SOURCES OF INCOME INSTABILITY: DATA NEEDS AND ANALYSIS

Introduction

The framework described in Chapter III led to the specification of two models. First, a method for identifying producers' income and export earnings instability was discussed. Secondly, a dynamic-stochastic simulation model was described. The simulation model will be used to study the effects of environmental and governmental variables on producers' income instability.

In this chapter, measures and sources of income instability are discussed. Both export commodities and those that are produced primarily for the internal market are considered. Initially, the study period covers the 20 year time span between 1964-83. Subsequently, the period is divided into two decades: 1964-73 and 1974-83. The Kenyan economy faced a new set of problems after 1973 that arose mainly from the energy crisis of that year. Therefore, disaggregation is done to facilitate further analysis of the sources of earnings or income instability over the 1964-83 period. The chapter is organized as follows. The first section describes the data. Empirical results are then presented and analyzed. Policy implications are drawn from the findings. The chapter concludes with a summary.

Data Needs

This study utilized secondary time series data from several sources. The main sources were, however, statistical abstracts of Kenya's Central Bureau of Statistics (CBS) and the International Financial Statistics (IFS) published by the International Monetary Fund (IMF). Complementary sources included various issues of Kenya Economic Surveys. From CBS, volumes of commodities exported to various trading partners were obtained. Quantities produced for sale and average prices paid to producers were also available. Prices paid for exports were quoted in the domestic currency. These were free on board (f.o.b.) prices.

An overview of agricultural production and marketing during the later part of the 1960s reveals that commodity prices were fairly stable with some producer prices exhibiting a small downward trend. Marketed production increased, especially for tea and coffee. This is attributed to an increase in the area under cultivation as small scale production expanded after independence.

Observed producer price fluctuations in the 1970s are partly due to the upward movement in energy prices that triggered worldwide inflation. Producer prices for domestically marketed commodities remained low until 1975 when significant increases occurred. Output of coffee, tea, maize, and liquid milk increased despite an estimated 12 percent decline in producers terms of trade between 1972 and 1975 (de Wilde, 1984).

From 1976 to 1983, producer prices for maize and milk were generally favorable for producers. Weather played an important role in quantities marketed. As for maize, the yield impacts resulting from the adoption of hybrid seed in the 1960s were declining. The restrictions of the International Coffee Organization, of which Kenya is a member, put a ceiling on the hectares of coffee cultivated.

On the international scene, the IFS Supplement on Exchange Rates reports the series defined as period exchange rate averages. Using the series, the price of exports in terms of an importer's currency is obtained by multiplying the f.o.b. prices by the relevant exchange rates. The value of exports in terms of importer's currency is the product of the price in the importer's currency and the quantity exported. For countries whose international trade is close to the world average, the Special Drawing Rights (SDR) provides an approximate trade-weighted basket of currencies. Kenya's currency was pegged to the SDR during the latter half of the study period. In this study, the SDR is used to value exports on the assumption that the move to peg Kenyan currency to the basket was motivated by the government's aspiration to minimize exchange rate instability. The SDR has been defined since 1970. Nevertheless, the SDR-U.S. dollar conversions prior to 1970 can be found in the IFS Yearbook (1985).

The choice of national currencies used in this study reflects the volume of bilateral trade and the importance of the selected currency in international trade. Regional concentration has been declining since 1964. However, western Europe remains the major geographical trading area. Exports to other African countries, particularly Uganda, have been increasing over the years. In the far east, Japan, Pakistan and India are the major importers of Kenyan agricultural products. South Yemen, Saudi Arabia, Iran and Israel are important trading partners in the middle east. Exports to the United States have increased significantly, especially after 1975. The value of exports to eastern Europe is the lowest of the geographical areas defined in the statistical abstracts.

On specific commodities, West Germany was the major importer of Kenyan coffee during the 1964-83 period. During the same period, the United Kingdom purchased most of the country's tea exports. The United States and Italy were the main importers of pyrethrum extract and hides and skins, respectively. Assuming that the payments were made in the importer's currency, then the changes in the Deutsche mark and the pound sterling were likely reflected in Kenya's export earnings due to the predominance of coffee and tea in export earnings.

Prices and exchange rates used in the study are defined in nominal terms. Hence the study focuses on instability including inflation. Nominal exchange rates, defined as the official parity for transactions are used. A more relevant rate would be the effective exchange rate, defined as the amount of local currency actually received for a unit of international transaction. Similar procedures would be applicable to the analysis of instability using real effective exchange rates.

Empirical Results

Measures of Instability

To derive an appropriate index of instability, fourteen main agricultural exports were considered. These are listed in Appendix A. Annual earnings from each commodity by currency were calculated. The sample coefficient of variation for earnings from each commodity was computed. Two regression models were used to correct for the trend: linear trend and log linear trend models. The models were fitted to all observations by currency.

In selecting the appropriate index of instability, the selection rules described in Chapter III were used. The number of cases an index is chosen for a given numeraire currency is presented in Table I. The figures indicate that, except for the Italian lira, IG_b was selected in 6 or more cases. In all the commodities, IG_a had the least number of cases. The implication of these findings is that for trend corrected data, a semilog trend model provides greater explanatory power in more cases than a linear trend model.

The six commodities listed in Table II were selected to test whether the numeraire currency influenced commodity instability. The appropriate index for all was IG_b. Numerically, the derived measures of instability were sensitive to the vehicle currency. The Special Drawing Rights (SDR) led to the fourth highest index in 4 out of 6 commodities under consideration. The correlation coefficients between earnings instability by currency are shown in Table III. The closer the correlation coefficient to unity, the less important is the choice of vehicle currency.

The concern of Kenyan exporters is the fluctuation of the domestic currency against those of its trading partners. Since the volatility represents a cost, then the objective of the exporter is to minimize the deviation between the actual and the expected values in terms of Kenyan currency. To this end, a knowledge of the relative instabilities between individual transaction currencies and the domestic currency is essential. From Table III, the US dollar, the Japanese yen and the Special Drawing Rights (SDR) are closely associated with the Kenya Shilling. Thus, using either of these currencies as the numeraire for calculating instability measures would yield values that do not diverge much from those derived using the domestic currency.

TABLE I

FREQUENCY DISTRIBUTION OF MEASURES OF EXPORT EARNINGS INSTABILITY FOR SELECTED NUMERAIRE CURRENCIES

Currency	Appropriate Index of Instability*		
	I_{CV}	IG_a	IG_b
Kenya Shilling (KSH)	6	2	6
United States Dollar (US$)	6	1	7
West German Mark (DM)	5	1	8
Italian Lira (IL)	10	0	4
Japanese Yen (JY)	5	1	8
Netherlands Guilder (NG)	5	1	3
Special Drawing Rights (SDR)	6	1	7
United Kingdom Pound (UKL)	7	1	6

* Appropriate index of instability is one that best measures the degree of instability for a given data set.

I_{CV} = instability index from non-detrended data

IG_a = instability index from linearly detrended data

IG_b = instability index from log-linearly detrended equations

TABLE II

EARNINGS INSTABILITY MEASURES FOR SELECTED EXPORT COMMODITIES, 1964-83

	Currency*						
Commodity	KSH	US$	DM(FR)	JY	NG	UKL	SDR
Coffee	34.48	39.23	50.09	31.27	41.37	37.23	38.55
Tea	22.25	21.37	26.85	26.06	27.45	22.41	23.55
Hides & Skins	28.61	40.20	51.58	44.07	52.26	47.73	46.33
Pyrethrum Extract	17.14	20.50	30.80	22.68	31.00	31.37	26.80
Beans & Peas	72.92	49.89	38.86	44.30	39.45	40.40	44.04
Tinned Pineapples	39.30	33.90	38.12	36.68	38.62	37.80	37.64

* KSH = Kenya Shilling
US$ = United States Dollar
DM(FR) = Deutsche Mark (Federal Republic of Germany)
JY = Japanese Yen
NG = Netherlands Guilder
UKL = British Pound Sterling
SDR = Special Drawing Rights

TABLE III

CORRELATION COEFFICIENTS BETWEEN EXPORT EARNINGS INSTABILITY BY VEHICLE CURRENCY: 1964-83*

Currency**	KSH	US$	DM(FR)	JY	NG	UKL	SDR
KSH	1.00 (0.00)						
US$	0.85 (0.03)	1.00 (0.00)					
DM(FR)	0.22 (0.68)	0.69 (0.13)	1.00 (0.00)				
JY	0.72 (0.11)	0.89 (0.02)	0.62 (0.19)	1.00 (0.00)			
NG	0.26 (0.61)	0.71 (.011)	0.93 (0.01)	0.80 (0.06)	1.00 (0.00)		
UKL	0.41 (0.42)	0.78 (0.07)	0.85 (0.03)	0.83 (0.03)	0.95 (0.00)	1.00 (0.00)	
SDR	0.66 (0.15)	0.91 (0.01)	0.78 (0.07)	0.93 (0.01)	0.83 (0.04)	0.80 (0.06)	1.00 (0.00)

* The values in parentheses are the probability that the calculated value of R is greater than the critical R under the hypothesis that rho = 0.

** KSH = Kenya Shilling
US$ = United States Dollar
DM(FR) = Deutsche Mark (Federal Republic of Germany)
JY = Japanese Yen
NG = Netherlands Guilder
UKL = British Pound Sterling
SDR = Special Drawing Rights

However, the overall situation shows that the domestic currency led to the lowest instability measures for only two commodity groups: Pyrethrum and hides and skins. It was the second lowest in coffee and tea. As for beans and peas, as well as tinned pineapples, the domestic currency was ranked seventh. In terms of correlation, the US dollar, the SDR and the Japanese yen were highly correlated with those derived using the Kenya currency as the numeraire. As a denominator, the Deutsche mark and the guilder were least correlated with the Kenya currency. Measures derived from the US dollar were correlated with all the denominators used. Thus, using the domestic currency as a numeraire does not necessarily lead to least unstable indices.

Regarding the instability measure for individual commodities, earnings instability for coffee ranges from 31.27 when valued in Japanese yen to 50.09 when valued in Deutsche mark. As stated earlier, West Germany has been consistently Kenya's leading importer of coffee. Assuming that contracts are made using the prevailing exchange rate between the Kenyan shilling and the importers currency, results suggest that valuing the earnings in a currency other than the mark would underestimate the instability measure for earnings. Given the close association between the Kenya Shilling and the U.S. dollar, lower instability measures could be obtained if the transactions were carried out in U.S. dollars. Great Britain is the main importer of Kenya's tea. The instability index when the exports are valued in shillings is close to that obtained when valued in pound sterling.

A distinction should be made between an appropriate instability measure for all commodities under consideration and one that is specific to an individual commodity. If the interest is on a vehicle currency that leads to least instability in terms of domestic currency, then the US dollar or a basket of currencies represented above by the Special Drawing Rights (SDR) would be the best alternative. Hence, if the measure is defined in terms of Kenya shilling, then the dollar and the SDR would be appropriate pegs. In this way, instability arising from changes in the exchange rates between foreign currencies is minimized. Brodsky and Sampson (1984) noted that SDR has provided the best exchange rate stability as compared to the US dollar, the French franc and the British pound for those SDR pegging countries.

Kenya's export earnings are concentrated on coffee and tea. The country is a member of the International Coffee Organization (ICO), a body consisting of the major consumers and producers. The organization regulates the world coffee market through the manipulation of quantities sold by the individual producer in the quota market. Often Kenya has had to sell some of its produce in the non-quota market where prices are generally lower than the quota market. Currently, it enjoys non-restricted but fairly concentrated marketing of tea.

The impact of earnings instability from coffee and tea have significant effects on domestic economy. Given the relatively inelastic demand for these commodities (Riedel, 1983), any fluctuations of the importer's currency relative to the shilling would not significantly affect the quantity exported. But, for the volume sold, earnings in terms of domestic currency would be fluctuating accordingly and the higher the instability of the exchange rate, the higher the earnings instability. These results create volatility in foreign exchange earnings and subsequently unstable import capability. Moreover, since producers' annual income from the exports depend on the quantities marketed, the foreign market price and exchange rates, fluctuations in foreign earnings are transmitted directly to the farmers. A direct source of income instability is the fluctuating output at the farm level that is not offset by the price changes in the world market.

Commodity earning instabilities were derived from a 20 year series of data. During the same time, instability indices for maize, wheat and milk in domestic currency values were 41.1, 29.6 and 20.6, respectively. Noting that coffee and maize are the most important commodities in Kenya's agricultural sector, the indices suggest that during 1964-83, both crops had measures that were over 30 when the domestic currency is the denominator. The results suggest that the hypothesis that the Kenya currency is the appropriate measure of the country's export earnings instability is not applicable to all commodities.

Sources of Instability

To the producers, earnings are a product of quantity sold and their per unit prices. A decomposition of the identity into its components would provide additional information. For convenience, the variance of earnings are taken as alternative measures of instability. Furthermore, it is assumed that the prices received by producers are proportional to the domestic export prices. The proportional contribution of each component to the total variability of commodity export earnings is indicated in Table IV. The figures indicate that

TABLE IV

COMPONENTS OF EXPORT EARNINGS INSTABILITY IN TERMS OF KENYA SHILLINGS, 1964-83

Commodity	Total Variability Var(ln PQ)	Components (%) Price Var(ln P)	Quantity Var(ln Q)	Covariance 2Cov(ln P, ln Q)
Coffee	0.1371	76.59	10.58	12.84
Tea	0.0527	105.69	47.82	-53.51
Hides & Skins	0.1124	52.22	31.23	16.55
Pyrethrum Extract	0.0454	241.85	197.36	-339.21
Beans & Peas	0.4105	8.21	84.24	7.55
Tinned Pineapples	0.2396	14.27	56.59	29.13

for coffee, tea, and hides and skins, price played a dominant role. The variability of quantity dominates in the case of pineapples and beans and peas. As for pyrethrum, the covariance term between price and quantity dominates.

The sign of the covariance term is often used as an indicator of the source of instability. If supply remains unchanged, movements in demand lead to quantity and price variations in the same direction. Price and quantity vary in opposite directions if demand does not change when shifts in supply occur. For a small open economy facing no international trade barriers, the demand for its exports is perfectly elastic. Similarly, producers who market exportables through the marketing board, which then takes the responsibility of marketing abroad, face an infinitely elastic demand at the board's prices. Consequently, price and quantity vary in the same direction whenever changes in the demand schedule occur. But, any shift in supply results in changes in the quantity exported only. If supply is perfectly inelastic, then quantity and price vary in opposite directions for any changes in supply. In this case, changes in demand results in price changes only.

A negative covariance term implies that demand changes have been relatively stable while supply changes have been unstable. In any particular year, if the value of prices and quantities are below or above the trend line, then a positive covariance term is expected. This would occur if supply changes in a steady manner while demand changes are relatively erratic.

From Table IV, tea and pyrethrum have negative covariance terms, suggesting that the source of instability has been on the supply side. For the rest of the export commodities, the signs of the covariance terms are positive, indicating that in general, demand fluctuations have been the main source of instability.

The above analysis has centered on exports of Kenya. Except for beans and peas, all the commodities are storable after some processing. In absence of suitable storage facilities at the farm level, the commodities are generally perishable. Hence, producers have to sell to marketing agencies immediately after harvesting. Thus, it is of interest to identify the sources of instability of producer income by considering the quantity delivered to the marketing boards and the average price to the producer. In this way, sources of instability of the domestically marketed commodities can be evaluated and compared with the indices for export-oriented commodities.

Policy changes on commodity prices occurred in 1975 to reflect the surge of inflation that started after 1972. To obtain more insights on producer income instability, data are divided into two sets. The first set covers the period 1964-73 while the second set covers the period 1974-83. In both cases, instability of the five major market-oriented commodities are considered.

With respect to coffee and tea, the sources of export earnings instability are presented in Table V. During the 1964-73 period, the variability of quantity exported was dominant. There was a low positive correlation between the quantity exported and the f.o.b. prices earned. Since the covariance terms are positive, one could conclude that volatility in the demand side was the main course of earnings variability. The importance of price variability as a source of earnings instability rose significantly in the later period for both commodities. In both cases, the covariance terms contributed more to total fluctuations than quantity terms. Correlation coefficients between the quantities exported and f.o.b. prices improved. Unlike the former period, there was a higher correlation between the earnings and quantities than between earnings and prices.

Of interest to producers is the income instability for the commodities they sell to the marketing agencies. In most cases quantities exported do not fully reflect quantities sold by farmers to the marketing agencies during the year because of storage by the marketing agencies. Also, commodity taxation by the government and marketing costs, both at the producer and the agency levels, reduce the price paid to producers. Using average producer prices, and gross

TABLE V

COMPONENETS OF EXPORT EARNINGS INSTABILITY FROM COFFEE AND TEA FOR SELECTED PERIODS*

	Commodity							
	Coffee				Tea			
	Total	Components (%)			Total	Components (%)		
Period	Var (ln PQ)	Var (ln P)	Var (ln Q)	2Cov (ln P, ln Q)	Var (ln PQ)	Var (ln P)	Var (ln Q)	2Cov (ln P, ln Q)
1964-83	0.1371	76.59	10.58	12.84	0.0527	105.69	47.82	-53.51
1964-73	0.0400	30.50	50.00	19.50	0.0199	29.65	69.35	1.01
1974-83	0.1940	72.47	4.38	23.19	0.0834	52.64	21.94	25.54

* Percentages indicate the proportional contribution of each component to total variability.

marketed production during the two periods, the decomposition process yields the results presented in Table VI. The striking feature for the export crops is that the stability of f.o.b. prices does not necessarily mean that average producer prices are stable. Considering the period 1964-83, volatility in price was a major source of income fluctuations in coffee, tea and wheat while variability in quantity contributed to most of the instability in income from maize and milk. The covariance terms indicate that except for coffee, supply fluctuations were the major sources of income instability. The negative correlation coefficients between the prices and quantities of tea, maize, wheat and milk imply that one of the variables was declining while the other was increasing. The original data indicated that in the 1960s, prices paid to farmers exhibited a slightly downward trend.

During the period 1964-73, variability in quantity was dominant (Table VI). The figures for the 1974-83 period suggest that price volatility was important for all commodities except for maize and milk which had quantity as the major source of variability. The 1964-73 period had variability in supply as an important instrument in total commodity income instability. Except for wheat, the covariance terms suggest that fluctuations in the demand for commodities were sources of income instability during the 1974-83 period. Unlike the former period, the correlation between prices and quantities was positive except in the case of wheat. The correlation between milk prices and quantities marketed remained positive in both sets of data.

Several factors contribute to the negative correlation between prices and quantities during the 1964-73 period. Generally, price

TABLE VI

COMPONENTS OF INCOME INSTABILITY FROM SELECTED MARKETED PRODUCTION

	Period											
	1964-73				1974-83				1964-83			
	Total	Components (%)			Total	Components (%)			Total	Components (%)		
Commodity	Var (ln PQ)	Var (ln P)	Var (ln Q)	2Cov (ln P, ln Q)	Var (ln PQ)	Var (ln P)	Var (ln Q)	2Cov (ln P, ln Q)	Var (ln PQ)	Var (ln P)	Var (ln Q)	2Cov (ln P, ln Q)
Coffee	0.0286	52.80	54.90	-7.69	0.2015	69.03	4.76	26.20	0.1347	77.13	9.43	13.44
Tea	0.0086	76.74	132.56	-109.30	0.1095	51.69	14.06	34.34	0.0754	105.31	23.74	-29.05
Maize	0.0934	22.27	86.51	-8.78	0.2324	7.79	73.54	18.67	0.1501	36.24	96.47	-32.71
Wheat	0.0485	11.55	111.08	-27.63	0.0087	59.77	55.17	-16.09	0.0736	61.68	46.06	-7.74
Liquid Milk	0.0531	22.60	74.39	3.01	0.0309	21.68	53.40	25.24	0.0603	34.16	151.41	-85.57

trends were declining while production was expanding. Expansion in production was attributed to increased yield per unit area especially for maize due to the rapid adoption of the hybrid seed technology. The introduction and subsequent rapid adoption of the new maize variety in the 1960's opened up an alternative price policy that producer prices would be reduced progressively as returns per unit area increased due to yield increases. This policy was implemented in 1966 to obviate unnecessarily large surpluses that could be exported at a loss. The ultimate producer price would be that at which surpluses could be exported profitably and at the same time encourage production to match with the domestic market needs (Leys, 1975 and Yoshida, 1966). Lobbying by producers, coupled with several periodic droughts, led to a reassessment of the policy that resulted in maize price hikes in 1971.

The area under the traditionally plantation crops, coffee and tea, expanded as a result of post independent government policy that encouraged smallholder participation. The subdivision of large scale farms and absence of appropriate technology for small scale production led to a decline in the production of wheat. In some cases, limited production activities hampered the diversion of resources away from those commodities whose relative prices were declining. It is not uncommon in Kenya for producers to depict this less "rational" behavior.

Notwithstanding the perception of underdevelopment theorists, agricultural production for export and domestic markets in Kenya are interdependent. Domestic exports are vulnerable to international market fluctuations while those directed to the domestic market are subject to government control. The linkages between these categories, in addition to government attempts to insulate domestic production from vagaries of world prices, reenforce the need to stabilize total income through balanced production.

Given that the government's primary goal is a secure domestic food supply, the share of export-oriented production that minimizes total income instability is worth noting. The variability of combined income from coffee and tea, the main exports of Kenya, has been fairly constant over the study period (Table VII). As compared with the combined income variability from maize, wheat and milk, income instability from exports has been higher than from domestic sales. Assuming no correlation between income from exports and domestic sales, then the S_e value has risen fro 0.12 in 1964-73 to 0.25 in

TABLE VII

PRODUCER'S INCOME INSTABILITY FROM AGRICULTURAL SALES FOR SELECTED PERIODS

Source	Period		
	1964-83	1964-73	1974-83
Variability of Income from Domestic Sales, Percent[a]	20.56	11.22	17.89
Variability of Income from Export Sales, Percent[a]	29.71	30.88	30.60
Share of Exports (Se), Percent[b]	0.32	0.12	0.25

[a] The index is a corrected coefficient of variation (I_{Gb}) derived from log-linearly detrended data.

[b] S_e is derived from equation (3.35).

the period 1974-83. These results imply that the share of export that leads to minimum income instability is relatively small.

Policy Implications

Analysis has revolved around important export and domestic market agricultural commodities. Results indicate that the data exhibited some trend factor. Among the common procedures for removing trend, a semi-log function led to the derivation of an appropriate measure of earnings instability. An appropriate measure or index is one that is founded in sound economic theory and statistical expectations. The index, IG_b, is a corrected CV in percentages and therefore, intercommodity comparisons are possible. The simple CV is not useful for trended data although it is commonly used.

The results of the study indicate that IG_b is sensitive to the numeraire currency. The Deutsche mark, for example, shows that in the case of coffee, the measure can differ by as much as 45 percent from that obtained when the Kenya currency is the denominator. The rest of the commodities exhibited similar results. Under such situations, a natural problem for exporters is to decide on the relevant vehicle currency. To the extent that instability in income is a cost, then the common choice would be that which minimizes this volatility. The results of the study imply that the US dollar or the Special Drawing Rights (SDR) could be better substitutes for the shilling. Moreover, the US dollar has high correlation with all the major currencies considered and also is an important currency in world trade.

An alternative option for a Kenyan exporting agency would be to request payments in US dollars or the Special Drawing Rights (SDR).

SDR is increasingly being accepted as a unit of international transaction. Alternatively, the national currency could be pegged to the US dollar or the SDR.

Similar studies on export earnings instability suggest that the source of income fluctuations is of crucial importance in a stabilization program. The effects of income stabilization will differ depending on whether the root cause is demand or supply shifts. Mixed results were obtained for the 20 year period covered in this study. For coffee, hides and skins, beans and peas, and tinned pineapples, demand changes have been the main source of income variability. Hence, for these commodities, foreign demand conditions heavily influence the instability of their proceeds. Fluctuations in supply are attributed to the instability of export earnings from tea and pyrethrum extract. Thus, there is no general rule for stabilizing all the major agricultural exports.

An examination of changes in the variability of earnings for coffee and tea show that instability as measured by variance increased. Also, the dominant source changed from being variability in quantity in 1964-73 to being price variability in the next decade. Furthermore, the values for their covariance terms increased. During the entire period, supply shifts were the major causes of earnings instability for the commodities that are produced primarily for the domestic market. But the primary sources of instability changed from volatility in supply in 1964-73 to fluctuations in demand in 1974-83 arising from big price changes for export crops.

Where the source of instability is external in nature, the stabilization program becomes an international problem. However, macroeconomic instruments such as currency exchange rates can be used to influence export earnings. For instance, the common maintenance of overvalued exchange rates results in higher prices of the primary exports given the inelastic nature of their demand in the world market. Supply dominated fluctuations in a system with a lot of government participation would require a reorientation of existing government intervention policies. Also, changes in existing government market control policies are essential for alleviating income instability caused by fluctuations in domestic demand.

In search for specific explanations of income instability, it is worth exploring the composition of proceeds from the quantity delivered to the marketing agencies rather than that from exports. Government policies have not been consistent when the whole period is considered. Compared to the earlier decade, during the 1974-83 period, the contribution of quantity components to total variability declined. In the second decade, income variability for coffee, tea, and maize have increased. Those of wheat and milk have declined. The correlations between prices and quantities changed from negative to positive for all the commodities except wheat. The overall condition has been a reversal from supply as a dominant source of instability to demand changes being the major factor.

As for export crops, the implication of the changes is that external markets are increasingly playing a key role in producers' income instability. In the case of commodities that are marketed domestically, fluctuations in money income tend to originate from the domestic market and not at the farm level. Government intervention practices in the operation of the market for the good have not been constructive in terms of stabilizing producers' income. It follows, therefore, that an evaluation of alternative producers' income stabilization programs are essential.

One general policy option emanates from this analysis. If the objective is to stabilize producers' money income, then the Kenyan government must develop the capacity to finance possible transitory deficits. Specifically, the importance of coffee and tea in Kenya's economy imply that fluctuations in their earnings should be alleviated if a more stable domestic economy is to be achieved. The importance of international trade is affirmed by the results indicating that income instability from exports has increased from 38.14 percent in 1964-73 to 172.11 percent during the 1974-83 period.

Chapter Summary

The central purpose of this chapter was to measure and identify income instability during 1964-83 and subperiods within the time span. On international trade, the objective was to develop a statistic for measuring Kenya's export earnings instability. In the process, earnings instability measures and sources for selected export crops were quantified and specified. It was noted that quantities exported and f.o.b. prices paid during a given year were not necessarily equal to quantities marketed and the average prices received by the producers. Due to a less than perfect market situation, it was assumed that producers may be more interested in income variability from commodities delivered to the marketing agencies rather than the instability of export earnings as derived from f.o.b. unit prices and the quantity exported by the marketing agency. Following this assumption, producer's income instability from selected marketed commodities were examined.

A common feature of export earnings instability indices is the use of foreign currency, which explicitly or implicitly is the US dollar, as the denominator when deriving instability indices. The approach ignores two important facets of trade and development: that producers are paid in domestic currency and that the overriding concern of most governments is domestic stability. Since governments can use macroeconomic instruments to insulate domestic producers, then export earnings instability measured in foreign currencies do not necessarily translate into income instability as realized by domestic producers. Moreover, producers' income variability may differ according to the primary destination of the product. In consequence, two hypotheses were formulated. First, an attempt to test the validity of the notion that the domestic currency was the appropriate numeraire was undertaken. Secondly, it was hypothesized that the primary destination of the product, whether for export or domestic market, influenced the magnitude and the source of instability.

Trend-corrected measures of instability using selected numeraire currencies and commodities were derived. The results indicate that the instability index was sensitive to the vehicle currency used. Also, the degree of instability varied with the commodity under consideration. The Kenya shilling did not often yield the lowest instability index.

Considering coffee and tea, the two most important export crops, fluctuations in price contributed most to their export earnings instability. However, during the first 10 years, the contribution of quantity to total variability was dominant. The dominance of price variability prevailed during the later decade. Hence, not only has variability of earnings increased but also the source has changed over the 20 year period. In consequence, using this criterion, the concern of the policy makers facing such situations should be more on external demand rather than domestic production. This requires stronger multilateral cooperation between producers and consumers as in the case of coffee or some other cohesive international commodity cartel.

Comparing producer income instability for 1964-73 and 1974-83, the variability in the income from coffee, tea, and milk has increased. That of wheat and maize has declined. In all cases, the proportional contribution of quantity to total variability has decreased. The sources of instability, as indicated by the signs of the covariance terms have shifted from supply dominated to demand dominated fluctuations in the case of coffee, tea, and maize. The situation for wheat and milk are supply and demand dominated fluctuations, respectively. In the case of coffee and tea, income instability measures support the findings obtained in terms of export earnings instability. Maize, the staple foodcrop in Kenya, followed the pattern of the primarily export crops. For wheat, the policy direction should be on domestic production.

Except in the case of wheat, there is an indication that changes in both export and domestic demand are becoming the major source of income variability for the market-oriented commodities. This suggests that a restructuring of the market is essential for increased income stability irrespective of destination. Furthermore, the increased price-quantity correlations exhibited by most of the commodities studied would suggest that potential gains in terms of increased stability might be obtained through price manipulation by the Kenya government. On total income instability, the results indicate that the high level of export earnings variability was accompanied by an increase in the proportion of exports in total income during 1974-83. Apparently, income stabilization measures favored only domestic marketed commodities.

This study is based on time series data for the period 1964-83. The results are, therefore, period specific and may not be appropriate for other periods. However, the validity of the results within the time span are not expected to change drastically. The analytical procedure is limited by the fact that the underlying production complexities are excluded. A detailed study is required to isolate the causes of production instabilities. Variation in output may be due to changes in yield per unit area or due to changes in area under cultivation. Also, changes in export earnings may be attributable to fluctuations in the effective exchange rate rather than the volatility in the quantities exported.

The next chapter presents the results of a simulation model. This is a follow-up of the findings reported in the current chapter. The objective of the model is to evaluate alternative government stabilization programs with the intention of predicting their effects on producer income instability.

CHAPTER V

EFFECTS OF GOVERNMENT STABILIZATION PROGRAMS

Introduction

In the proceeding chapter, measures and sources of producers' income instability for selected marketed agricultural commodities in Kenya were presented and discussed. It was shown that the instability index was sensitive to the numeraire currency used and the commodity concerned. Also, sources of income fluctuations varied with the commodity. Given the nature of production and marketing, it was proposed that commodity market restructuring would be an alternative policy goal in an attempt to stabilize producers' income irrespective of the destination of the produce.

The results of a policy simulation model are presented and discussed in this chapter. The details of the model were described in Chapter II. Owing to the limited influence the Kenya government has on international trade, the study is restricted to domestically marketed commodities. The primary goal is to evaluate the effects of government intervention policies on producer income instability. Thus, the chapter is organized as follows. The next section describes the data used. In the third section, pre-input and input equations are stated. Subsequently, simulation results for selected scenarios are presented. A summary is presented in the last section.

Data Requirements

Producers are paid in the national currency. Hence, derived instability measures are denominated in Kenya shillings. Time series data from 1964-83 are used. However, due to structural changes that have affected some commodities, selected subperiods are used in the estimation of the equations.

Post-independence policy on maize started with the drought and famine of 1965. Following the event, producer prices and national strategic reserves were increased in an attempt to stabilize domestic supply. Several subsequent policies have revolved around producer prices and the strategic reserves. The area in wheat cultivation reached its peak in 1968. Since then, its area has been declining. The two cereal crops have not had consistent post-independence pricing policies. Milk production quotas were abolished in 1970 and now producers are paid uniform prices for any grade of whole milk delivered to the Kenya Co-operative Creameries. The impact of the policy changes were felt in subsequent years.

As discussed earlier, agricultural markets for the major food commodities in Kenya can be described as functioning in a non-Walrasian environment. The actions of the government lead to quality adjustments that equilibrate the market at preannounced producer and consumer prices. Hence, in addition to prices, data sets of quantities produced and crop areas were assembled. These data were used to estimate, econometrically, the initial supply parameters of the model. Although the model is capable of linking domestic and world markets, concentration on domestic marketed commodities negated the necessity of incorporating these linkages into the current model.

Results

Initial Input Information

The parameters of the aggregate supply function were estimated. A common assumption in such approaches is that the data are free of measurement errors. In absence of ideal data sets, measurement errors are suspected. However, these are assumed to be relatively unimportant.

Equations from initial estimation had Durbin "h" statistics which were less than the critical values at the 5.0 percent level, indicating that the hypothesis of no serial correlation could not be rejected. An autoregressive least squares procedure was adopted yielding the following, with t-values in parentheses:

$$\ln QSW = 3.770 + 0.321 \ln RW + 1.126 \ln WH \qquad (5.1)$$

$$(1.117) \quad (4.475^*) \quad (4.394^*)$$

$$R^2 = 0.63, \quad D.\ W. = 2.202, \quad N = 16$$

$$\ln QSM = -13.856 + 0.546 \ln RM + 1.951 \ln MH - 0.465 \ln RW \qquad (5.2)$$

$$(-2.882^*) \quad (3.408^*) \quad (4.476^*) \quad (-2.593^*)$$

$$R^2 = 0.76, \quad D.\ W. = 1.510, \quad N = 19$$

$$\ln QSME = 7.253 + 0.299 \ln PME - 0.333 \ln RM + 0.506 \ln QSM \qquad (5.3)$$

$$(4.851^*) \quad (2.264^*) \quad (-2.664^*) \quad (3.357^*)$$

$$R^2 = 0.57, \quad D.\ W. = 2.45, \quad N = 13$$

where

QSW = quantity of wheat delivered to the marketing agency, in metric tons.

RW = expected unit revenue from wheat. Defined as the product of preannounced price and the expected output per hectare where expected output is the previous year's output per hectare. The details and justifications are given in Chapter III.

RM = expected unit revenue from maize. Defined as the product of preannounced price and the expected output per hectare where expected output is the previous year's output per hectare. The details and justifications are given in Chapter III.

WH = hectares allocated to wheat production.

QSM = quantity of maize delivered to the marketing agency in metric tons,

MH = hectares allocated to maize production,

QSME = quantity of liquid milk equivalent delivered to the creameries in liters.

PME = expected average unit milk price to the producer. This is the current value lagged one year.

ln = the natural logarithm.

* implies that the parameters are significant at less than 0.05 level.

Since the equations were specified in double-log form, coefficients associated with regressors are elasticities. The function is linearly homogenous and thus exhibits constant returns to scale. The results indicate that quantity responses to change in land area are high. Also, there is an inverse relationship between the quantity of maize supplied and the expected unit revenue from wheat. The same case applies to milk production and maize revenue. These observations are expected because in certain areas, production activities compete for land. The positive relationship between maize and liquid milk supply suggests complementarity. This could be attributable to the use of maize as a major ingredient in the manufacture of dairy feed, in addition to absence of effective competition for some basic resources.

The parameters estimated above and the values of exogenous variables, assumed to be equal to their 1983 levels, formed the initial state variables. The values of the exogenous variables in 1983 are given in Appendix A. Weather factors, represented mainly by rainfall, were assumed to be the source of stochastic events. A twenty-year rainfall data set from representative weather stations in Kenya was gathered. The set was then used to derive, where possible, an empirical distribution of rainfall during the relevant months. Having noted the frequency distribution of rainfall, a normal probability distribution was considered as appropriate. Furthermore, it was assumed that the random events were log-normally distributed, following the preassumption made in Chapter III.

Uniformly distributed random numbers on the interval (0,1) were generated using the RANF(NARG) sub-routine. These random numbers were translated to normally distributed random variates using the GAUSF function. GAUSF generates random numbers according to a Gaussian distribution with mean zero and standard deviation of one. Given a random number from a Gaussian distribution with mean $\hat{u}$ and standard deviation $\hat{\sigma}$, random variates can be obtained using the relationship

$$RNG = \hat{u} + \hat{\sigma} * GAUSF \qquad (5.4)$$

where

RNG is the random variate.

In this study, both TEMP and W are random weather variates derived from the relationship in (5.4). The input equations were as follows:

$$QWS = 3.770 + 0.321RW + 1.120WH + TEMP \qquad (5.5)$$

$$QSM = -13.856 + 0.546RM + 1.951MH - 0.465RW + W \qquad (5.6)$$

$$QSME = 7.253 + 0.299PME - 0.333RM + 0.506QSM + W \qquad (5.7)$$

Equation (5.5) refers to wheat supply while equation (5.6) and (5.7) refer to maize and milk supply, respectively. The stochastic elements, TEMP and W, denote rainfall conditions in the representative growing areas for the respective commodities. In Kenya, maize and liquid milk production activities tend to be closely related whereas wheat production is mainly associated with the production of beef cattle and sheep. Thus, it is plausible to assume that the disturbance terms in equation (5.5) are different from those in equations (5.6) and (5.7).

In an open economy scenario, it was assumed that prices were random. Price observations for the commodities were those paid in the world market. The data for estimating the means and the standard deviation were obtained from World Bank publications. Thus, given the means and standard deviations for the respective commodities, random prices were then generated with the assumption that their distribution was Gaussian.

Policy actions adopted in the study are described in Chapter III. In each casE, the decision rules revolve around expected revenues. Thus, simulation runs are undertaken to test the consequences of different policy actions on producers' income as represented by revenues from each commodity. To derive unit revenues for the dairy activity requires a knowledge of hectares allocated to it. This was not forthcoming. Hence, it was assumed that the quantity supplied could be a proxy for the revenues associated with dairying given that prices are often fixed by government.

The required sample size for the simulation runs can be calculated using the procedure outlined in Snedecor and Cochran (1967). The required sample size, n, is given by

$$n = 4s^2/E \qquad (5.8)$$

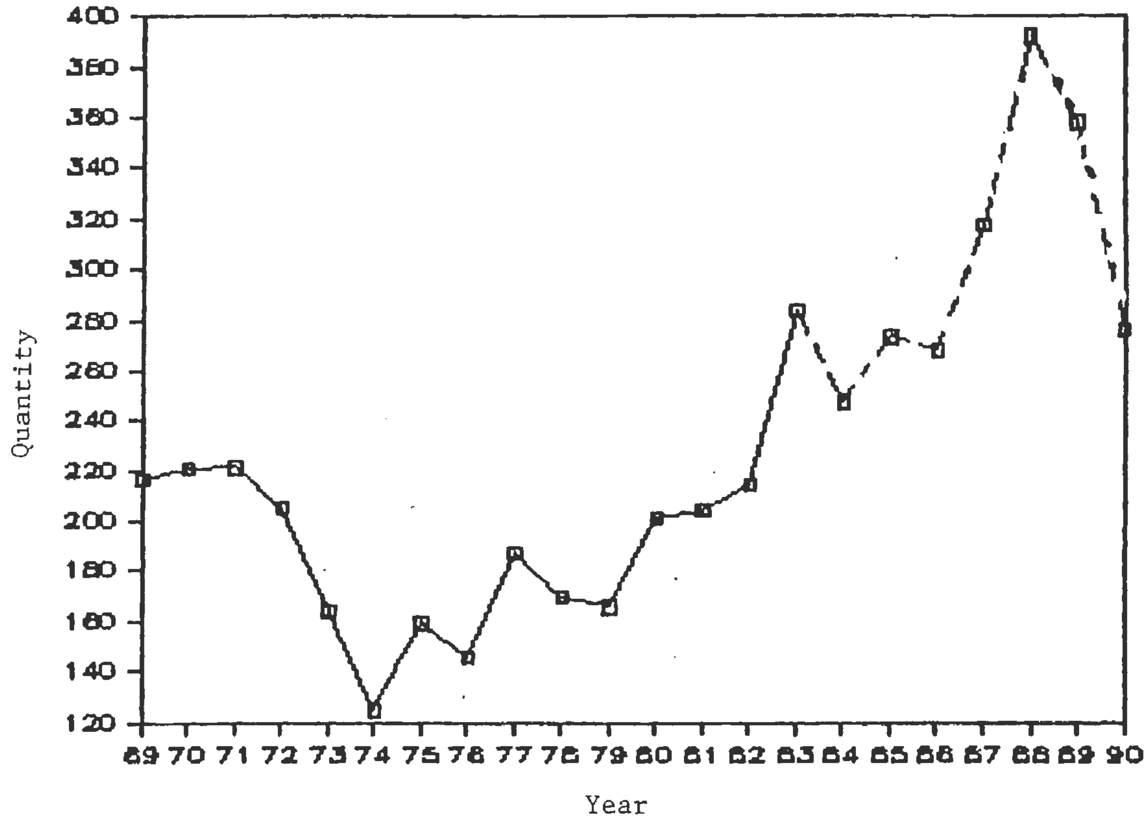
where s^2 is an estimate of population variance and E is the allowable error. S^2 for wheat was 1.04, for maize and milk equivalent, the values were 1.30 and 1.26, respectively. Using the above relationship and assuming the allowable error is a metric ton, then the sample size that could be used in all the studies was at most six. However, a larger sample of 15 was chosen. Studies that have followed similar approaches have used larger sample sizes. Bigman (1985) assumed a sample size of 20. Performance measures derived are obtained from 20 annual replicates. Thus, overall results represent long run performance measures.

The preceding discussion referred to the initial state of the system. The sequential nature of the model implies that subsequent states are derived from the initial state after adjustments. The adjustments depend upon the objectives of the simulation experiments.

Results of the Simulation Experiments

Four simulation experiments were carried out to test the effectiveness of predetermined government policies. The details of each scenario were described in Chapter III. Briefly, the first alternative adopts a strategy whereby the government preannounces commodity prices and brings about market equilibrium under the price regimes. The scenario is defined here as one with fixed producer prices. The second situation is one with no government intervention. Producer prices are determined by purely economic forces. Similar price situations are adopted for the third and the fourth policy alternatives. However, in the third case, government intervenes through the maintenance of a floor producer price. In the fourth strategy, government intervention comes in the form of a predetermined minimum revenue. In each case, the performance measures are means and variability of farmers output and revenues.

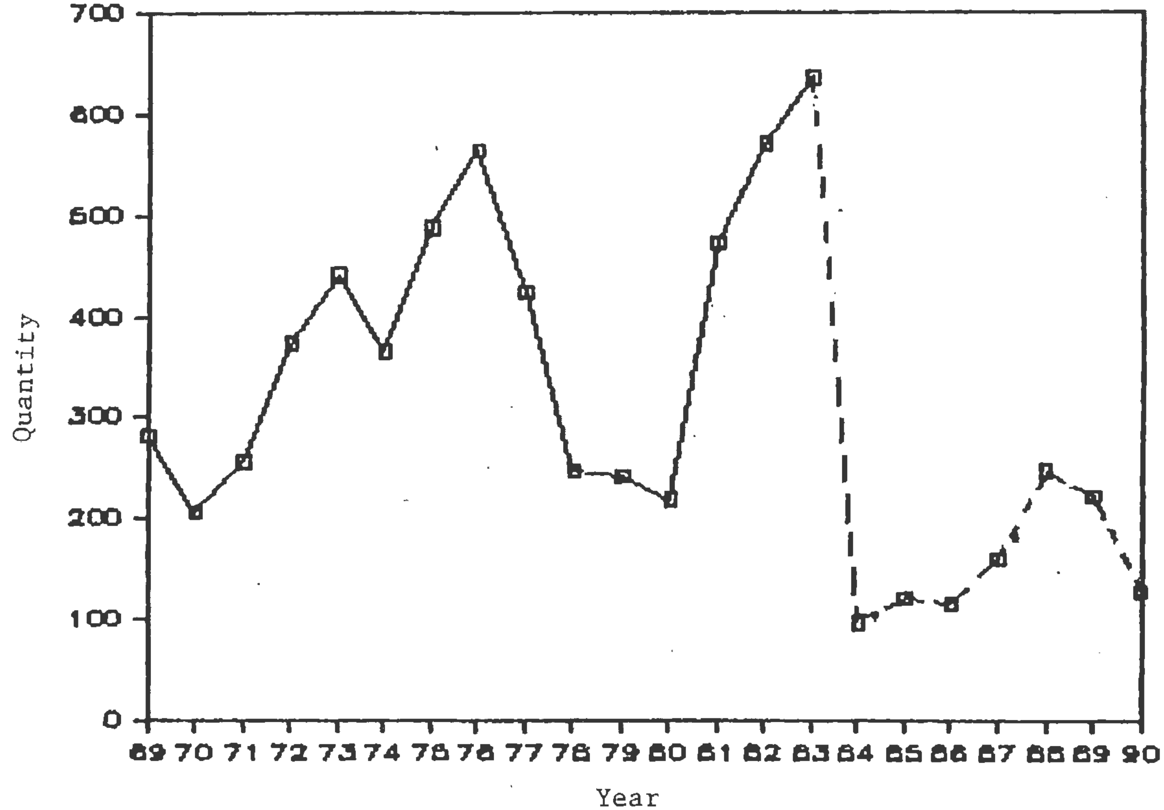
Assuming that producer prices are fixed, then, variability in income would be attributable to changes in the quantities marketed. In Figures 5, 6, and 7, actual quantities marketed are depicted from 1969 to 1983, while the simulated values are illustrated from 1984 to 1990. The results suggest that under the assumed scenario, output for all the commodities would drop in 1984 and then rise in the latter years. In the case of wheat and maize the peak period is 1988. For milk, the peak period is 1989.



Key:

—— Actual output, 1969-1983.
--- Simulated projection, 1984-1990.

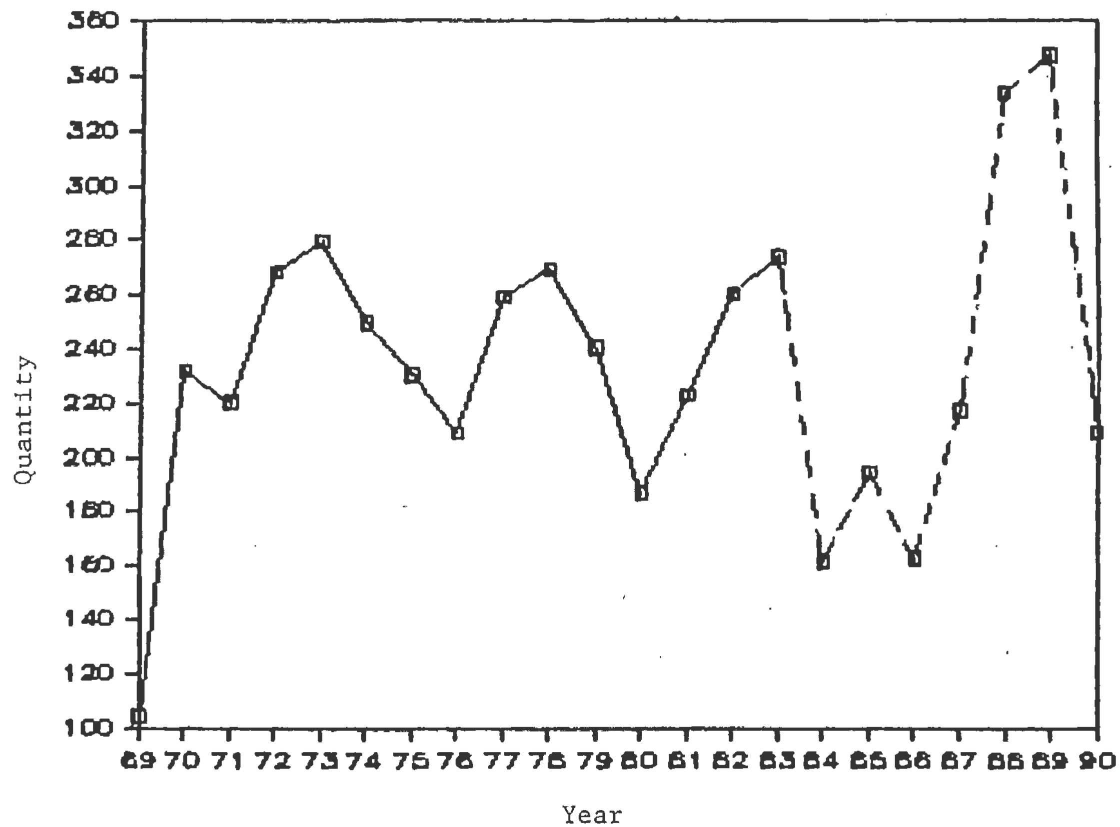
Figure 5. Actual and Simulated Output of Wheat in Thousands of Metric Tons



Key:

—— Actual output, 1969-1983.
--- Simulated projection, 1984-1990.

Figure 6. Actual and Simulated Output of Maize in Thousands of Metric Tons



Key:

—— Actual output, 1969-1983.
--- Simulated projection, 1984-1990.

Figure 7. Actual and Simulated Output of Liquid Milk in Thousands of Metric Tons

Table VIII summarizes the results of the simulation experiments. An obvious feature is the different effects the policies have on the individual commodities. For wheat, absence of government intervention reduces the quantity marketed. A guaranteed minimum revenue program leads to the highest levels of output. Wheat supply ranges from 211800.8 to 314574.8 metric tons. Absence of government intervention provides the maximum maize output. Quantities of maize supplied range between 147,673 metric tons under a fixed price scenario to 473,428 meric tons without government intervention. As for milk, a guaranteed minimum revenue strategy for maize and wheat lead to highest output. The scenario that maximizes output does not necessarily maximize unit revenues. These figures suggest that current fixed producer price policy neither enhances producer output nor unit revenues.

A common concern of governments is the stability of output and producer earnings. To this end, the Kenya government attempts to increase production and at the same time maintain reasonable stability in output and producer revenues. Table IX indicates that minimum income instability is achieved by adopting a fixed price strategy. In addition, the strategy leads to the most stable supply except for maize where the alternative is a guaranteed minimum revenue policy.

As percentages of fixed price values, the figures in Table IX show that only wheat output would fall below the fixed price results whenever other alternatives are adopted. But without government intervention, revenue would fall by about 3 percent from the fixed price value. For maize and milk, outputs rise whenever strategies other than fixed price policy are adopted.

To conclude, the model suggests that the current policy is

TABLE VIII

SIMULATION MODEL: SUMMARY STATISTICS BY POLICY

		Fixed Producer Prices	No Government Intervention	Guaranteed Minimum Revenue	Minimum Price Support
a) Wheat					
Quantity	Tonnes	296832.10	211800.80	314574.80	226810.70
Standard Error	Tonnes	63186.59	153266.70	101754.50	172644.50
Revenue	KSh/Ha	12218.88	11813.80	19165.00	16117.37
Standard Error	KSh/Ha	1885.41	29734.46	14147.00	44208.13
b) Maize					
Quantity	Tonnes	147672.90	473427.50	197940.70	457795.50
Standard Error	Tonnes	63113.29	242849.10	82967.00	230170.10
Revenue	KSh/Ha	1516.22	12167.82	4346.27	13318.42
Standard Error	KSh/Ha	379.99	30231.90	3553.62	31613.92
c) Milk Equivalent					
Quantity	Million Liters	231820.10	818898.20	1031430.00	805020.60
Standard Error	Million Liters	77614.99	348919.90	844700.00	348330.10

TABLE IX

SELECTED PERFORMANCE MEASURES FOR COMMODITIES BY POLICY

		Fixed Producer Prices	No Government Intervention	Guaranteed Minimum Revenue	Minimum Price Support
a) Wheat					
Quantity*	Tonnes	100.00	71.43	106.09	76.49
CV %	Tonnes	21.29	51.69	32.35	76.12
Revenue*	KSh/Ha	100.00	96.68	156.85	131.91
CV %	KSh/Ha	15.43	243.35	73.82	274.29
b) Maize					
Quantity*	Tonnes	100.00	320.59	134.04	310.01
CV %	Tonnes	42.74	164.45	41.92	550.28
Revenue*	KSh/Ha	100.00	802.51	286.65	878.40
CV %	KSh/Ha	25.06	1993.90	81.76	237.37
c) Milk Equivalent					
Quantity	Million Liters	100.00	353.25	444.93	374.26
CV%	Million Liters	33.48	150.51	81.90	43.27

* As a percentage of fixed producer price scenario.
CV % Coefficient of Variation, percent.

suitable for stability of income from the cereals studied. Also the option stabilizes the output of wheat and milk. An alternative to fixed price policy for maize is the guaranteed minimum revenue option that is accompanied by a rise in revenue variability. None of the four policy options considered could be singly applied to all the commodities studied and achieve the desired goals in spite of their interrelationships at the farm level.

Chapter Summary

The need to use a flexible analytical tool led to the development of a simulation model for this later part of the research. The model was used to evaluate four policy alternatives for stabilizing producers' income. Only the supply sector was considered on the assumption that production was not directly influenced by consumer preferences. Rather, the prevailing market quantities and prices were predetermined by the government. Three supply equations representing wheat, milk and maize production were estimated by autoregressive least squares technique. Most of the coefficients were highly significant in spite of low R^2 values (a situation not unusual for developing countries).

Performance measures derived from the data generated by the simulation suggest that fixed price policies were appropriate for stabilizing the producers' income from maize and wheat. Similarly, the program led to the least unstable output of wheat and milk. However, a policy that guarantees a minimum revenue favored maize output stability but enhanced its revenue instability. The interdependence of the commodities at the farm level and thus a modified policy alternative for the three commodities was not forthcoming. Consequently, there is a need to extend the model to incorporate other likely policy alternatives.

The next chapter summarizes the findings from the two analytical procedures used in the study. Conclusions are also presented. The chapter concludes with the policy implications of the study and the scope for future research.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary

The central purpose of this study was to identify and quantify the important sources of farm income instability in Kenya. In addition, the research has attempted to evaluate alternative stabilization policies under selected economic scenarios. To accomplish this goal, a number of agricultural commodities were selected.

Basically, the analysis centered on five commodities: coffee, tea, maize, wheat and milk. However, the initial study included four other export commodities. These additional commodities were hides and skins, pyrethrum extract, beans and peas, and tinned pineapples. The purpose was to provide a larger sample on which more relevant conclusions could be made. Exports were identified by their destination. Time series Kenyan data were obtained from various issues of the Central Bureau of Statistics and Economic Surveys, Kenya. The relevant exchange rates were obtained from International Financial Statistics. World commodity prices were obtained from various issues of the Commodity Trade and Price Trends, World Bank. The study covered the period 1964-1983.

To establish a suitable numeraire currency, earnings from exported commodities were valued in seven currencies and a basket of currencies represented by the Special Drawing Rights (SDR). Two regression models were used to correct for trend: linear and log-linear. For each commodity by currency, a "corrected" coefficient of variation was calculated as described by Cuddy and Della Valle. The measure facilitated comparisons across several types of trend relations.

Sources of instability were determined by decomposing statistical identities. In this analysis, more emphasis was on the five most important commodities: Coffee, tea, maize, wheat and liquid milk. Since producers are paid in domestic currency, income from the commodities were in terms of Kenya Shillings. Decomposing multiplicative identities were relevant to income defined as the product of price and quantity marketed. Additive identities were decomposed whenever producers' income was an aggregate.

The second part of the study was concerned with the evaluation of alternative government stabilization policies in unstable environments. This was achieved through a simple sequential simulation model. The parameters were estimated by autoregressive least square technique. The stochastic component was assumed to be weather. The demand component was not relevant in this analysis because the government through its agencies determine the equilibrating quantities situation at government preannounced prices.

Four policy alternatives were considered. The first assumed continuation of existing fixed producer prices policy. The second assumed that producer prices were random and reflected those prevailing in the world market. The third scenario considered a government guaranteed minimum income policy. The final scenario involved a government set price floor with market prices above the minimum floor. Performance measures were calculated from each simulation. These measures included average qualities supplied, average per hectare revenue and their variabilities.

Analytical results indicated that export earnings instability varied with the commodity and the currency involved. Of interest to the Kenyan producer is instability of domestic currency in relation to Kenya's trading partners. Instability measures derived from the Kenya currency was highly correlated with the US dollar and least correlated with the West German mark. Most indices derived from the various currencies were highly correlated with the US dollar.

To determine the sources of earnings instability, variance of total income was decomposed. In this case, the variance of earnings was taken as an alternative measure of instability. The results showed that price fluctuations were the main sources of total earnings variability. In the case of less important exports such as pineapples, beans and peas, quantity variability dominated.

The sign of the covariance term, negative or positive indicates whether fluctuations in supply or demand have been the source of instability. For the period 1964-83, the results suggested that except for coffee, the fluctuations in supply were the most important sources of income instability. Variability in producer price was dominant in total income from coffee, tea and wheat, while fluctuation in output was dominant in the case of maize and milk. Between 1964 and 1973, variability in quantity was dominant. Except for milk, supply dominated total income instability. For the latter decade, the contribution of quantity to total income instability was important for milk and maize. However, volatility in demand was important in all commodities except in the case of wheat. For the commodities considered in the study, the variability of farm income from exports was 30.88 percent during the 1964-73 period and 30.60 percent in the period 1974-83. Variabilities from domestic sales rose by about 7 percent between 1964-73 and 1974-83.

Results of the simulations suggested that for wheat and maize, the existing fixed price policy led to maximum per hectare income stability. A guaranteed income policy led to the most stable output for maize while a fixed price policy was relevant for the rest. In terms of total output, the guaranteed minimum per unit revenue scenario led to the highest output in wheat and milk. But, for maize a non-intervention policy as defined here was the appropriate strategy.

Conclusions

In reviewing procedures for measuring income instability, a number of commonly used techniques have been identified. It was noted that the term "instability" has neither been defined nor measured precisely. Consequently, several indices have emerged, often with limited comparability. An important issue in all instability studies is what sort of fluctuations are being measured.

It is believed that producers adopt strategies that minimize variability. In this study, an assumption was made that producers income fluctuate along a time path and that the frequencies of these oscillations are at least somewhat predictable. Consequently, they should be incorporated in to the producers' decision-making process. Accordingly, instability refers to temporary deviations from producers income. A commonly accepted measure of instability is the variance. However, the coefficient of variation is preferred when dealing with the variability of two or more variables with different means.

In Chapter I, four hypotheses were formulated for subsequent testing. First, it was postulated that export earnings instability could be approximately measured in Kenya's currency. An appropriate measure in this context is one that is least unstable and highly correlated with most other transaction currencies used. Using the Kenya currency as the numeraire resulted in the lowest indices for hides and skins and pyrethrum extract. For tea and tinned pineapples, the U.S. dollar led to least unstable indices. The relevant currencies for coffee and beans and peas were the Japanese yen and the Deutsche mark, respectively. However, in terms of correlation to other currencies considered, the U.S. dollar and the SDR were the best alternatives. The U.S. dollar, the Japanese yen and the SDR were closely correlated with the Kenya shilling. Thus, the official exchange rates did not translate different currencies uniformly.

The second hypothesis was that impacts on producer income instability were greater from exported commodities than from those marketed domestically. To compare income from export and domestic sales, the local currency was used as the numeraire. During the 1964-73 period, income instability from exports were lower than instabilities from domestic sales.

For the period 1974-83, the instabilities for exports were higher than for domestic sales except in the case of maize, which had the highest variability among the quantities considered. The results, thus, suggest that income instability from exports have increased, while those from domestic sales have declined except in the case of maize. Aggregate income instability from exports remained relatively constant while that of domestic sales rose slightly between 1964-73 and 1974-83. The variability of combined income from exports was consistently higher than that from domestic sales.

The third hypothesis assumed that effective policy instruments for stabilizing producers' income could be formulated. From the simulation results, the current fixed and preannounced producer price policy stabilized producers' commodity income. The same policy stabilized output of wheat and milk. A guaranteed minimum revenue strategy enhanced the stability of maize output. Absence of government intervention led to the highest instability values for milk output and revenue from maize. The highest instability measure for maize output arose from a minimum price support policy.

Finally, it was postulated that certain policies could be developed which could increase the stability of producers' income. To identify possible policy directions, some sources of income instability for each of the commodities studied were identified.

Some policy implications can be drawn from this study. These are summarized below.

1. In Kenya, the domestic currency of transaction is the Kenya Shilling. Hence, the appropriate measure of export earnings instability is that which is highly correlated with the local currency. In this case, the alternative currencies were the U.S. dollar, the Japanese yen and the SDR.

2. A fixed exchange rate regime insulates an economy that is more unstable than its trading partners, while a flexible one would be relevant for less volatile economies. This study indicates that a flexible regime would favor coffee exports, while a fixed would favor tea exports since its instability is generated internally. The importance of the two crops in Kenya's external trade means that a managed floating exchange rate regime would be a better strategy.
3. Income instability from externally marketed commodities could be alleviated through the institution of second-best policies. These would require resource shifts to less volatile activities. Alternatively, if the source is demand, then a form of international stabilization policy is relevant.
4. In the case of domestic sales, income instability could be managed through the use of suitable policy instruments. The role of government in stabilizing producer's income is particularly important where demand is the main source of instability.
5. The current fixed price policies have tended to stabilize revenues from grains. However, multiobjective programs are not often achieved through a single policy instrument. In this study, guaranteed minimum revenue policy led to increased output of maize but enhanced its revenue instability.

Limitations and Need for Further Study

This study suffers from a number of drawbacks. Primarily, decomposition of statistical identities precludes any direct reference to underlying structural relationships. Furthermore, due to data constraint, aggregate data were used. The results may not necessarily extend to the micro-level. Kenya produces a wide variety of agricultural commodities. However, only five most important commodities were studied in details. The selection criterion was the degree at which they influence Kenya's commercial agriculture.

The disturbance terms were assumed to be normally distributed. The sample size was dictated by the availability of data and the need to capture producers' income instability at a time when there has been a political consistency. Ideally, the structural stability of the two subperiods should have been tested.

In the simulation model, only supply aspects of three commodities were considered. More detailed information on weather is required. A more rigorous study should cover all the sectors that affect producers' income instability. These would include the farm input sector and the importance of unofficial markets. The use of nominal rather real values in this model and the earlier one was precipitated by lack of consistent price deflators.

A wide range of problem areas exist for further research. First, the structural relationship between export commodities and those marketed locally deserves further study. A research that considers not only marketed production but total production would provide much needed information for better decisions. Such a study could include changes in the monetary sector and their impact on income variability. The effects of risky production and product market environments on the overall welfare of the producers and consumers should be rigorously investigated. Finally, and perhaps of more immediate importance, is the need to analyze the long run implications of price rigidities on quantities produced and supplied to markets.

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APPENDIXES

APPENDIX A

BASIC DATA USED IN THE STUDY

TABLE X

KENYA DOMESTIC AGRICULTURAL EXPORTS IN METRIC TONS, 1964-83

YR	QC	QT	QS	MNQ	HSQ	FEQ	AFQ	WQ	BPQ	BBQ	TPQ	CNQ	WEQ
1964	42304	16567	57868	6330	5610	263	15362	1303	12823	2359	10553	4857	6533
1965	38399	15917	58246	6875	7411	274	10937	1370	9389	843	9073	6938	3913
1966	54461	22608	55750	8595	7602	321	18776	1438	12442	1032	6106	5778	5075
1967	50748	18480	41443	8280	6959	327	25359	1417	5632	746	6169	7954	2317
1968	37594	27499	41696	7094	6988	366	28408	1798	17711	1036	5278	8772	3547
1969	50969	32835	35755	6663	6548	367	29870	1821	10849	824	7959	9141	16564
1970	53725	36100	44508	7180	5983	265	31827	1635	9583	636	7465	23174	15056
1971	56426	34281	35150	7631	8271	369	28502	1313	12666	1046	10887	10604	15298
1972	63142	47297	38640	1024	10522	511	40942	1605	30768	2952	9776	15540	20815
1973	75317	51479	44926	6664	8226	358	35608	1499	18730	2774	13396	9381	12690
1974	71681	49599	72077	6780	9032	475	15299	1348	11646	2028	8678	20363	13507
1975	67615	52550	42717	8280	11940	314	15626	1231	19050	1112	20004	14327	14013
1976	77546	59267	29365	9775	14158	507	27224	1238	11470	1193	29904	11543	19327
1977	94314	70220	24935	9344	11374	418	17730	1361	22020	1063	45327	1100	11714
1978	85392	84966	25663	3033	10893	261	22626	1165	14779	1581	42082	0	9412
1979	77241	94023	25941	2643	13081	390	23030	1080	9735	1206	41048	73	11222
1980	80066	74759	49797	1253	9485	285	5201	1706	10137	230	39453	10700	11820
1981	86108	75330	36358	1890	12964	149	7794	1113	6960	565	40884	4222	10620
1982	100968	80413	40428	2916	11136	215	11705	1453	37814	878	39935	3272	9725
1983	90444	59541	36741	2267	9153	221	30318	1182	91657	1179	47755	5	6038

Source: Kenya Central Bureau of Statistics, Statistical Abstracts, Various Issues.

TABLE XI

KENYA DOMESTIC AGRICULTURAL EXPORTS: F.O.B. PRICES
IN KENYA SHILLINGS PER KILOGRAM, 1964-83

YR	PCN	PTN	PS	MMP	HSPN	PEPN	AFP	WF	BPP	BGPN	TFPN	CNP	WEP
1964	7.29	7.31	2.08	6.85	4.61	152.93	0.3619	7.80	0.81	6.39	1.69	1.21	2.70
1965	7.34	7.65	1.32	7.18	4.74	143.41	0.4095	8.10	1.01	6.94	1.71	1.42	1.06
1966	6.96	7.71	1.20	6.89	6.77	149.25	0.4213	7.80	0.93	7.59	1.75	1.52	1.11
1967	6.17	8.00	1.00	6.90	5.08	148.17	0.3655	6.90	1.16	6.80	1.77	1.39	1.07
1968	6.81	7.30	0.87	8.53	4.76	136.77	0.3564	6.40	0.94	6.16	1.67	1.46	1.09
1969	6.61	8.87	0.96	8.74	5.71	121.14	0.3438	6.00	0.97	6.66	1.82	1.49	1.38
1970	8.29	7.23	0.84	8.53	5.52	132.07	0.4107	4.40	1.07	7.14	1.79	1.37	1.52
1971	6.92	7.09	0.87	10.20	5.90	149.79	0.3959	4.00	1.13	8.17	1.78	1.41	1.58
1972	7.84	6.99	1.07	9.55	7.18	148.52	0.3003	4.60	1.04	7.67	1.89	1.35	1.62
1973	9.50	6.59	2.13	11.88	12.61	164.10	0.6480	10.70	1.46	7.44	2.22	1.30	1.91
1974	10.71	7.82	4.71	13.75	9.78	192.21	0.6388	10.30	2.97	8.00	3.26	1.59	2.12
1975	10.40	8.74	3.34	12.57	9.07	223.33	0.7958	6.90	2.42	9.69	3.54	1.59	2.46
1976	24.06	10.72	2.85	17.17	12.09	225.91	0.9997	8.10	2.89	9.69	4.67	1.73	2.79
1977	45.33	20.44	3.30	16.26	14.09	238.17	1.3455	11.40	2.49	12.25	4.64	2.29	3.13
1978	29.20	14.87	3.03	17.98	18.04	312.73	0.8994	11.90	2.88	12.03	4.55	0.00	3.16
1979	28.63	13.63	3.70	20.34	21.05	281.84	1.3418	12.90	3.04	14.04	4.54	15.54	3.50
1980	27.01	15.51	4.38	25.35	22.50	633.62	1.2475	11.10	2.99	15.89	4.60	3.12	3.56
1981	25.40	16.22	4.82	27.62	14.20	802.98	0.9687	17.50	5.62	20.66	5.87	7.92	5.17
1982	28.64	19.30	5.36	31.11	14.19	896.06	1.2156	16.70	3.27	23.24	7.26	9.87	7.24
1983	35.40	24.70	6.21	33.78	13.83	608.55	0.9433	15.90	2.98	25.22	8.75	57.87	9.30

Source: Kenya Central Bureau of Statistics, Statistical Abstracts, Various Issues.

TABLE XII

QUANTITY MARKETED IN THOUSANDS OF METRIC TONS, CROP AREA IN HECTARES AND RAINFALL IN MILLIMETERS, 1964-83

YR	KCP	KTP	GSMT	BSWT	CSMET	MH	WH	RFL
1964	41.4	20.2	135.2	134.7	75086.0	30200	113900	1160.50
1965	39.3	18.9	103.8	172.2	77986.0	39000	108500	974.33
1966	56.9	21.4	134.3	128.4	89246.0	57300	120900	1127.68
1967	48.8	22.6	248.8	162.2	96378.0	57600	130100	921.20
1968	39.6	29.8	352.6	216.3	76889.0	51600	139100	1193.46
1969	53.9	36.1	281.9	221.2	104152.0	55800	132700	892.75
1970	58.3	41.1	205.7	221.3	232013.0	59300	121100	1255.80
1971	59.5	36.3	256.6	205.7	220351.0	66300	92700	1086.33
1972	62.0	53.3	373.0	164.4	258437.0	77200	87200	1079.48
1973	71.2	56.6	440.3	124.6	279853.0	75800	83600	892.63
1974	70.1	53.4	365.4	159.5	249843.0	63700	89300	927.43
1975	66.2	57.7	487.8	145.5	230607.0	68100	89900	1094.65
1976	80.3	62.0	564.7	166.8	208658.0	74300	85600	852.95
1977	97.1	86.3	424.0	169.9	259450.0	85400	80900	1259.50
1978	84.3	93.4	246.3	165.9	269796.0	72800	77200	1372.75
1979	75.1	79.3	241.7	201.0	240559.0	56800	75800	1230.13
1980	91.3	89.9	217.9	204.6	196885.0	70700	79400	900.08
1981	90.7	90.9	472.9	214.4	222985.0	67200	98500	1171.53
1982	88.4	95.6	571.3	234.7	260336.0	81000	73100	1230.60
1983	95.3	119.3	637.1	242.3	274162.0	78000	76500	860.58

Source: Kenya Central Bureau of Statistics, <u>Statistical Abstracts</u>, Various Issues.

TABLE XIII

EXCHANGE RATES: NATIONAL CURRENCY AND S.D.R. UNITS PER U.S. DOLLAR, PERIOD AVERAGE, 1964-83

YR	KSH	DM	IL	JY	NG	UKL	US$	SDR
1964	7.143	3.9748	624.50	361.97	3.6068	0.3581	1.00	1.0000
1965	7.143	3.9940	624.70	361.49	3.6004	0.3576	1.00	1.0000
1966	7.143	3.9985	624.50	362.35	3.6193	0.3580	1.00	1.0000
1967	7.143	3.9863	624.10	362.15	3.6024	0.3547	1.00	1.0000
1968	7.143	3.9920	623.40	360.55	3.6198	0.4178	1.00	1.0000
1969	7.143	3.9253	627.30	358.37	3.6240	0.4184	1.00	1.0000
1970	7.143	3.6465	627.20	358.07	3.6166	0.4174	1.00	1.0000
1971	7.143	3.4820	618.40	347.86	3.4945	0.4092	1.00	0.9970
1972	7.001	3.1896	583.20	303.17	3.2095	0.4004	1.00	0.9211
1973	7.143	2.6726	583.00	271.70	2.7956	0.4082	1.00	0.8338
1974	7.343	2.5878	650.30	292.08	2.6884	0.4278	1.00	0.8315
1975	8.367	2.4603	652.90	296.79	2.5290	0.4520	1.00	0.8236
1976	8.277	2.5180	832.30	296.53	2.6439	0.5565	1.00	0.8662
1977	7.729	2.3222	882.20	268.51	2.4543	0.5733	1.00	0.8565
1978	7.729	2.0086	848.70	210.44	2.1636	0.5215	1.00	0.7957
1979	7.475	1.8329	830.90	219.14	2.0060	0.4722	1.00	0.7740
1980	7.420	1.8177	856.40	226.74	1.9881	0.4303	1.00	0.7683
1981	9.047	2.2600	1136.80	220.54	2.4952	0.4976	1.00	0.8481
1982	10.922	2.4266	1352.50	249.08	2.6702	0.5725	1.00	0.9059
1983	13.312	2.5533	1518.80	237.51	2.8541	0.6597	1.00	0.9355

Source: International Monetary Fund. IFS. Supplement on Exchange Rates, 1985, Yearbook, 1985.

TABLE XIV

AVERAGE PRICES PAID TO PRODUCERS: KENYA SHILLINGS PER UNIT,* 1964-83

YR	PPC	PPT	PPM	PPW	PPME
1964	7.000	7.210	36.20	52.3	49
1965	6.670	7.410	35.50	51.9	55
1966	5.640	7.300	40.10	54.9	59
1967	5.830	7.830	35.30	56.8	57
1968	6.404	5.850	30.30	56.3	59
1969	6.304	6.189	27.60	54.5	52
1970	7.470	6.738	27.60	45.1	52
1971	6.365	5.505	33.50	50.6	59
1972	7.769	6.015	38.90	50.5	77
1973	9.207	5.927	38.90	56.7	77
1974	10.078	7.206	46.30	80.4	77
1975	10.686	8.078	69.80	104.7	85
1976	25.230	10.569	76.60	120.3	105
1977	39.750	21.492	86.90	133.3	132
1978	28.181	15.832	77.50	143.6	132
1979	26.349	13.567	88.90	146.3	132
1980	26.348	17.743	95.40	163.9	146
1981	22.594	17.723	100.00	166.7	185
1982	27.000	19.408	107.70	187.6	215
1983	34.890	21.840	155.90	222.2	215

* PPC and PPT are in Kenya Shillings per Kilogram.
PPM, PPW and PPME are in Kenya Shillings per 100 Kilograms.

Source: Kenya Central Bureau of Statistics, <u>Statisical Abstracts</u>, Various Issues.

APPENDIX B

DESCRIPTION OF VARIABLES USED IN THE STUDY

TABLE XV

DESCRIPTION OF DATA VARIABLES

Commodity	Year	F.O.B. Price	Export Quantity	Marketed Production	Average Price To Producer
Coffee	YR	PCN	QC	KCP	PPC
Tea	YR	PTN	QT	KTP	PPT
Sisal	YR	PS	QS	---	---
Meat and Meat Products	YR	MMP	MMQ	---	---
Hides and Skins	YR	HSPN	HSW	---	---
Pyrethrum Extracts	YR	PEPN	PEQ	---	---
Animal Feed	YR	AFP	AFQ	---	---
Beans and Peas	YR	BPP	BPQ	---	---
Wool	YR	WP	WQ	---	---
Butters and Ghee	YR	BGPN	BGQ	---	---
Tinned Pineapples	YR	TPPN	TPQ	---	---
Cashew Nuts	YR	CNP	CNQ	---	---
Wattle Extracts	YR	WEP	WEQ	---	---
Maize	YR	---	---	QSMT	PPM
Wheat	YR	---	---	QSWT	PPW
Milk Equivalent	YR	---	---	QSMET	PPME

TABLE XVI

DEFINITION OF ABBREVIATIONS

KSH	Kenya Shilling
DM	Deutsche Mark (Federal Republic of Germany)
IL	Italian Lira
JY	Japanese Yen
NG	Netherlands Guilder
UKL	Pound Sterling (United Kingdom)
US$	United States Dollar
SDR	Special Drawing Rights
MH	Hectares under maize
WH	Hectares under wheat
RFL	Total Rainfall for selected weather stations

APPENDIX C

LISTING OF COMPUTER SIMULATION PROGRAM

```
C +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C         * KENSIM.FOR * IS THE SIMULATION PROGRAM USED IN THIS STUDY
C @@@@@@@@@@ NOT ALL THE VARIABLES WERE USED @@@@@@@@@
C +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
      FUNCTION GAUSF (NDUMY)
C
C GENERATES RANDOM NUMBERS ACCORDING TO GAUSSIAN DISTRIB.
C WITH MEAN VALUE=ZERO AND STD =1
C SOURCE J. P. CHANDLER, OSU, STILLWATER
C Adapted by M. FOLK and I. ROF, OSU, STILLWATER
C
C FOR A RANDOM NUMBER FROM GAUSSIAN DISTRIBUTION WITH MEAN
C VALUE EQUAL TO 'AMEAN' AND STANDARD DEVIATION EQUAL TO
C 'ASIGMA' USE...
C      RNG=AMEAN+SIGMA*GAUSF(DUMMY).
C RANF RETURNS A RANDOM NUMBER FROM A DISTRIBUTION UNIFORM
C  (0,1).
C
      DATA NARG /0/
C DEFEAT THE IDIOTIC EMR OPTIMIZATION
      NARGA=NARG
      TEST=RANF(NARG)
C   GENERATE AN EXPONENT'LY  DISTRIBUTED RANDOM NUMBER.
  10  R = RANF(NARGA)
      IF(R)10,10,20
  20  GAUSF=-ALOG(R)
C              GENERATE  ANOTHER
  30  R=RANF(NARG)
      IF(R)30,30,40
  40  R = -ALOG(R)
C PERFORM THE REJECTION TEST
      IF((GAUSF-1)**2-R-R)50,50,10
C
  50  IF(TEST-.5)60,70,70
  60  GAUSF=-GAUSF
  70  RETURN
      END


C  DUMMY LINE  --  DELETE  --  DELETE  --  DELETE  --  DELETE  --
C  RAND2  --  RANF, ASEARCH, HULK, HWANG SPECTRAL, FSRAN
      FUNCTION RANF (NARG)
C  SHUFFLES USING MULTIPLE GENERATORS WITH THE SAME PERIOD, AS DONE BY
C  MARSAGLIA.  THIS GAVE A VERY SHORT PERIOD ON THE IBM 1130.
C
C  GENERATES PSEUDO-RANDOM NUMBERS, UNIFORMLY DISTRIBUTED ON (0,1).
C  THIS VERSION IS FOR THE IBM 360.
C
C  J. P. CHANDLER, COMPUTER SCIENCE DEPT., OKLA. STATE U.
C
C  METHOD...  COMPOSITE OF THREE MULTIPLICATIVE CONGRUENTIAL GENERATORS
C  G. MARSAGLIA AND T. A. BRAY, COMM. A.C.M. 11 (1968) 757
C
C  IF RANF IS CALLED WITH NARG=0, THE NEXT RANDOM NUMBER IS RETURNED.
C  IF RANF IS CALLED WITH NARG.NE.0, THE GENERATOR IS RE-INITIALIZED
C  USING IABS(2*NARG+1), AND THE FIRST RANDOM NUMBER FROM THE NEW
C  SEQUENCE IS RETURNED.
C
      EQUIVALENCE (RAN,JRAN)
```

```
      DIMENSION N(128)
C
      DATA NFIRST/7/,K/7654321/,L/7654321/,M/7654321/
C
C  MULTIPLIERS USED BY VAN GELDER....
C
C     DATA MK/105005B/,ML/10405B/,MM/20005B/
      DATA MK/282629/,ML/34821/,MM/65541/
C
      IF(NARG)20,10,20
   10 IF(NFIRST)30,60,30
C                               RE-INITIALIZE USING NARG.
   20 KLM=IABS(2*NARG+1)
      K=KLM
      L=KLM
      M=KLM
C                               INITIALIZE.
   30 NFIRST=0
C                               2**24 ....
      NDIV=16777216
C                               EXACT REAL REPRESENTATION OF 2**31 ....
      RDIV=32768.*65536.
C                               FILL THE TABLE.
      DO 50 J=1,128
      K=K*MK
   50 N(J)=K
C                               COMPUTE THE NEXT RANDOM NUMBER.
   60 L=L*ML
      J=1+IABS(L)/NDIV
      M=M*MM
      NR=IABS(N(J)+L+M)
      RAN=FLOAT(NR)/RDIV
C                               FIX UP THE LEAST SIGNIFICANT BIT.
C
      IF(J.GT.64   .AND.   RAN.LT.1.)   JRAN=JRAN+1
      RANF=RAN
C                               REFILL THE J-TH PLACE IN THE TABLE.
      K=K*MK
      N(J)=K
      RETURN
      END
C
C ***********************************************************
C
C OUTER LOOP (S) AND INNER LOOP (J) COUNTERS
C
      INTEGER S,J
C
C DECLARE INITIAL PARAMETERS
C******WHEAT****
      REAL AW,BW,CW,FW,WA,WU,WEP,WH
C
C************MAIZE************
      REAL AM,BM,CM,DM UM,ACM,EPM,HM
C*******************MILK**********
      REAL AME,BME,CME,DME,EME,UME,ACME,EPME
C
C VARIABLES IN SUPPLY AND DEMAND
C*****WHEAT*****
      REAL GSWA(1:20,0:30),TRW(1:20,0:30),SGDW(1:20,0:30)
```

```
      REAL SW(1:20,0:30),SRW(1:20,0:30),RW(1:20,0:30)
      REAL TQSWA(20),TSQDW(20),TSW(20),TSRW(20),TRWS(20)
      REAL AVQSWA(20),AVSQDW(20),AVSW(20),AVSRW(20),AVRW(20)
      REAL CVSWA(20),CVQDW(20),CVSW(20),CVSRW(20),CVRW(20)
      REAL CVQS(20),CVQD(20),CVS2(20),CVR(20),DIF(20)
      REAL WCP,SR(1:20,1:30),QM(1:20,0:30),TSR(20),TQM(20),AVSR(20)
      REAL AVQM(20),CONS(1:20,0:30),RT(1:20,0:30)
      REAL CVSR(20),CVQM(20),CVSRF(20),CVQMF(20),GEXPW(1:20,0:30)
      REAL GEXRW(20)
C
C****MAIZE*****
      REAL QSM(1:20,0:30),TRM(1:20,0:30),QDM(1:20,0:30),GEXRM(20)
      REAL RM(1:20,0:30),TQSM(20),TQDM(20),TSRM(20),AVQSM(20),AVQDM(20)
      REAL AVRM(20),VSM(20),VDM(20),VRM(20),CVSM(20),CVDM(20),CVRM(20)
      REAL GEXPM(1:20,0:30)
C
C*******MILK****
      REAL QSME(1:20,0:30),TRME(1:20,0:30),QDME(1:20,0:30)
      REAL GMME(1:20,0:30),TQSME(20),TQDME(20),TGMME(20),AVQSME(20)
      REAL AVQDME(20),AVGMME(20),VSME(20),VDME(20),VGMME(20),CVSME(20)
      REAL CVDME(20),CVGMME(20),GEXPME(1:20,0:30),GEXGME(20)
C
C INTERNATIONAL TRADE
C********************
C
C       REAL GIW(20),QIM(20),GIME(20),GEW(20),QEM(20),QEME(20)
C
C  DEBUG FLAG
      INTEGER DEBUG
C
C INITIALIZE CONSTANTS
      DEBUG = 1
C
C INPUT INITIAL VARIABLES
      READ*,AW,BW,CW,WH,PW,AVRW(0),WZ
      READ*,AVQSWA(0),WA,WSD,WEP
      READ*,AM,BM,CM,HM,DM,PM,AVRM(0),ZM
      READ*,AVQSM(0),ACM,SDM,EPM
      READ*,AME,BME,CME,DME,LQSM,PME,ZME,AEM,SDME,EPME
      READ*,AVSQDW(0),AVQDM(0),AVQDME(0),AVQSME(0)
      PRINT*,'FIRST LINE:',AW,BW,CW,WH,PW,AVRW(0),WZ
      PRINT*,'SECOND LINE:',AVQSWA(0),WA,WSD,WEP
      PRINT*,'THIRD LINE:',AM,BM,CM,HM,DM,PM,AVRM(0),ZM
      PRINT*,'FOURTH LINE:',AVQSM(0),ACM,SDM,EPM
      PRINT*,'FIFTH LINE:',AME,BME,CME,DME,EME,PME,ZME,AEM,SDME,EPME
      PRINT*,'SIXTH LINE:',AVSQDW(0),AVQDM(0),AVQDME(0),AVQSME(0)
      PRINT*,'DEBUG = ',DEBUG
C
C SIMULATION STARTS HERE
        DO 1000 S=1,15
C COMPUTE SEQUENCES FOR REFERENCE SOLUTION: WHEAT
      DO 400 J=1,30
      TEMP=GAUSF(DUMMY)
      PRINT*, 'GAUSF VALUE RETURNED IS ',TEMP
      W1=2.53+2.09*TEMP
      IF (DEBUG.EQ.1) THEN
      PRINT*,'W1=',W1
      ENDIF
C  GUARANTEED MIN VAR
      RW(S,J-1)=AVRW(S-1)
```

```
      RM(S,J-1)=AVRM(S-1)
C VARIABLES FOR WORLD PRICES
C
CC       QSWA(S,J-1)=AVQSWA(S-1)
CC       QSM(S,J-1)=AVQSM(S-1)
CC       QSME(S,J-1)=AVQSME(S-1)
      PMRN=6.907+5.691*TEMP
      IF(PMRN.GT.0) THEN
      PMR=PMRN

            PWRN=7.313+5.624*TEMP
      IF(PWRN.GT.0) THEN
      PWR=PWRN
      ENDIF
      PMERN=9.06+8.161*TEMP
      IF(PMERN.GT.0) THEN
      PMER=PMERN
      ENDIF
      T=BME*PMER
      IF (DEBUG.EQ.1) THEN
CC       PRINT*,'AVQSWA(S-1)=',AVQSWA(S-1),'AVQSM(S-1)=',AVQSM(S-1)
CC       PRINT*,'AVQSME(S-1)=',AVQSME(S-1)
      PRINT*,'PMR=',PMR,'PWR=',PWR,'PMRN=',PMRN,'PWRN=',PWRN
      PRINT*,'PMER=',PMER,'T=',T,'PMERN=',PMERN
      PRINT*,'PM=',PM,'PW=',PW,'PME=',PME,'QSWA(S,J-1)=',QSWA(S,J-1)
      ENDIF
C SUPPLY FUNCTIONS
C
      QSWA(S,J)=AW+BW*RW(S,J-1)+CW*WH+TEMP
      QSM(S,J)=AM+BM*RM(S,J-1)+CM*HM+DM*RW(S,J-1)+W1
      QSME(S,J)=AME+T+CME*RM(S,J-1)+DME*LQSM+W1
C       IF (PMER.LT.PME) THEN
C       PMER=PME
C       ENDIF
C
      WU=WZ+WA*WSD
      UM=ZM+ACM*SDM
      UME=ZME+AEM*SDME
      IF (DEBUG.EQ.1) THEN
      PRINT*,'WU=',WU,'UM=',UM,'UME=',UME
      ENDIF
C
C CONSUMER PRICES
C
      WCP=8.544
      CPM=6.993
      CPME=7.633
C       PPB=6.875+0.204*TEMP
C DEMAND FUNCTIONS
C
      SQDW(S,J-1)=1*AVSQDW(S-1)
      QDM(S,J-1)=1*AVQDM(S-1)
      QDME(S,J-1)=1*AVQDME(S-1)
      SQDW(S,J)=WU-WEP*WCP
      QDM(S,J)=UM-EPM*CPM
      QDME(S,J)=UME-EPME*CPME
C
C DERIVING REVENUES (INCOMES)
C
      TRW(S,J)=QSWA(S,J-1)*PWR
```

```
C        IF (PWR.LT.PW) THEN
C        PWR=PW
C        ENDIF
       TRM(S,J)=QSM(S,J-1)*PMR
C        IF (PMR.LT.PM) THEN
C        PMR=PM
C        ENDIF
       RW(S,J)=TRW(S,J)/WH
       RM(S,J)=TRM(S,J)/HM
C
C DEBUG:
       IF (DEBUG.EQ.1) THEN
       PRINT*,'S=',S,'    J=',J
       PRINT*,'QSWA(S,J)=',QSWA(S,J)
C        PRINT*,'SQDW(S,J)=',SQDW(S,J)
       PRINT*,'TRW(S,J)   = ',TRW(S,J),'RW(S,J)=',RW(S,J)
       PRINT*,'QSM(S,J)=',QSM(S,J),'QDM(S,J)=',QDM(S,J)
       PRINT*,'TRM(S,J)=',TRM(S,J),'RM(S,J)=',RM(S,J)
       PRINT*,'QSME(S,J)=',QSME(S,J),'QDME(S,J)=',QDME(S,J),'PMER=',PMER
CC       PRINT*,'AVSQDW(S-1)=',AVSQDW(S-1),'AVQDM(S-1)=',AVQDM(S-1)
CC       PRINT*,'AVQDME(S-1)=',AVQDME(S-1).
       ENDIF
C DERIVING GOVERNMENT EXPEDITURES (GEX)
C
C Price Support Program (GEXP) Leading to Producers' Expect'ion
C*****************************************************************
       PWD=PW-PWR
       IF (PW.GT.PWR) THEN
       GEXPW(S,J)=TRW(S,J-1)*PWD
       ENDIF
       PMD=PM-PMR
       IF (PM.GT.PMR) THEN
       GEXPM(S,J)=TRM(S,J-1)*PMD
       ENDIF
       PMED=PME-PMER
       IF (PME.GT.PMER) THEN
       GEXPME(S,J)=QSME(S,J-1)*PMED
       ENDIF
       IF (DEBUG.EQ.1) THEN
       PRINT*,'GEXPW(S,J)=',GEXPW(S,J),'GEXPM=',GEXPM
       PRINT*,'GEXPME(S,J)=',GEXPME(S,J)
       ENDIF
C
CCCC Guaranteed Minimum Income Program(GMR) -A Basis for Expect'ion
C *****************************************************************
       IF (AVRW(S).LT.0.8*AVRW(S-1)) THEN
       PRINT*,'GOVERNMENT PAYS THE DIFFERENCE'
       ENDIF
       IF (AVRM(S).LT.0.8*AVRM(S-1)) THEN
       PRINT*,'GOVERNMENT PAYS THE DIFFERENCE'
       ENDIF
C
C CALCULATE SUBSIDY
       IF(AVRW(S).LT.0.8*AVRW(S-1)) THEN
       GEXRW(S)=0.8*AVRW(S-1)-AVRW(S)
       ENDIF
       IF(AVRM(S).LT.0.8*AVRW(S-1)) THEN
       GEXRM(S)=0.8*AVRM(S-1)-AVRM(S)
       ENDIF
       IF (DEBUG.EQ.1) THEN
```

```
      ENDIF
C NET TRADE(From International Trade)
C ++++++++++++++++++++++++++++++++++++
C       IF(AVQSWA(S).LT.AVSQDW(S)) THEN
C       QIW(S)=AVSQDW(S)-AVQSWA(S)
C       ENDIF
C       IF(AVQSWA(S).GT.AVSQDW(S)) THEN
C       QEW(S)=AVQSWA(S)-AVSQDW(S)
C       ENDIF
C       IF (AVQSM(S).GT.AVQDM(S)) THEN
C       QEM(S)=AVQSM(S)-AVQDM(S)
C       ENDIF
C       IF (AVQSM(S).LT.AVQDM(S)) THEN
C       QIM(S)=AVQDM(S)-AVQSM(S)
C       ENDIF
C       IF (AVQSME(S).GT.AVQDME(S)) THEN
C       QEME(S)=AVQSME(S)-AVQDME(S)
C       ENDIF
C       IF (AVQSME(S).LT.AVQDME(S)) THEN
C       QIME(S)=AVQDME(S)-AVQSME(S)
C       ENDIF
C       PRINT*,'QEW(S)=',QEW(S),'QIW(S)=',QIW(S),'QEM(S)=',QEM(S)
C       PRINT*,'QIME(S)=',QIME(S),'QEME(S)=',QEME(S)
  400 CONTINUE
C
C COMPUTE REFERENCE SOLUTION
C
      TQSWA(S)=0
      TSQDW(S)=0
      TSRW(S)=0
      TQSM(S)=0
      TQDM(S)=0
      TSRM(S)=0
      TQSME(S)=0
      TQDME(S)=0
      CVSWA(S)=0
      CVQDW(S)=0
      CVRW(S)=0
      VSM(S)=0
      VDM(S)=0
      VRM(S)=0
      VSME(S)=0
      VDME(S)=0
      DO 610 J=11,30
      TQSWA(S)=QSWA(S,J)+TQSWA(S)
      TSQDW(S)=SQDW(S,J)+TSQDW(S)
      TRWS(S)=RW(S,J)+TRWS(S)
      TQSM(S)=QSM(S,J)+TQSM(S)
      TQDM(S)=QDM(S,J)+TQDM(S)
      TSRM(S)=RM(S,J)+TSRM(S)
      TQSME(S)=QSME(S,J)+TQSME(S)
      TQDME(S)=QDME(S,J)+TQDME(S)
610   CONTINUE
      AVQSWA(S)=TQSWA(S)/20.0
      AVSQDW(S)=TSQDW(S)/20.0
      AVRW(S)=TRWS(S)/20.0
      AVQSM(S)=TQSM(S)/20.0
      AVQDM(S)=TQDM(S)/20.0
      AVRM(S)=TSRM(S)/20.0
      AVQSME(S)=TQSME(S)/20.0
```

```
      AVGDME(S)=TQDME(S)/20.0
C COMPUTE CV'S
      DO 620 J=11,30
      CVSWA(S)=TQSWA(S)+(QSWA(S,J)-AVQSWA(S))**2
      CVQDW(S)=TSQDW(S)+(SQDW(S,J)-AVSQDW(S))**2
      CVRW(S)=TRWS(S)+(RW(S,J)-AVRW(S))**2
      VSM(S)=TQSM(S)+(QSM(S,J)-AVQSM(S))**2
      VDM(S)=TQDM(S)+(QDM(S,J)-AVQDM(S))**2
      VRM(S)=TSRM(S)+(RM(S,J)-AVRM(S))**2
      VSME(S)=TQSME(S)+(QSME(S,J)-AVQSME(S))**2
      VDME(S)=TQDME(S)+(QDME(S,J)-AVQDME(S))**2
C
  620 CONTINUE
      CVQS(S)=(SQRT(CVSWA(S)/20)*100)/AVQSWA(S)
      CVQD(S)=(SQRT(CVQDW(S)/20)*100)/AVSQDW(S)
      CVR(S)=(SQRT(CVRW(S)/20)*100)/AVRW(S)
      CVSM(S)=(SQRT(VSM(S)/20)*100)/AVQSM(S)
      CVDM(S)=(SQRT(VDM(S)/20)*100)/AVQDM(S)
      CVRM(S)=(SQRT(VRM(S)/20)*100)/AVRM(S)
      CVSME(S)=(SQRT(VSME(S)/20)*100)/AVQSME(S)
      CVDME(S)=(SQRT(VDME(S)/20)*100)/AVQDME(S)
C
C PRINT RESULTS OF REFERENCE SOLUTION: WHEAT
      PRINT*,'AVQSWA(S) = ', AVQSWA(S)
C      PRINT*,'TSQDW(S) = ',TSQDW(S)
      PRINT*,'AVRW(S)= ',AVRW(S)
      PRINT*,'CVQS(S) = ',CVQS(S)
      PRINT*,' CVR(S) = ',CVR(S),'AVQSM(S)=',AVQSM(S)
C      PRINT*,'AVQDM(S)=',AVQDM(S),'TQSM(S)=',TQSM(S)
C      PRINT*,'TQDM(S)=',TQDM(S)
      PRINT*,'CVSM(S)=',CVSM(S)
      PRINT*,'CVRM(S)=',CVRM(S),'AVRM(S)=',AVRM(S)
C      PRINT*,'TSQME(S)=',TQSME(S),'TQDME(S)=',TQDME(S)
      PRINT*,'AVQSME(S)=',AVQSME(S)
      PRINT*,'CVSME(S)=',CVSME(S),'PME=',PME
C      PRINT*,'CVDME(S)=',CVDME(S)
C
 1000 CONTINUE
       END
```

APPENDIX D

SOME COMMON INDICES OF INSTABILITY

TABLE XVII

DESCRIPTION OF SELECTED INSTABILITY INDICES

Index	Description
United Nations	Used by the United Nations, 1952. Obtained from sum of absolute deviations of yearly earnings as a percentage of the larger of two consecutive annual earnings.
Coppock	Developed by Coppock, 1962. Uses deviations from trend line.
Linear least-squares	Derived from the sum of squared deviations from a linear trend line.
Exponential least-squares	Derived from the sum of squared deviations from an exponential trend line.
International Monetary Fund	Deviation from a three year weighted average of previous years earnings are obtained. Current year's values are weighted by 0.5. Two previous years are weighted by 0.25
Deviation from an n-year moving average	Absolute deviations from an n-year moving average are calculated. Value of n is determined a priori.
Average percentage deviations from least-squares trendline	As for linear least-squares but uses average percentage deviation from linear trend.
Transitory income	Developed by Knudsen and Parnes. Uses normalized variance of transitory income.
Coefficient of Variation	Standard deviation divided by the mean. Is often applied to raw and detrended data.
"Corrected" coefficient of variation	Developed by Cuddy and Della Valle. Adjusts the coefficient of variation by $\sqrt{(1-R^2)}$
Gelb's (1979)	Variation Measure on a filtered stochastic process.

APPENDIX E

AN APPLICATION OF COPPOCK'S INDEX

TABLE XVIII

WORKSHEET FOR COMPUTING COPPOCK'S INDEX

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Year	Quantity MT	Price KSh/Kg	Revenue KSh. (1)*(2)	Ln of Revenue Ln(3)	1st.Difference of Revenue	Ln 1st Difference (Trend)	Ln Difference Square (6)**2	(5)-M	(8) Square
1964	42304	7.29	308396160	19.54689	-0.09001	-0.20701	0.04285	-0.21317	0.04544
1965	38399	7.34	281848660	19.45688	0.29629	0.17928	0.03214	0.17313	0.02997
1966	54461	6.96	379048560	19.75317	-0.19109	-0.30810	0.09492	-0.31425	0.09875
1967	50748	6.17	313115160	19.56208	-0.20134	-0.31835	0.10135	-0.32450	0.10530
1968	37594	6.81	256015140	19.36074	0.27457	0.15756	0.02483	0.15141	0.02292
1969	50969	6.61	336905090	19.63531	0.27912	0.16211	0.02628	0.15596	0.02432
1970	53725	8.29	445380250	19.91443	0.19785	0.08084	0.00654	0.07469	0.00558
1971	56426	9.62	542818120	20.11228	-0.09215	-0.20916	0.04375	-0.21531	0.04636
1972	63142	7.84	495033280	20.02013	0.36837	0.25136	0.06318	0.24521	0.06013
1973	75317	9.50	715511500	20.38850	0.07041	-0.04660	0.00217	-0.05275	0.00278
1974	71681	10.71	767703510	20.45891	-0.08777	-0.20478	0.04193	-0.21093	0.04449
1975	67615	10.40	703196000	20.37114	0.97579	0.85878	0.73751	0.85263	0.72698
1976	77546	24.06	1865756760	21.34693	0.78405	0.66704	0.44495	0.66089	0.43677
1977	94314	43.33	4086625620	22.13098	-0.49405	-0.61106	0.37339	-0.61721	0.38095
1978	85392	29.20	2493446400	21.63693	-0.12004	-0.23705	0.05619	-0.24320	0.05915
1979	77241	28.64	2212182240	21.51689	-0.02233	-0.13934	0.01942	-0.14549	0.02117
1980	80066	27.01	2162582660	21.49456	0.01130	-0.10571	0.01117	-0.11186	0.01251
1981	86108	25.40	2187143200	21.50586	0.27925	0.16224	0.02632	0.15609	0.02436
1982	100968	28.64	2891723520	21.78511	0.10184	-0.01517	0.00023	-0.02132	0.00045
1983	90444	35.40	3201717600	21.88695					

TABLE XIX

CALCULATION OF THE COPPOCK INDEX*

Calculating the Index According to Equation (2.1)

a) Mean of (5)
b) Log-variance (7)
c) Square Root of (b)
d) Antilog of (c)
e) Value in (c) less one
f) Instability Index (Coppock's I-I)

Deriving Coppock's Index Using M as defined in Equation (2.2) [M is Derived from the First and the Last Obsevations]

Value of M calculated as in Equation (2.2)
a) Use Row (4)
   i) Last Minus First
   ii) Divide i) by n-1 to Obtain M
b) Calculate 1st difference less M (Row (8)
c) square of (b)
d) Sum of (c)
e) Divide (d) by n-1
f) Find the square root of (d)
g) Find the antilog of (f)
h) Subtract one from (g)
i) Multiply (h) by 100 to obtain the Index

Conclusion

The instability indixes derived from the original and the "simpler" approach differ by 0.0088, implying that they are essentially the similar.

* For details on procedures, see Coppock, Joseph D. (1962): pp. 23-24 and Knudsen, O. and Andrew Parnes (1975): p. 12.

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