STABILIZING EXPORT REVENUE THROUGH FUTURES MARKETS:
AN APPLICATION TO COCOA EXPORTING COUNTRIES

by

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(ABSTRACT)
Many developing countries that rely heavily on primary commodity exports to provide a major portion of their exchange revenues confront large variability in their incomes. This has been a factor of major concern to the developing countries as revenue instability is considered to deter development as well as affect the welfare of those engaged in production of such commodities. Producing countries have adopted several programs and policies that attempt to lessen the price and revenue instabilities, or to raise export receipts. These attempts based on various commodity agreements have met with limited success. More attention has been paid to the alternative market solutions to this problem as international action even among producers has proven ineffective. Futures market is an obvious choice since well organized futures markets exist for most of the primary commodities.

The present study investigated the potential of futures markets as a means of obtaining lower variance in revenue using the data from cocoa markets in London and New York. Data for four representative cocoa producers were analysed to develop strategies that reduce the variance in revenue. Two hedging strategies based on optimal hedge ratio concept and
three selective strategies were tested for their ability to reduce risk and also to maintain the revenue trade-offs at a lower level. The analyses were carried out using two sample periods each 29 and 22 years long and tested in a 4 year data base outside the sample.

The results confirmed that the producers facing both price and quantity risks in their production should only hedge a portion of their output. Adoption of a variance minimizing or utility maximizing hedges at a higher levels of risk aversion parameter as well as some selective strategies for hedging were found to give lower variance in revenue. There was always some trade-off associated with adopting these strategies. Selective strategies obtained a reduction in revenue with less trade-offs compared to optimizing strategies but were limited by the requirements of large cash outlays to meet the margin payments. For countries depending heavily on the revenue from cocoa hedges based on variance minimizing or utility maximizing strategies would be preferred over selective strategies. The ability to make good crop forecasts would greatly improve the success of hedging.
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CHAPTER 1
INTRODUCTION

Many developing countries rely heavily on primary commodity exports to provide a large portion of their income. Instability in export receipts is one of the major development obstacles faced by these countries. The performances of these economies as well as the individual producers are affected adversely by these unstable incomes. The tendency for the export revenues of the 'less developed countries' (LDC'S) to show wide fluctuations is attributed to the concentration of the exports of the LDC's in a few primary commodities and to certain characteristics of the nature of market supply and demand for these commodities.

In most of these countries a significant portion of the export revenue depends on a single or a few commodities. Commodity exports including oil accounted for almost 80% of the revenue earned by the developing countries during the period 1976 - 1979. During this period 'leading commodity exports', as described by the International Monetary Fund, accounted for more than 50% of the income in 83% of the countries (IMF, various issues). At least 33% of the revenue in 95% of the countries, and 66% of the revenue in 56% of the countries were accounted for by exports of primary commodities. During the period 1980-82, primary commodities accounted for more than 50% of the income in the 52 countries classified as developing economies (The World Bank, 1985). This heavy
dependence make those economies very susceptible to even modest market fluctuations.

The demand for most primary commodities, except for oil and some minerals, has shown relatively slow growth during the last few decades. It has even declined significantly in some cases. This is caused by technological improvements such as development of substitutes and changes in consumer spending habits in the developed countries where most of the demand originates. The share of the non-fuel primary products in world exports dropped to 18% in 1982, compared to 28% in 1980 (The World Bank, 1985). The share of the primary products in world exports was 42% and 54% in 1965 and 1954 respectively. During the same period the export volume from the developing countries increased 180% against the growth of 230% in the exports by the developed countries. Therefore, the growth of the exports of the LDC'S relative to the growth in the world trade has declined in volume as well as value terms.

As a consequence, the ability of those countries to maintain the rate of increase in imports necessary to ensure a satisfactory level of development has declined. Further, the frequent fluctuations in the market situation has introduced a new level of instability to the performance of those economies even in the short run. This situation has led many commodity producers to pursue means of overcoming weak and adverse income trends. For many LDC's the ability to switch from weak to strong export oriented sectors is limited by resource availabilities, climate and
technology. For most countries the economic cost of switching from one output sector to another is prohibitive.

International commodity agreements negotiated among producer countries with or without the participation of the major consumer countries is the conventional mechanism pursued by producing countries to reduce fluctuation in price and or revenue and to improve the price levels. These agreements involve a combination of activities such as buffer stocks, buffer funds, export quotas and production controls.

However, in practice these commodity agreements have seldom realized the desired outcomes. The process of negotiating such agreements have been extremely lengthy and costly. Further, many proposed commodity agreements have not been able to secure the support of the developed countries which is crucial to the success of those schemes. And in some cases even the producer countries themselves have not been able to agree on common terms making commodity agreements negotiated over substantially long periods impracticable. Also, in practice, the commodity agreements have become too complicated to monitor and enforce. The so called 'commodity debate' at best has only served as a forum for information exchange and discussion of the international commodity problem.

The integration of the capital and international commodity markets, as observed by Schuh (1985), probably eliminated whatever chances that existed for those commodity agreements to succeed within narrowly defined limits. One outcome subsequent to these changes that has significant implications on the world commodity markets is the realignment of the
exchange rates based on monetary transfers. The implicit price changes induced by immense monetary transfers non-related to trade have made the price support schemes confined to the commodity markets virtually impracticable. Due to these reasons and many unsolved questions relating to the economic justification for these programs, the initial enthusiasm with which these were undertaken has subsided during the recent past.

However, the heavy dependance of developing countries on the export revenues from primary exports will continue to exist in the foreseeable future. In view of the changes taken place in the world agriculture as a whole, Schuh (1985) proposes that the emphasis of the developing countries should be not on producing food per se but rather on producing new streams of incomes through cash, export or raw material crops. The emerging system of international food and agriculture represented by international trade has allowed the developing countries to have the choice of having their food produced elsewhere, while sharing the benefits of relative comparative advantage on both sides. Under these circumstances, the discussion about alternative approaches to the commodity problem will continue to be a top priority policy issue for the years to come.

As an alternative for reducing commodity price fluctuations, it is proposed that the LDC's individually use market institutions to reduce variability in their export revenues. This proposition is made on the assumption that it is the stability of returns that a country needs to be concerned with rather than the price of the commodity per se. This
proposition rests on the argument that it is the exchange earnings within a certain period that affect the ability of a country to maintain the required rate of imports, debt servicing and other services essential to meet development goals.

One way of achieving stability in income is to fix a price for the commodity well in advance of production. If the producers can sell forward their output they can realize the same benefits of a stabilized price. The three major forms of market institutions that may be used to achieve this are forward contracts, futures exchanges and option markets.

The market institution proposed to be used by developing country exporters for this purpose is the futures markets (Mckinnon 1967, Gilbert 1985a). The use of futures markets by these countries has been suggested to provide a better solution to the problem of stabilizing revenue from commodity exports. By using futures markets, the countries are free to choose a level of protection against income short-falls that is consistent with their portfolio of incomes, thereby overcoming the problems encountered in negotiating a solution acceptable to a group of countries with diverse objectives. It would probably serve the interests of the consumer countries better than inflexible commodity agreements that limit the choices available to them.

A cash forward contract is a commitment to deliver a certain quantity at a specified future date at a mutually agreed price, payable on delivery. If the output is certain, the forward contract completely eliminates the revenue uncertainty. Even when the output is uncertain, a significant
reduction in revenue uncertainty may be obtained. However, the possibility of making a forward contract is limited by the willingness of the buyers. As the price is mutually determined, the producer could find that buyers are not willing to make forward contracts at prices acceptable to the seller.

The futures markets separate the timing of price fixing from physical delivery and thereby overcome the above limitation in the cash markets. By selling the appropriate quantity of the futures contracts, the producer can assume a position identical to forwards. The seller can use the futures exchange to fix the price and retain the freedom to market the output to a buyer of his/her choice.

Futures markets exist for many primary commodities exported by developing countries. There are futures markets for all 'core commodities' except for fibers and tea in the UNCTAD's integrated program for commodities. Most of these commodities are traded for contract periods 18 - 23 months forward. However, the more distant contracts are not as liquid as the nearby contracts. These contracts provide the opportunity for commodity exporting countries to fix their prices and quantities to stabilize incomes at least over a short planning horizon of one or more production periods into the future.

In spite of these reasons and long standing interest in futures, the participation of developing countries in these markets has been minimal. This is a due to a number of issues that need to be examined before a country can engage in futures trading.
Strategies for successful utilization of the futures markets by producer countries are yet to be demonstrated. The mechanics of the futures trading are less well understood among many developing country trading agencies. These countries are usually hostile to any speculative trading and normally treat futures trading in this context.

Futures contracts are 'marked to the market' daily requiring the participants to make margin payments when the market price moves against their position. These margin requirements may limit the potential participants. Developing countries would require access to large amounts of 'hard currencies' to engage in the activities of the futures markets. Most of the commodity exporting countries are already severely constrained in credit availabilities and this could be a serious limitation to the participation in futures activities. Therefore, it is important to have an idea about the approximate financial outlays necessary for a commodity exporting country as margin requirements, commission payments etc. to maintain hedged positions. The possibility of using the expected crop or another assets as co-lateral for above requirements need to be examined.

The indeterminacy surrounding the optimal hedged position reduces producer participation in the futures markets even in the U.S. where well functioning futures markets exist. Lack of familiarity with the operational aspects of the market, small scale of operation and the unavailability of credit to meet margin payments are also important among others. In the developing countries the same reasons will prevent individual
producer participation in the futures activities even if easy access to these markets is ensured. However, in many of the developing countries private or state marketing boards have been set up to regulate internationally traded commodities. These trading institutions are better equipped to engage in futures marketing than private individuals. It is assumed that the institutional set up is available within these countries to pass down the benefits of the stabilized revenue to individual producers by way of locally guaranteed prices extending over the same periods.

It is further assumed that the futures price is not unduly affected by participation of government trading institutions in the market and the assumptions of pure competition hold. It is quite likely that the trading of large volumes by these institutions can affect the price initially, but it is not possible to determine and accommodate this in the analysis. In order to obtain an idea about the possible price effects the volumes needed to be traded relative to the volumes actually traded will be examined.

Risk averse behavior on the part of producers and by exporting countries will be assumed. Use of various degrees of risk aversion can facilitate comparison between hedging strategies of the relative trade-offs between income stabilization and income level. Enumeration of risk behavior will be discussed later along with the theoretical models.

Cocoa is selected as the case study for several reasons.
Many developing countries that export cocoa earn a major portion of their export income from cocoa.

Cocoa has traditionally shown very high volatility in price and output among primary commodities.

Futures contracts in cocoa have been traded for a number of years in sufficient volume to permit country hedging.

Some cocoa producers have shown an interest in participating in the futures market.

Adequate data to conduct the analysis are available.

Cocoa is a typical example of a primary commodity produced for exporting. All the important cocoa producers are also major exporters and almost all the output enters international trade. Exports are mainly in the form of dried beans and less than one third is exported as one of the semi-processed forms.

Cocoa production is characterized by geographical concentration. Four West-African countries (Ghana, Ivory Coast, Nigeria and Cameroun) and Brazil account for nearly 80 percent of world production and exports (Gill & Duffus, 1985). The rest of the output is shared by a large number of small producers in the tropical developing countries. In most African countries cocoa production is organized as a smallholding crop. Table
1.1 depicts the world production of cocoa by the main producers for various points between 1946 to 1984. The table shows the growth in the world output as well as the changes in the distribution of output among major producers.

Revenue from the exports of cocoa accounts for more than 50 percent of the total export earnings of Ghana. In Cameroun and Ivory Coast, nearly 25 percent and 20 percent of the total export earnings is contributed by cocoa. In Nigeria the share of the revenue from cocoa has declined in the recent years due to increased income from petroleum exports, but cocoa is still the second most important commodity. Among the major producers, only Brazil has a very small portion of its revenue contributed by cocoa (IFS, various issues). Therefore, the West-African producers have the most potential to benefit from hedging. The hedging study will therefore concentrate on Ghana, Nigeria, Ivory Coast and Cameroun.

Cocoa prices fluctuate widely and frequently. Table 1.2 depicts several price series for cocoa in the international markets during 1950 to 1984. In 1980 constant dollars, the ICCO average daily price fluctuated between 133.1 U.S. cents/kg in 1965 and 574.2 cents/kg in 1977. The World Bank indices of fluctuation in commodity prices calculated for annual price data for 1955 to 1981 indicated that cocoa has one of the highest price fluctuations (25.3) for any developing country export (The World Bank, 1983). The fluctuation in the price of cocoa is found to be quite large compared to quantity fluctuations. Blandford (1979) measured the
Table 1.1

WORLD PRODUCTION OF COCOA BY COUNTRY

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SOURCE- GILL & DUFFUS,
Table 1.2
WORLD PRICES OF COCOA IN THE INTERNATIONAL MARKETS

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<th>CURRENT $</th>
<th>1980=100</th>
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<th>CURRENT $</th>
<th>1980=100</th>
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<td>1955</td>
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<td>1970</td>
<td>75.4</td>
<td>253.9</td>
<td>67.5</td>
<td>227.3</td>
<td>67.5</td>
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<td>1975</td>
<td>164.5</td>
<td>275.1</td>
<td>124.6</td>
<td>208.4</td>
<td>124.6</td>
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<td>1980</td>
<td>232.3</td>
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<td>260.4</td>
<td>260.4</td>
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Source: Gill & Duffus, 1985
instability in the quantity and value of cocoa in the world markets using a standardized coefficient of variation. Measured as absolute deviation from the exponential trend, this index showed that the fluctuation in real price is 250 percent greater than the quantity fluctuation.

The major terminal markets for cocoa are in London, New York and Paris. The futures markets in London and New York predominate and the prices in these 2 markets have shown a tendency to move together (Petzel, 1984). The London Cocoa Terminal and the Coffee, Sugar and Cocoa Exchange, Inc. (CS&CE) regulate the futures activities in London and New York respectively. Futures contracts in cocoa in London has been traded since 1928 with a break between 1940 to 1950 due to war time controls. Since 1979 New York Futures trading in cocoa has been conducted under CS&CE and the contract specifications have been adjusted to be comparable with those in London. The participants in these markets are known to be constituted of a wide range of hedgers and speculators, but the absence of the producer country exporting groups has been noted (Petzel, 1984).
OBJECTIVES

The objectives of the present study are,

1. To investigate the possibility of using the futures market by selected cocoa producer countries to reduce export income instability.

2. To estimate the financial outlays necessary for margin deposits, margin calls and commissions for cocoa producer countries to engage in hedging.
HYPOTHESIS

Two hypotheses will be tested for each country selected for the study.

1. A routine hedge in the cocoa futures market could have obtained a lower variance in income than spot (cash) marketing to a cocoa exporting country during the period 1960 - 1981.

2. A selective hedging strategy in the cocoa futures market could have obtained a lower variance in income than spot(cash) trading without sacrificing as much income as routine hedges during the period 1960 - 1981.

Ex-ante testing of the models outside the data base used to generate the decision rules will be conducted for the period 1981 - 1984.

The rest of the thesis is organized as follows. Chapter 2 presents the rationale for commodity stabilization and discusses theoretical evidence on price stabilization and futures markets as alternative solutions to the problem of revenue stability. The analytical approaches to the empirical evaluation of the futures solution are also discussed. Chapter 3 presents the futures trading models tested, methods of analysis and data. Results of the simulations of various hedging strategies are discussed in chapter 4. Chapter 5 contains the summary findings and conclusions.
Variability in revenue is considered detrimental to the economic growth of developing countries. The economic theory pertaining to this situation is easily illustrated. A high degree of instability in earnings will induce risk averse producers to remove resources from such investments causing low output and employment (Ghatak and Ingersent, 1985). When wide revenue fluctuations occur planning becomes difficult. Uncertainty in the revenue stream makes scheduling loans and repayments impossible and input productivity declines due to cyclical variations in use. The risk associated with fluctuations can lead to the development of synthetic substitutes thereby causing downward movements in the long run demand. Wide fluctuations in exchange availabilities caused by unstable export prices and revenues can be particularly harmful in the case of countries overly exposed to debt or possessing inadequate resources to overcome such shocks.

Undesirable effects of price instability are as much evident at the micro level as in the aggregate. A frequent observation is the ineffi-
cient investment decisions influenced by the short-run trends thereby leading to long term consequences in the aggregate situation. Another effect is the misallocation of resources in the production processes. Depressed prices result in reduced production and income due to unused production capacity. When the opposite situation occurs it can cause strains on production resources (Ghatak and Ingersant, 1985).

Therefore the quest for commodity price stabilization relate to the welfare considerations and development objectives of the less developed producer countries. Stable and consistent export earnings are expected to help maintain a level of exchange availabilities for exporters that allow more control of investment and other decisions associated with development. It also improves a country's ability to borrow in the international capital markets and maintain good credit standards.

To the extent that stable export earnings make domestic prices stable, commodity stabilization is also expected to lead to efficient investment in the producing sectors. Stability improves producer price forecasting ability and is expected to lead to more efficient resource use. Stabilization of the prices of some primary commodities are also expected to lead to a situation of improved demand for the commodity by reducing the uncertainty surrounding the future price movements. This type of consideration is important in primary commodities that are industrial inputs with close synthetic substitutes (The World Bank, 1983).
Empirical Evidence

Econometric estimation of relationships between changes in commodity exports and various growth indicators has been attempted in several studies. These are in general reduced-form models that explore the impact of change in export receipts on various parameters relating to the development goals of the countries.

Coppock (1962) examined bivariate correlations between an export variability index and variables related to the growth of economies of developed and developing countries. He constructed a log-variance index of export instability to represent the fluctuation in export receipts. This index was constructed by subtracting the arithmetic mean of the first difference of the logarithm of total exports from the first difference to estimate the deviation from the trend and then by taking the square root of the squared deviation. Analyses was carried out for thirty one to eighty three developing and developed countries for the period and sub-periods between 1946 - 1958 depending on data availability. He found that the instability in export earnings is most closely related to the variability in volume and prices of exports and imports. He obtained significantly positive correlation with the rate of growth of prices and this log-variance index of export instability but could not find any correlation with rate of growth of exports or GNP. Export instability, therefore, was considered to have caused inflation but to have negligible effect on the variables pertaining to real economic growth. However, his
analysis is subject to several methodological problems. The instability index referred to a period different from that of income and growth variables. He also treated the developed and developing countries together in the model. Due to these shortcomings his results have not received wide acceptance.

MacBean (1966), studied the performances of 31 to 56 developing countries during the period or sub-periods between 1946 to 1959 using both bivariate correlations and multivariate regression. This study used a moving average based index of import purchasing power of exports to represent income instability. He reported significant positive correlations between this index and the rate of growth of investment and the rate of change of prices. He obtained coefficient estimates significantly different from zero for export instability index in regressions with the rate of growth of GDP and the ratio of investment to national income as dependent variables. The export instability index and the rate of growth of exports had significantly positive coefficient estimates in multivariate regressions with the rate of growth of capital formation as the dependent variable. These findings contradicted the widely held belief that investment is discouraged by the presence of instability. His results further suggested positive association of export instability with import instability, inflation and rate of growth of investments but not with the rate of growth of GDP. This study had a very important impact on shaping the views on instability in the western world. McBean's findings too have not escaped criticisms. Maizels (1968) noted
incongruences of some of the periods over which variables are defined. The instability index based on moving average too has low acceptability as a measure of instability.

Kenen and Voivodas (1972) used multivariate regression to study the effects of an export-instability index on the growth rate of investment, growth rate of GDP and the ratio of investment to GDP. They examined the estimated coefficients of the above index for several sample periods for a number of developing countries. In different sample periods for different groups of countries significantly positive coefficient estimates were obtained for the export-instability index with the rate of investment as the dependent variable, and significantly negative estimates were obtained with the ratios of investment to GDP as the dependent variable. The coefficient estimates for the instability index with the growth rate of GDP were insignificant. The changes were not robust to the changes in the sample periods and composition showing specification bias.

Glezakos (1973) also employed multivariate regression analysis to examine the relationship of per capita GDP growth rate with export instability and export growth rate. He excluded from the sample those developing countries for which the correlation between exports and imports were not significant at 5% level. For the 36 developing countries in which current exports were highly associated with current imports, he obtained a significantly negative coefficient estimate for export instability and a positive estimate for the rate of export growth, for the period 1953 - 1966. These results contrast those of Coppok and MacBean
and show evidence of negative effects of instability on growth. However, the validity of his results have been challenged based on the criterion used in screening countries for the sample and the way equations were specified.

The studies discussed provide mixed results concerning the impact of export instability on growth. These studies neither provide strong evidence that export instabilities affect economic growth nor disprove it. Several general criticisms apply to all these studies. They all are reduced form partial equilibrium models and are affected by the deficiencies associated with such models. Incongruities in the compilation of macroeconomic variables and omitted-variables bias the results. The various indices of export instability employed in these studies have been subjected to much criticism. The lack of well defined statistical relationships between instability in prices and revenues and various indices of development is mostly attributed to the difficulty in accurately approximating the necessary variables.

**COMMODITY AGREEMENTS**

**Issues in Commodity Stabilization**

It is important to distinguish between several important concepts underlying the objectives of any commodity stabilization scheme. These differences are often overlooked in discussions about commodity stabili-
zation. Appreciation of these concepts is helpful in understanding the complex nature of the problem and the appropriateness of possible solutions.

The first consideration relates to the level of stability desired by any scheme to stabilize the price. There are two aspects to be considered here although the difference between them are quite subtle. The difference is crucial to the goal achievement of any stabilization scheme.

The stabilizing price can be set either in relation to some external price, or be confined to a level of fluctuation around the trend in price taken as given for that commodity. The former requires the influence of the direction of average price movement over time. It seeks to improve or rather to prevent a decline in the price level of the commodity relative to an index of import prices or manufactured product price. The stabilization to even out fluctuations on the other hand is rather internally defined in the sense it treats the long term price trend as given and does not intend to influence the direction of price movement.

The above distinction is not mutually exclusive as action geared to stabilize price around a trend itself sets to establish a price level. Nevertheless it needs to be clearly identified that the two approaches cater to different objectives, since this can influence the methods selected for goal achievement. While stabilization to reduce fluctuations remains an immediate goal, it helps in meeting longer run development goals.
The second important consideration is that the stabilization of price and revenue is not necessarily the same thing. Stabilization at a set level of price is expected to lead to a certain level of export revenue or exchange availability to a country. This is not simply realized through stabilization of price as the relative magnitudes of demand and supply elasticities affect the level of revenue realized. In the case of agricultural commodities production uncertainty too is present and need to be considered.

Commodity agreements seek to establish a range of prices that reflect the interests of both the consumers and the producers of the commodity. The price is set at a level practicable to be controlled by the price control procedures specified. Such an agreement may employ international buffer stocks, national stocks, export quotas or any combination of these. Commodity control through buffer stock programs has evolved as the most popular among the producer countries because of its' simplicity compared to other schemes. Almost all the commodity programs attempted so far have had buffer stocks as the main form of management with export quotas and production controls to support it. The discussion in the following section will examine the theoretical aspects of commodity stabilization through buffer stocks in relation to the issues raised above.
Theoretical literature on the desirability of price stabilization start from the work of Waugh (1944) who looked at the welfare changes from the price stabilization in the presence of supply shifts. Oi (1961) conducted similar analysis for demand shifts. Massel (1969) noticed that previous analysis considered either demand or supply fluctuations in isolation and presented an integrated model.

The Waugh-Oi-Massel (W-O-M) model and many subsequent extensions of them assume linear demand and supply schedules, additive stochastic disturbances, instantaneous adjustment of supply and demand to market changes and price stabilization at the mean price that would have prevailed before intervention. Massel used the expected value of the change in producer and consumer surplus as a measure of gain or loss of welfare to each group. The general conclusion from this analysis was that price stabilization would increase the net welfare to society as a whole. In terms of the distribution of the gains from price stabilization, if the price instability is caused from random shifts in supply, Massel showed that the producers would receive net gains. Consumers gain from price stability if the random shifts in demand causes the instability.

The results are significantly modified if strong non-linearity in the demand and supply functions and more realistic assumptions about the nature of shifts are assumed. Just et al. (1978) showed that distribution of welfare gains of price stabilization under the assumptions of non-
linearity and multiplicative stochastic disturbances in the supply and demand schedules are significantly different from those derived under linearity. If the aggregate excess demand function is convex then the gains from stabilization are distributed more in favor of the consumers than producers in all cases. Further, the international distribution of welfare gains will be shifted from exporting to importing countries. Therefore, importing countries are more likely to gain from price stabilization unless procedures to transfer some of the gains to the producer countries are implemented.

General conclusions drawn from the theoretical work on the welfare effects of price stabilization can be stated as follows. From the aggregate (Global) point of view, price stabilization improves net welfare implying that with suitable compensation to 'losers' everyone could be better-off. However, from a distributional point of view, identification of 'gainers' or 'losers' is not straight foreword. Who receives the benefits of the price stabilization is dependant on the source of instability and the functional forms assumed for the nature of demand and supply.

The theoretical justification for price stabilization as a means of revenue stabilization has not been very encouraging. Often the underlying objective of any stabilization scheme is to prevent fluctuations of total export earnings and exchange capabilities for the participant countries over a certain period and not just the preserving of a higher gross price
level. Under these circumstances analysis of the revenue effects of the price stabilization requires careful attention.

Nguyen (1979) analyzed the conditions under which the price stabilization within the basic framework of the W-O-M model would also lead to revenue stability or instability. With the demand and supply expressed in log-linear form and assuming additive stochastic disturbance terms, his analysis showed that complete price stabilization using buffer stocks will likely destabilize revenue if the market instability is largely "supply induced" and stabilize revenue if market instability is "demand induced". For most primary commodities the demand is originated in the developed countries and is therefore relatively stable. The supply is more unstable due to vagaries of weather and political instability in the producer countries and therefore relatively unstable.

This study further showed that if the ratio of price elasticities of the demand and supply (evaluated at long-run equilibrium output) is less than the ratio of variances in demand shifts and supply shifts, price stabilization reduces the long-term level of revenue of the participants. In the long term, for many agricultural exports price elasticity of demand is relatively lower than that of the supply. The variance in demand shifts can be greater relative to supply shifts due to business cycles in the developed economies. Under these situations complete price stabilization is likely to reduce the long-term level of earnings too.

In a subsequent study Nguyen (1980) considered a more realistic policy rule of partial price stabilization that would reduce but not entirely
eliminate price fluctuations. A decision rule for partial price sta-

bilization around its geometric mean was found to stabilize both price and the earnings except when market instability is wholly supply induced and the price elasticity of demand is greater than or equal to unity. In a "supply induced" market instability condition, price stabilization will not have adverse effects on the earnings stability if the demand faced by the producers before intervention is inelastic. Given this situation he argued that the price and revenue stability can be achieved for almost all commodities.

The assumptions of the analysis based on the W-O-M model are not the most satisfactory, especially for the analysis of price stabilization of agricultural commodities. The assumption of linearity for the demand and supply schedules allow the price to be conveniently stabilized at the mean, but this is not likely to be the case. The assumption of non-linearity in the demand and supply schedules represents the reality better but makes the price stabilization infeasible as the buffer stock will face the non-zero probability of running out of stocks or accumulating stocks (Newbery and Stiglitz, 1980). Additive disturbances in the supply schedule does not seem to be very appropriate for the analysis of agri-
cultural supply because weather conditions and natural hazards affecting the crops tend to destroy a portion of the crop rather than an absolute quantity. Depending on the cause of instability in supply and demand shifts, the model can give misleading results. Further the analysis based on the consumer and producer surplus does not give enough information
about the distribution of benefits among the producer and consumer countries and ignore the important aspects of risk.

Another very crucial question in the design of a successful price stabilization program is the determination of stabilizing price or the range of prices. A key concept in preserving the efficiency of the free-market is that price is allowed to retain its role in providing signals to the producers and consumers about the proper allocation of resources. Any stabilization scheme designed to reduce the unnecessary volatility in the price should help preserve this allocative function. It is analytically difficult and near impossible to segregate short-run and longer term impacts of price using the available econometric techniques.

The experiences with the already negotiated commodity agreements have shown that the reluctance of the producer countries to ratify those agreements is a major factor that prevent the progress of the integrated program for commodities sponsored by the UNCTAD. The inability to reach agreement results from the different levels of desired optimal price stabilization across countries. The relative importance of the revenue from each commodity is different for different producer countries. Schmitz et. al (1981) showed that risk averse multi-product firm is more likely to prefer price stability in the commodity that contribute more to the total revenue and price instability in the others. This is probably true in the case of multi-commodity producing countries too. This
makes it extremely difficult to design a scheme acceptable to all producers.

The literature on the welfare and the revenue effects of the price stabilization is extensive. Nevertheless, the usefulness of this analysis as a solution to the problem of revenue uncertainty in the primary commodity producers does not appear to be very encouraging. These results are not surprising given the extremely complex nature of the fundamental problem. Therefore, solutions other than the conventional approach to the problem of commodity stabilization have assumed an important place in the revenue stabilization debate in recent years.

**FUTURES MARKETS**

**Prospects for Producer Hedging**

Commodity producers in agriculture face both output and price uncertainty in their production decision. Even after all the decisions related to the production are made, the output is stochastic. Production under risk has been extensively examined in several empirical and theoretical studies. Some of the early studies in this regard were carried out by Sandmo (1971), Baron (1970), Batra and Ullah (1974) and Ratti and Ullah (1976). These models were usually set up within a framework of maximization of expected utility of profit with a risk averse decision maker. The general result is that production varies inversely with the
degree of risk. If the producers encounter only price risk, the output varies inversely with the degree of price risk (Sandmo, 1971) and the producers degree of risk aversion (Baron, 1970), Pope (1982). In the absence of a forward market, joint occurrence of the output risk and the price risk does not necessarily alter these conclusions. The optimal scale of output still varies inversely with producers degree of risk aversion and the degrees of price and output risks.

If the producer faces only price risk, the forward markets allow producers to eliminate income risk. The range of price distribution and the producers degree of risk aversion only affect the optimal forward position. In such instances the optimal ratio of hedged quantity to the output is unity. Most of the early hedging studies were conducted within this framework and showed that if the production is certain or could be predicted accurately that the producers would in fact hedge a major portion or all output (Peck, 1978), (Halthausen, 1979) (Feder et. al, 1980). If both price and output risks are present the optimal forward contracting level is not as simple. When the output is divergent from the amount hedged, the price distribution in the futures market affects the wealth of the producer through the "exposed" futures position.

McKinnon (1967) considered producer hedging under joint output and price uncertainty. He cast his model in a variance minimization framework which examined how the optimal hedge changes when the variance in revenue distribution is minimized through hedging. His analysis showed that the optimum ratio of the output that should be hedged would be lower than
unity when both output and price are stochastic. The optimal hedge ratios were found to be inversely related to the degree of variability in the output.

Rolfo (1980) investigated the optimal hedging decision of a risk averse producer within a utility maximization framework and also when the producers preferences are expressed by a logarithmic utility function. Application of this model to a sample of cocoa producers showed that the optimal hedge ratios would be considerably below unity in contrast to the situation where uncertainty is limited to price. The results indicated that those countries having very high volatilities in price and quantity of their produce should only hedge a fraction of their output.

Gilbert (1985a) studied the relative effectiveness of stabilization using futures markets and buffer stocks in a theoretical study. He showed that if costless trading on unbiased futures markets is available, then the risk reduction benefits from the commodity price stabilization would become zero or negative. The reason for this is that the relatively small producer countries whose production is statistically uncorrelated with the price shifts do not receive any output risk reduction benefit from price stabilization. Also, the large producers for whom the production is correlated to the price movement do not receive complete protection from revenue uncertainty through stabilized price. But on the other hand with the existence of a futures market even the large producers can adopt futures positions that reduce revenue fluctuation. Under price stabilization therefore, the large producers would be worse off unless suitable
income transfers are made. Futures markets on the other hand would allow each producer to adopt a position that insure them against price movements as well as production uncertainties.

The series of theoretical and empirical analysis of the profitability of producer hedging under both output and price risk leads to the following general conclusions. Both the optimal scale of production and the optimal forward position depend on the joint distribution of price and quantity risk and the producers degree of risk aversion (Grant, 1985). If the producers output is not statistically correlated with the price, risk reduction from the futures marketing is unambiguously positive even when the output risk exists. If the output is statistically correlated with the price, the optimal quantity of futures contracts to be traded become smaller and is determined in relation to the degree of output risk. However, the producers may still utilize the correlation between its' own fluctuating output and the fluctuating market price to reduce the variance in total returns by choosing the quantity of futures contracts to be traded.

Other major arguments in favor of the use of futures markets are that it would provide each country an opportunity to take a position that is optimum for its portfolio of incomes and in doing so prevent any distortion in the market price through intervention. It will also cost less to operate a futures market than the establishment of a buffer stock as the futures markets already exist for many commodities.
However, Gilbert (1985b) showed that if the producer countries are credit constrained, futures would not provide an ideal hedging instrument. The futures contracts are marked to the market daily requiring ready access to credit markets to meet these margin payments. Since one major reason for intervention in the commodity markets is the unavailability of credit to smooth out fluctuations in income, he concluded that the credit constraints would equally limit the participation of the producer countries in the futures markets. On the other hand there is evidence that the establishment of futures markets will help overcome the instabilities due to imperfections in the market situations. Turnovsky and Campbell (1985) showed that the existence of futures markets would also reduce the variability of spot price in the presence of disturbances and sometimes may even increase the mean spot price. These considerations lead to the presumption that a futures solution to the commodity problem may be superior to the current attempts to intervene in the market. Also the already established producer cartels may have a useful role within the futures solution by way of financing the futures positions of the member producer countries or providing collateral.

**Hedging Studies**

A hedge represents a temporary position in the futures to offset the price risk arising from the commitment in the cash market. The traditional view of producer hedging is the short hedge where the producer
sells an amount equal to his expected output in the futures market. Keynes, in his "normal backwardation" theory, stated that the futures price is at a discount to the spot price because the short hedgers pay a premium to the long hedgers for bearing risk. Working (1953) rejected this passive view of hedging because he observed that most hedging is discretionary and is initiated with the intention of profiting from favorable movements in the futures and spot prices. He identified three types of commercial hedging in the futures markets: arbitrage hedging, selective hedging and operational hedging. None of these types of hedging were directly related to risk reduction. Producer hedging is examined in the work by McKinnon (1967), Peck (1975), Halthausen (1979) and Rolfo (1980). The approaches taken by McKinnon (1967) and Rolfo (1980) are most relevant to the situation considered here and will be discussed in detail.

The characterization of hedging as a means of managing business risk led to the application of portfolio theory to analyse hedging behavior. Portfolio theory as applied to hedging in general assumes the existence of a stream of expected outputs subject to both price and quantity risks and buying and selling of futures to adjust this distribution of expected returns from the risky outputs, independent of other assets. In the present problem it involves looking at the distribution of returns from cocoa exports following futures trading assuming certain behavior of expected production and prices.

The expected utility maximization model introduced by Von Neumann-Morgenstern (1944) provided an analytical framework for the economic
analysis of risky prospects. Three kinds of risk behavior by decision agents are assumed in this framework. Decision makers fall between the two extremes, risk preference and risk aversion with risk neutrality described as being not concerned with risk. Behavior of most producers in agriculture is considered risk averse. The expected utility framework describe risk averse behavior as having associated a higher utility to a certain outcome than a risky prospect with a range of outcomes and probabilities giving the same expected outcome. This approach uses the risk utility function concept in describing individual risk behavior. An individual’s degree of risk aversion is described by the Arrow-Pratt risk aversion coefficient represented by the ratio of the first and second derivative of the risk utility function. This measure ranges from negative values for a risk seeker to positive values for the risk averse with the degree represented by the absolute magnitude of the coefficient. A zero coefficient represents risk neutrality. If the decision agent’s utility function is assumed to be quadratic and when the activities are normally distributed in returns, choosing among the risky prospects using the first two moments is consistent with the Von Neumann-Morgernstern utility maximizing model as well as the mean-variance (E-V) portfolio analysis of Markowitz (1959).

Portfolio theory provides an orderly framework to choose among risky action. There are several decision models or rules employed in the selection process. Expected income-variance (E-V) analysis is undoubtedly the most popular risky decision model used in agricultural economic re-
search. The E-V model suggest that decision agents select activities or portfolios after examining mean income (E) versus the variance of income (V).

The efficient frontier concept is used to find the choices with efficient combinations of risk and return. The concept of E-V efficiency divides the risky prospects into two subsets of efficient and inefficient portfolios. A portfolio is efficient when no other portfolio with the same (or smaller) variance has a larger mean and no other portfolio with the same (or larger) mean has a smaller variance. Selection of portfolios from the efficient subset ensures no loss of expected utility. The most efficient set for a decision agent is given by the point on the frontier that is tangent to the agents utility isoquant. The use of E-V model in the general "efficient frontier" is illustrated in figure 2.1.

The point "c" represents the minimum attainable level of risk for income level c. The points such as "b" and "a" are efficient outcomes at higher levels of income and risk. Any point below the corresponding point on the frontier represents an inefficient combination as it gives a lower expected return for the same level of risk.

McKinnon (1967) treated the producer hedging within the mean-variance framework. He developed a model for the optimum forward sale assuming the producers are interested in reducing the variance in revenue.

The variables in this model are defined as follows:

P = spot price at harvest
FIGURE 2.1 Illustration Of The "Efficiency Frontier"
Pf = futures price at planting (pre-harvest)
X = output at harvest
Xf = amount of forward sale (pre-harvest)
Y = end of period revenue. If the futures price is assumed to be
an unbiased predictor of the spot price at harvest, then the expected
value of P is equal to the futures price, E(P) = Pf. The end of period
revenue distribution adjusted for the gain or loss in the futures market
can be expressed as,
\[ Y = PX + (Pf - P)Xf. \]
Therefore the expected income is
\[ E(Y) = E(PX) + XfE(Pf - P) \]
\[ = E(PX), \text{ as } E(P) = Pf. \]
The variance in revenue is
\[ \sigma_Y^2 = E[(Y - E(Y))^2]. \]
Minimizing the variance in revenue with respect to Xf, the optimal hedge
is,
\[ X_f^* = \rho \frac{P_X}{P} + \mu \]
where,
\[ \rho = \frac{\text{covariance}(X,P)}{\sigma_X \sigma_P}, \]
and
\[ \rho = \text{degree of correlation between } X \text{ and } P, \]
\[ \frac{X_f^*}{\mu_X} = \rho \frac{s_X/m_X}{\mu_P/p_f} + 1. \]

Expressed as a ratio of the expected output, the expression for the optimal hedge is,

This expression shows that the optimal hedge would be less than the full output when both output and price are stochastic because \( \rho \) would be negative for many producers whose output tend to be negatively correlated with the price. Further it can be seen that the optimal hedge ratio will be smaller when (a) greater the output variability (\( \sigma_X \)) relative to price variability (\( \sigma_P \)), and (b) higher the negative correlation between price and the output (\( \rho \)). The conventional unitary optimum hedge ratio is obtained when the output is certain (\( \sigma_X = 0 \)) or the output of the producer is statistically independent of the price variation (\( \rho = 0 \)).

Rolfo (1980) constructed a similar model except he maximized expected utility instead of minimizing revenue variance. His model was quite similar to that of McKinnon (1967) except he treated the distributions of spot and futures prices differently. Variables in his model were defined as follows.

\begin{align*}
P & = \text{the distribution of cash price at harvest} \\
P_f & = \text{the distribution of futures price at harvest} \\
Q & = \text{the distribution of output}
\end{align*}
\[ f = \text{the futures price hedged} \]
\[ n = \text{the optimal hedge ratio} \]
\[ m = \text{the risk parameter} \]
\[ W = \text{revenue distribution adjusted for futures gain or loss} \]

Therefore, the end of period cash distribution, \( W \) can be expressed as
\[ W = PQ + n (f - P_f). \]

The variance in the end of period revenue is equal to
\[ \text{var } W = E[(W - E(W))^2] \]
where,
\[ E \text{ is the expectation operator. Therefore,} \]
\[ E(W) = E(PQ) + n(f - E(P_f)) \]
and solving for \( \text{var } W \),
\[ \text{var } W = E((PQ + n(f - P_f)) - (E(PQ + n(f - P_f))))^2 \]
\[ = E(PQ + n(f - P_f) - E(PQ) - n(f - E(P_f)))^2 \]
\[ = E(PQ + nf - np_f - E(PQ) - nf + nE(P_f))^2 \]
\[ = E((PQ - E(PQ) - np_f + nE(P_f))^2 \]
\[ = E(PQ - E(PQ))^2 + n^2(E(P_f - E(P_f))^2 \]
\[ - 2nE(PQ - E(PQ))(P_f - E(P_f)) \]
\[ = \text{var } PQ + n^2 \text{var } P_f - 2n \text{ cov}(PQ, P_f) \]

Therefore the variance in end of the period cash distribution is,
\[ \text{var}(W) = \text{var}(PQ) + n^2 \text{ var}(P_f) - 2n \text{ cov}(PQ, P_f). \]

Substituting the expressions for the mean and variance in the expected utility formulation gives
\[ EU = E(W) - m(\text{var } W) \]
where,
\[ E(W) = E(PQ) + n(f - E(P_f)) \text{ and,} \]
\[ \text{var}(W) = \text{var}(PQ) + n^2 \text{var}(P_f) - 2n \text{cov}(PQ, P_f) \]
\[ EU = E(PQ) + n(f - E(P_f)) - m[\text{var}(PQ)] - 2n \text{cov}(PQ, P_f) - mn \text{var}(P_f) \]
\[ EU = E(PQ) + n(f - E(P_f)) - m \text{var}(PQ) + 2mn \text{cov}(PQ, P_f) - mn^2 \text{var}(P_f) \]

Therefore maximizing EU with respect to n,
\[ \delta EU / \delta n = (f - EP_f) + 2m \text{cov}(PQ, p_f) - 2mn \text{var} P_f = 0 \]

and by solving for \( n^* \) the optimal hedge becomes,
\[ n^* = \frac{(\text{cov PQ,Pf})}{\text{var P_f}} + \frac{(f - EP_f)}{2m \text{var P_f}} \]

The utility maximizing model of Rolfo allows exclusive consideration of producer risk. Examination of this expression shows that the optimal hedge ratio is negatively dependent upon the producer's degree of risk aversion. By assuming different risk parameters, one can analyse how the optimal hedge changes as producer risk attitudes change. Like McKinnon, Rolfo found that the optimal hedge for a producer with both price and output risk is less than the expected output.

The variance minimization approach of McKinnon (1967) and the utility maximizing approach of Rolfo (1980) are intricately related. The assumption of unbiasedness in the futures markets used by McKinnon (1967) is analytically convenient but may not be justified by empirical evidence. If the distribution of the cash price and the futures price is treated
separately, then the expression for variance in the end of period cash
distribution for McKinnon (1967) and Rolfo (1980) become identical.

Given the end of the period cash distribution variance is
\[
\text{var}(W) = \text{var}(PQ) + n^2 \text{var}(P_f) - 2n \text{cov}(PQ, P_f),
\]
and following the notation used above and minimizing with respect to \( n \), the
number of contracts to minimize variance hedge similar to McKinnon (1967)
can be determined as
\[
\frac{\partial \text{var } W}{\partial n} = 2n \text{var}(P_f) - 2 \text{cov}(PQ, P_f) = 0.
\]
Solving for \( n \) gives optimal number of contracts \( n^* \) as,
\[
n^* = \frac{\text{cov}(PQ, P_f)}{\text{var } P_f}.
\]
Unlike the expression developed by McKinnon (1967), this expression shows
the optimal hedge to be an explicit function of the distributions of both
the futures and cash price distributions and the quantity distribution.
The first expression in the optimal hedge expression of Rolfo (1980) is
the same as the variance minimizing hedge for McKinnon model.

Selective Hedging

A hedge can be either routine or selective. A routine hedge is placed
once, usually at the beginning of the production cycle and is held until
lifted at the end of the period. Both the hedges considered by Rolfo
(1980) and McKinnon (1967) fall in this category. Research shows that a
hedge employed routinely can substantially reduce the variance in revenue
(Peck, 1975). These routine hedges reduce the mean incomes substantially.
Sometimes this trade-off in revenue may not be acceptable to many hedgers. A producer hedged in the futures has 'locked in' a certain level of profit. If the producer's expectations about basis and costs were correct, the profit from hedging would remain the same. Such a routine hedge also deprives the producer from realizing large 'wind-fall' profits when the spot price increases after placing the hedge. Therefore, various selective strategies are analysed in an effort to increase the hedging returns while decreasing the variance in revenue. A selective hedge is placed at some stage of production and is usually guided by a single or a combination of rules. A multiple selective hedge is placed and lifted several times within one production cycle. A selective strategy would protect the hedger by keeping him/her hedged in futures when the price moves against the producer and would allow him/her to realize the gains of an unexpected price increase by keeping out of the market when the market is rising. This type of strategy reduces risk and also increases profits compared to a routine hedge.

The various approaches to selective hedging are categorized under two methods. The fundamental approach to selective hedging is based on the analysis of various supply and demand factors that determine the price at which hedges should be placed. This approach relies on the efficiency of the market to reflect all currently available information in the price and has very strong theoretical appeal. The use of econometric price forecasts is a very popular fundamental tool. However, the limitation
in using this approach is the difficulty of accurately modelling the market to catch the effect of all the factors that determine the price.

The technical approach to selective hedging rely on the past price behavior to give signals to guide the timing of hedges. Technical trading systems are based on the existence of various degrees of inefficiencies in the market. There are a wide variety of trading rules used in the technical trading systems. Moving averages are among the most widely used technical tools. These are popular because of the simplicity in concept and computation and the ability to provide clear, objective signals. The rationale behind using a moving average is that an uptrend is preceded by a preponderance of buying over selling whereby the price rises over the average in the period before. A downtrend is characterized by strong selling relative to buying leading the price to fall below the average. By nature, moving averages signal turns in a delayed manner. A signal immediately following the move thereby allowing transactions at or near the peak price change ensures greatest profits to the hedger. Therefore the choice of an 'optimal' length of a moving average is important to the success of hedging. The optimal moving average should be short enough in length to signal a position early in the move and long enough to isolate small moves, prevent unnecessary transactions and lower 'whipsaw' losses.

There are several different kinds of moving averages, i.e. simple, linearly weighted, exponentially weighted, etc., that are used. One of the more popular systems involves two moving averages where signals are
generated by the 'crossing' of two shorter and longer moving average. The use of a third 'leading' moving average or penetration levels are sometimes used to improve the price signals provided by double moving averages.

Irwin and Uhrig (1983) compared the efficiency of some of these trading rules with U.S. futures markets. This study compared four trading systems across a number of commodities including cocoa and tested them outside the data base. The double moving average cross-over system, where the intersection of a short moving average and a long moving average was treated as the signal to place and lift hedges, gave the highest profit both within and outside the data base when used to hedge cocoa. They used the dominant contract to hedge, always holding either a short or a long position depending on the price signal. This system will be modified to suit the requirements of the cocoa producer countries and compared to routine and selective strategies.

There are other trading systems based on the past price behavior that are useful from the point of view of variance minimization. One such strategy is hedging early in the season before the information about the forthcoming crop can impact on price. Very early in the season the price tends to trade around the long term average price. Depending on output variability, this may or may not be result in revenue stability without much trade-off in average revenue. A second scheme based on past prices is the use of a 5 year moving average excluding the high and low price.
A hedge is placed when the price reaches a level determined at a certain percentage above the calculated-5 year moving average.

These strategies have not been tested in terms of their ability to stabilize and or improve export revenue for cocoa producing countries. In the next chapter these strategies will be analyzed using cocoa prices and production for 1960 to 1985.
CHAPTER 3
DEVELOPMENT OF HEDGING STRATEGIES

The study will be conducted by simulating several cocoa hedging strategies over time using historical data and by comparing the outcomes in a mean-variance setting. Simulation involves setting up a model of real world situation and conducting experiments on the model. In the context of hedging it involves the simulation of selected hedging strategies using historical yields and prices. The study will develop strategies to reduce variance in revenue from the exports of cocoa using data for 1959-60 - 1980-81 and then will conduct the tests outside the data base using data for 1981-2 to 1984-5. The efficiency of the selected hedging strategies will be evaluated by comparing the means and variances of the net returns generated in each strategy among themselves and with assumed cash positions.

FUTURES TRADING MODELS

The purpose of the futures trading models in the study is to simulate cocoa future trading returns by the four major producers over a historical period. The number of trades, profits and losses from each trading system can be tracked and compared with each other using selected decision rules.
The trading models input daily prices of the contracts selected for trading.

The following trading models will be employed in the study.

1. modified McKinnon variance minimizing hedges

2. Rolfo mean-variance optimizing hedge ratios

3. 5 year moving average price excluding the two extreme prices

4. hedging 1 year ahead, and

5. dual moving average crossover system.

All the trading models will be simulated for the period 1959-60 to 1980-81 for the U.S. cocoa futures in New York with the years 1981-82 to 1984-85 reserved for testing outside the data base. Data for the London cocoa futures too will be analysed for the first two strategies. The London market is an important trading center for most of the African cocoa going to Europe and is therefore included for comparison. Rolfo (1980) analysed data for four producer countries using data for cocoa futures in London during the period 1952-53 to 1975-76. This analysis will be repeated for the same market with additional data, and tested outside the base to see the changes in the optimal parameters since that analysis. The set of countries and data period for the London market is identified as "London" and the data for New York market as "New York" in the fol-
lowing discussion. The simulations will be carried out for the four major West African producers, Ivory Coast, Ghana, Cameroun and Nigeria. Reliable data for Cameroun are not available for the years before 1960 and therefore not included in the London sample.

The production year for cocoa starts in October. Usually forecasts for the forthcoming crop in the producing countries are made at this time. Most uncertainty pertaining to the early crop development is resolved by this time and the crop forecasts incorporate all the available information to that point in time. However, the actual production is still uncertain as the developing crop is affected by factors such as weather and diseases. Revised forecasts are issued as new information concerning the crop becomes available.

Such crop forecasts are periodically published by the large traders dealing in cocoa and by the cocoa study group at International Cocoa Organization (ICCO). Forecasts of the forthcoming crop for the major producer countries are provided by Gill and Duffus, the largest cocoa trader in the international cocoa market. These are published starting September/October and updated bimonthly. Quarterly crop forecasts are published by the ICCO starting at the beginning of the season. The Gill and Duffus statistics are more appropriate for this analysis since they are an independent source and provide more frequent estimates. The first Gill and Duffus forecast in October can be considered to reflect all the information available about the forthcoming crop up to the last day of September.
Cocoa main crop is harvested through March and the summer harvest is small compared to the main crop. Therefore, the March futures contract was chosen for analysis since most of the output is realized by this time. For those trading models where hedges were only placed and lifted once, the hedge was placed on the last day of September and lifted on the first Friday in March. The September price of March futures was assumed to be the best price forecast available before harvest for both cash and futures prices after harvest. The futures price in March for the same contract and the spot prices in March were used as realized prices at harvest. The spot price for the London market will be the shipment price quoted for the last market day in March. Similar quotations are not available for the New York market and the average spot price for Ghanian cocoa for the month of March will be used instead.

DATA SOURCES

The New York futures prices used for analysis were purchased from Commodities Inc. and include daily open, high, low, close and open interests. The futures and shipment price series for the period 1953 - 1985 for the London market was collected from the issues of London Financial Times. The New York spot prices were obtained from the Cocoa Market Report published by Gill and Duffus. Output data for the countries in the study were obtained from Cocoa Statistics published by the same source. Ghana and Ivory Coast output prior to 1960 include the main crop only. Outputs
for Nigeria for the whole study period and for Ghana, Ivory Coast and Cameroun since 1960 refer to the total crop.

**ANALYSIS AND ESTIMATION**

Empirical determination of the optimal hedge ratios will be done by estimating the coefficients in the models described above using historical data. The optimal ratios of the expected outputs for the two markets will be used to simulate hedge programs within the data bases for which they were developed. Testing outside the data base will be done by simulating these hedges for the period 1981 - 1985. The selective strategies too will be simulated within the data base and outside the data base. In order to obtain the information about the margin requirements maximum draw-downs for the same periods will be computed. This will provide information about the possibility of depending on the various financing schemes to meet the margin requirements.

**DERIVATION OF OPTIMAL HEDGE RATIOS**

1. **Variance Minimizing Hedge Ratio**

In the earlier chapter it was shown that the variance minimization hedging model presented by McKinnon (1967) can be easily modified to accommodate the more realistic assumption of separate distributions in the
cash and futures markets. The following expression for the optimum variance minimizing hedge was developed. The optimal hedge as a ratio of the expected output is,

\[ n^* = p \frac{s_P}{\mu_P - P} + 1. \]

Given the following variable definitions:

- \( P(0) \) = the forecast cash and futures markets price as reported in the futures market before harvest in September
- \( P_f(0) \) = the futures price at harvest
- \( P(t) \) = spot price at delivery, in March
- \( Q_f(0) \) = crop forecast before harvest, in September
- \( Q(t) \) = realized output in March and by defining the forecast errors in cash price (\( e_P \)), futures price (\( e_f \)) and in production (\( e_Q \)) as the difference in forecast and realized value divided by the forecast we can write,

\[ P = f(1 + e_P) \]
\[ Q = Q_f(1 + e_Q) \]
\[ P_f = f(1 + e_f). \]

By substituting these terms into the expression for an optimal hedge, it can be written as:
The Rolfo optimum hedge ratio under utility maximization developed earlier is,

\[
\eta^* = \frac{(f - E P_f)}{2m \text{var } P_f} + \frac{(\text{covar } PQ, P_f)}{\text{var } P_f}.
\]

Using the variable definitions in 3.2.1 and defining \( m \) as the risk aversion parameter, the optimum hedge ratio can be written as,

\[
\frac{n_1^*}{Q_1^P} = \frac{\text{cov}((1 + e^P)(1 + e^Q), e^P)}{\text{var } (e^P)} + \frac{E(e^P)}{2mf(q^P_1) \text{var } (e^P)}.
\]

This expression can be determined by first estimating the forecast errors in the price and quantity distribution using historical data.

The hedges will be simulated for the appropriate ratio of the expected crop based on the October forecast. The profits and losses of holding the appropriate contract and the maximum draw down for the margin payments will be estimated monthly. The analysis will be conducted for Ghana, Nigeria, and Ivory Coast using data for the London market and Cameroun will be included in the New York sample with the above 3 countries.

**Utility Maximization**
The first part of this expression is identical to that of modified McKinnon variance minimizing hedge derived in the section 3.4.1. It can also be seen that the optimal hedge is a decreasing function of the risk aversion parameter. The prices and quantities for the analysis will be the same as for previous model. Several values of the risk parameter (m) will be assumed to see how the hedge varies as the risk attitudes of a country change. There are no prior guidelines for making assumptions about the risk aversion levels of a country. Empirical findings on individual producer risk preferences suggest that the producers in the developing countries are risk averse (Young, 1979). Elicited risk aversion coefficients for agricultural producers indicate very small positive coefficient values which are very close to risk neutrality. Therefore a range of values covering the empirically estimated risk coefficients for the individuals will be used.

SELECTIVE HEDGING STRATEGIES

Production Prediction Equations

Some of the selective hedging strategies in the study will make use of production forecasts one year before the actual harvest is completed. For the accurate prediction of cocoa production at this early stage models consisting of data on the age structure of the cocoa plantations, cultural operations, local pricing policies etc. would be necessary. Such data
are not widely available for use and therefore future production will be estimated using historical yield patterns. Both a linear time trend model and a set of moving averages will be estimated to forecast realized yields between 1955 - 1980 in each of the four countries. Moving averages were included in an attempt to catch the lag effects of changes in the age structures, cultural operations and yield cycles. The "best" model will be selected based on the $R^2$ value of the equation and the simplicity and robustness of the estimators.

**The Five Year Average Price Method**

In this method the average price of cocoa for the previous five years excluding the two extremes is calculated. This becomes a target price level for hedging the current crop. A range of prices 5 - 25 percent above the target price are analysed to see if returns can be increased above the average. The hedge is placed only when the futures price reach this target price level and then held there until the end of harvest. In the present case the hedge will be placed on the March contract and held until the first Friday of that month. The contract amount will be equal to the expected crop available at the time of placing the hedge. In the event the hedge is placed before the September of the previous year, the output forecast obtained by following the trend yields will be used. The hedges will be re-examined in September and adjusted to reflect the output forecast available at that time.
Hedging One Year Ahead

This strategy will explore hedging very early in the season in the previous March over a period of one year duration as a variance reduction strategy. The hedge will be placed in the year t-1 on the March contract for year t. At this time no forecasts about the forthcoming crop are available from the sources described above. Therefore the expected crop to hedge will be determined on a time trend. If the crop forecast made on September is the first available forecast and tend to be better than the time trend forecast. Therefore the amount hedged will be adjusted to that level on the last day of September. The profits and losses of adopting this method will be recorded for each hedge as with the other methods.

The Dual Moving Average Crossover (DMAC) Method

Irwin and Uhrig (1983) determined that the optimal crossover system for cocoa was based on 14 day and 36 day moving averages. They speculated using the contract dominant at all times by maintaining futures position, either long or short, during the whole study period depending on the signal given by the system. Long positions will be excluded from the present study as they are not consistent with the hedged position. All moving averages will be computed using the days closing price. The hedge will be placed in the March contract in an amount equal to the expected
crop when the short (14 day) moving average crosses the long (36 day) moving average from above. The hedge will be placed on the next market day at the opening price. The hedge will be lifted by buying back the same amount if the moving averages cross again with the short average approaching the long average from below. It will be placed again if the averages cross again. The use of a short leading average to strengthen the sell signal given by the crossing action of the two averages will be explored, using both weighted and non-weighted averages.
CHAPTER 4
RESULTS AND DISCUSSION

MEASURES OF PRICE AND PRODUCTION UNCERTAINTIES

The various measures of price and production uncertainties as well as the correlations between the price and production uncertainties were examined for each country in the study for the two markets. Table 4.1 depicts the mean, standard deviation and the T statistics for the forecast errors in cocoa production and prices. The price and quantity forecast errors were measured as the deviation from the expected price and output as a ratio of the expected value. The output forecast error means are all positive but small except for the Ivory Coast. The t test of the hypothesis that the forecast error is zero is not rejected except for the Ivory Coast output which shows upward bias in both samples. The forecast errors in futures price in the both markets are very small and not significantly different from zero. The T statistic fails to reject at 5 percent level of probability the hypothesis of unbiasedness in the forecast error in the spot price in New York during the period 1960-81. This shows that the futures prediction in September for cash spot price in March in New York on the average tends to be biased upward.

Table 4.2a and 4.2b shows the variances and covariances between the forecast errors in output for the two samples. The errors in output
TABLE 4.1
MEAN AND STANDARD DEVIATION OF QUANTITY AND PRICE FORECAST ERRORS

<table>
<thead>
<tr>
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<th>MEAN</th>
<th>STANDARD DEVIATION</th>
<th>T</th>
</tr>
</thead>
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<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity</td>
<td></td>
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<td></td>
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<td>0.04</td>
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<tr>
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<td>0.135</td>
<td>0.66</td>
</tr>
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<td>IV. Coast</td>
<td>0.089</td>
<td>0.155</td>
<td>3.10</td>
</tr>
<tr>
<td>Price</td>
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<td></td>
</tr>
<tr>
<td>Futures</td>
<td>0.020</td>
<td>0.260</td>
<td>0.41</td>
</tr>
<tr>
<td>Spot</td>
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<td>0.275</td>
<td>1.36</td>
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<tr>
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<td>0.10</td>
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<td>Price</td>
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<td>Spot</td>
<td>0.240</td>
<td>0.240</td>
<td>2.46</td>
</tr>
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### TABLE 4.2a

VARIANCE-COVARIANCE AND CORRELATIONS BETWEEN FORECAST ERRORS IN PRODUCTION: LONDON, 1953-1981

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<th>GHANA</th>
<th>NIGERIA</th>
<th>IV.COAST</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COVARIANCE MATRIX</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>GHANA</td>
<td>.0155789</td>
<td>.0090928</td>
<td>.0047426</td>
</tr>
<tr>
<td>NIGERIA</td>
<td>.0090928</td>
<td>.0186464</td>
<td>.0071884</td>
</tr>
<tr>
<td>IV.COAST</td>
<td>.0047426</td>
<td>.0071844</td>
<td>.0241698</td>
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<table>
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<th>GHANA</th>
<th>NIGERIA</th>
<th>IV.COAST</th>
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</thead>
<tbody>
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<td><strong>CORRELATION COEFFICIENTS</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>GHANA</td>
<td>1.00000</td>
<td>0.53349</td>
<td>0.24441</td>
</tr>
<tr>
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<td>0.0000</td>
<td>0.0029</td>
<td>0.2013</td>
</tr>
<tr>
<td>NIGERIA</td>
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<td>1.00000</td>
<td>0.33842</td>
</tr>
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<td>0.0000</td>
<td>0.0725</td>
</tr>
<tr>
<td>IV.COAST</td>
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<td>0.33842</td>
<td>1.00000</td>
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<tr>
<td></td>
<td>0.2013</td>
<td>0.0725</td>
<td>0.0000</td>
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</table>

Values beneath the correlation coefficients indicate probability under $H_0: \rho = 0$. 
### TABLE 4.2b


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<th>IV. Coast</th>
<th>Cameroun</th>
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<td><strong>Covariance Matrix</strong></td>
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<th>Cameroun</th>
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<td><strong>Correlation Coefficients</strong></td>
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<td>0.51645</td>
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<td>0.1079</td>
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<td>0.09799</td>
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<tr>
<td>Cameroun</td>
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<td>0.5628</td>
<td>0.6644</td>
<td>0.1844</td>
<td>0.00000</td>
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</table>

Values beneath the correlation coefficients indicate probability under H0: ρ = 0.
prediction are strongly correlated among the 3 producer countries Ghana, Ivory Coast and Nigeria. The correlations between the errors in the production forecasts for the above 3 countries and Chaperon are relatively small (Table 4.2b). A close relationship in the prediction of output in all the countries should be expected as all of them belong to the same geographic region. The covariances between the forecast errors in production and spot prices were negative in both markets. Correlations between the errors in price and production forecasts are significantly negative for all countries (Table 4.3). As the output variability in the four countries tend to move together, this can be considered as the result of the joint output effect on price rather than the individual country effect.

Correlations between revenue and output errors are negative among the countries but statistically non-significant (Table 4.4). Correlations between revenue and spot price forecast errors are positive but not statistically significant for Ghana, Nigeria and Cameroun. They are significantly negative for the Ivory Coast in the both markets (Table 4.5). This indicates that the revenue from cocoa exports in the Ivory Coast tends to decrease with an increase in the spot price. It should be noted however, that the errors in output forecasts for Ivory Coast in the both periods were significantly positive and the same relationship was found for the error of spot price forecast in the New York market. The Ivory Coast has increased its cocoa output in recent years and has now become the largest producer of cocoa. Therefore, the variability of
TABLE 4.3

COVARIANCE AND CORRELATIONS BETWEEN FORECAST ERRORS IN PRODUCTION AND FORECAST ERRORS IN SPOT PRICES

<table>
<thead>
<tr>
<th></th>
<th>GHANA</th>
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<th>IV.COAST</th>
<th>CAMEROUN</th>
</tr>
</thead>
<tbody>
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<td><strong>COVARIANCE MATRIX</strong></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>LONDON</td>
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<td>-0.018807</td>
<td>-0.01709</td>
<td>-</td>
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<tr>
<td><strong>CORRELATION COEFFICIENTS</strong></td>
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<tr>
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<td>0.00126</td>
<td>0.4251</td>
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</table>

Values beneath the correlation coefficients indicate probability under H0:RHO=0.
TABLE 4.4

CORRELATIONS BETWEEN FORECAST ERRORS
IN PRODUCTION AND REVENUE

|          | Ghana | Nigeria | IV. Coast | Ghana
|----------|-------|---------|-----------|------
| London   |       |         |           |      
| Revenue  | -0.11537 | -0.42484 | 0.32422 | -0.59479 |
|          | 0.6092 | 0.0487 | 0.1410 | 0.0035 |

<table>
<thead>
<tr>
<th></th>
<th>Ghana</th>
<th>Nigeria</th>
<th>IV. Coast</th>
<th>Cameroun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ghana</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production</td>
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<td>0.12356</td>
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<td>0.5830</td>
<td>0.0238</td>
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<td>0.1912</td>
</tr>
<tr>
<td>Cameroun</td>
<td>-0.28150</td>
<td>-0.10329</td>
<td>-0.08379</td>
<td>0.49486</td>
</tr>
<tr>
<td></td>
<td>0.2044</td>
<td>0.6474</td>
<td>0.7108</td>
<td>0.0192</td>
</tr>
</tbody>
</table>

Values beneath the correlation coefficients indicate probability under H0:H0=0.
## TABLE 4.5

CORRELATIONS BETWEEN REVENUE AND SPOT PRICE FORECAST ERRORS

### LONDON

<table>
<thead>
<tr>
<th></th>
<th>GHANA</th>
<th>NIGERIA</th>
<th>IV. COAST</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPOT</td>
<td>0.02848</td>
<td>0.19198</td>
<td>-0.62822</td>
</tr>
<tr>
<td>PRICE</td>
<td>0.8834</td>
<td>0.3184</td>
<td>0.0003</td>
</tr>
<tr>
<td>ERROR IN</td>
<td>0.90498</td>
<td>0.86725</td>
<td>0.12968</td>
</tr>
<tr>
<td>PRICE</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.5026</td>
</tr>
</tbody>
</table>

### NEW YORK

<table>
<thead>
<tr>
<th></th>
<th>GHANA</th>
<th>NIGERIA</th>
<th>IV. COAST</th>
<th>CAMEROUN</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPOT</td>
<td>0.04330</td>
<td>0.28594</td>
<td>-0.71404</td>
<td>0.20972</td>
</tr>
<tr>
<td>PRICE</td>
<td>0.8483</td>
<td>0.1970</td>
<td>0.0002</td>
<td>0.3489</td>
</tr>
<tr>
<td>ERROR IN</td>
<td>0.85676</td>
<td>0.77807</td>
<td>-0.15471</td>
<td>0.76014</td>
</tr>
<tr>
<td>PRICE</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.4918</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Values beneath the correlation coefficients indicate probability under $H_0: \rho = 0$. 
its output has heavier impact on price than any other country. This implies that hedging would be more attractive to the Ivory Coast for income stabilization than speculating in the cash market.

**PRODUCTION PREDICTION EQUATIONS**

The equations for the prediction of cocoa production in March a year before harvest were estimated using historical data and the linear time trend variables as described in chapter 3. The details of the estimated equations are given in the appendix table 1. The equations for predicting the output of Ghana and Cameroun were constituted of a linearly weighted and a simple 3 period moving average in the models respectively along with a linear time trend variable and had R² values of 0.56 and 0.66 respectively. The output prediction equation for Ivory Coast included a linear time trend variable and a squared 3 period moving average and had a R² value of 0.95. Nigerian output had evidently taken a downtrend after 1973 and separate equations were estimated for the two periods before 1973 and after. The equation for the first period was consisted of a trend variable and the second equation included a trend variable and a 3 period moving average. The two equations had R² values of 0.64 and 0.77 respectively. The equations were picked considering high R² values compared to others and the simplicity in use.
The optimum hedge ratios for each country following the variance minimization and utility maximization assumptions are presented in the table 4.6. For the variance minimization strategy, the portion of the expected output that should be hedged in the London market are 60, 72 and 68 percent for Ghana, Nigeria and the Ivory Coast respectively. In an earlier study, Rolfo (1980) estimated these ratios to be 61, 65 and 78 percent respectively for the same countries for a sample that did not include the years 1976-77 to 1980-81. Considering the differences in the production pattern and in the price levels during the two periods, the optimal hedge ratios across the sample periods compare well. For the sample period 1960-81, the optimal ratios for variance minimization on hedging in the New York market are estimated as 62, 70, 73 and 68 percent for Ghana, Nigeria, Ivory Coast and Cameroun respectively.

The optimum ratios of the expected output to be hedged under the utility maximization framework were calculated for a range of risk aversion coefficients (m) representing different degrees of risk averse behavior by the producer countries. The results are reported in table 4.6 under each country for various risk coefficient levels. The optimum hedge ratios do not deviate significantly from that of the variance minimization
### Table 4.6

**OPTIMAL HEDGE RATIOS BY COUNTRY**

<table>
<thead>
<tr>
<th>STRATEGY</th>
<th>OPTIMAL HEDGE RATIO</th>
<th>GHANA</th>
<th>NIGERIA</th>
<th>IV.COAST</th>
<th>CAMEROUN</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LONDON</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VARIANCE MINIMIZATION</td>
<td>0.60</td>
<td>0.71</td>
<td>0.68</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>m=0.01</td>
<td>0.60</td>
<td>0.71</td>
<td>0.68</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>m=0.001</td>
<td>0.60</td>
<td>0.71</td>
<td>0.68</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>m=0.0001</td>
<td>0.59</td>
<td>0.70</td>
<td>0.66</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>m=0.00001</td>
<td>0.52</td>
<td>0.56</td>
<td>0.49</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>m=0.000001</td>
<td>-0.21</td>
<td>-0.79</td>
<td>-1.24</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>NEW YORK</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VARIANCE MINIMIZATION</td>
<td>0.62</td>
<td>0.70</td>
<td>0.73</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>m=0.01</td>
<td>0.62</td>
<td>0.70</td>
<td>0.73</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>m=0.001</td>
<td>0.62</td>
<td>0.70</td>
<td>0.73</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>m=0.0001</td>
<td>0.62</td>
<td>0.68</td>
<td>0.71</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>m=0.00001</td>
<td>0.52</td>
<td>0.48</td>
<td>0.46</td>
<td>0.17</td>
<td></td>
</tr>
<tr>
<td>m=0.000001</td>
<td>-0.61</td>
<td>-1.56</td>
<td>-2.01</td>
<td>-4.40</td>
<td></td>
</tr>
</tbody>
</table>
which is consistent with the infinite risk aversion by the producer countries, until the risk aversion coefficient drops below 0.0001. Below this level, the optimal hedge ratio drops sharply. The London market results suggest inverse or long hedging is optimal when the risk aversion coefficient falls below 0.000001. For the countries trading in the New York market, long hedging became optimal when the risk parameter fell below 0.0000001. The risk coefficient level at which the transition from traditional short hedging to the long hedging takes place is lower for trading in the New York market because the mean error in the futures price forecast is only a third of that in the London market.

The change in the optimal hedge ratio at the higher levels of the risk aversion parameter is very small. So the simulation results for variance minimization and utility maximization are almost identical. Therefore, for utility maximization hedges, only the hedge simulations at the risk aversion coefficients of 0.0001 and 0.000001 for the London market and 0.00001 and 0.0000001 for the New York market are presented. Below these levels inverse hedging became optimal and was not considered.

The portion of the output that should be hedged short following any one of these criteria is shown to be considerably below unity. Even when the producer countries are extremely averse to risk not more than two thirds of the output should be hedged. As the producer countries become increasingly risk neutral they select to speculate in the cash market and depend less and less on hedging.
Variance Minimizing Hedge

The results of the hedge simulation following the optimal ratios that minimize the revenue variance are presented in the table 4.7. For each sample the mean revenues and variances over the sample and post-sample periods are shown. For comparison purposes the means and variances are compared in percentage terms to the cash revenue and variance over the same period (shown in parentheses).

For the countries in the London sample, routine hedges within the data base produced only marginal differences compared to cash. Hedging decreased the variance of Ivory Coast revenue by 6 percent and the those of Ghana and Nigeria by 3 and 2 percent respectively, with less than 2 percent trade off in mean revenue. However, tests outside the data base produced significantly lower variances in revenue for a modest trade-off in income for all three countries. The reduction in revenue variance was highest for Nigeria (42%) followed by Ghana (35%) and Ivory Coast (30%). The trade off in mean revenue ranged between 6 to 9 percent. The variance in cash revenue during the post-sample period was 33 percent less than that within the sample period. Examination of the hedging and cash returns indicates that hedging has generally been successful in reducing revenue fluctuations.

The New York market simulations over the period 1959-60 to 1980-81 produced a 11 percent and 9 percent reduction in revenue variance for Ghana and Nigeria respectively with less than 2 percent reduction in mean
### Table 4.7

**REVENUE MEAN AND VARIANCE BY COUNTRY FOR VARIANCE MINIMIZATION HEDGE**

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>COUNTRY</th>
<th>WITHIN BASE</th>
<th>OUTSIDE BASE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MEAN</td>
<td>VARIANCE</td>
</tr>
<tr>
<td>LONDON</td>
<td>GHANA</td>
<td>555 (99)</td>
<td>355741 (97)</td>
</tr>
<tr>
<td></td>
<td>NIGERIA</td>
<td>556 (99)</td>
<td>359354 (98)</td>
</tr>
<tr>
<td></td>
<td>IV.COAST</td>
<td>552 (98)</td>
<td>343274 (94)</td>
</tr>
<tr>
<td></td>
<td>CASH</td>
<td>563 (100)</td>
<td>365167 (100)</td>
</tr>
<tr>
<td></td>
<td>GHANA</td>
<td>1383 (98)</td>
<td>1344813 (89)</td>
</tr>
<tr>
<td></td>
<td>NIGERIA</td>
<td>1387 (98)</td>
<td>1369194 (91)</td>
</tr>
<tr>
<td></td>
<td>IV.COAST</td>
<td>1382 (98)</td>
<td>1330102 (88)</td>
</tr>
<tr>
<td></td>
<td>CAMEROUN</td>
<td>1376 (98)</td>
<td>1311213 (87)</td>
</tr>
<tr>
<td></td>
<td>CASH</td>
<td>1412 (100)</td>
<td>1504960 (100)</td>
</tr>
</tbody>
</table>

Units for London are Pounds Sterling per metric ton and for New York Dollars per metric ton.

Numbers within parenthesis indicate percentage of cash position.
The risk reduction benefits of hedging to Ivory Coast and Cameroun within the sample were insignificant. In post-sample period tests through 1984-85, substantially lower revenue variances were obtained for all the countries similar to the London sample results. While the variance reductions were even greater in magnitude, the income trade-offs were lower compared to London market. This indicates that the countries would have obtained greater reduction in revenue variance at a lower trade-off in revenue by hedging in the New York market rather than in London.

**Expected Utility Maximization**

The hedge simulation results for London based on the optimal utility maximization ratios assuming various values of risk aversion coefficients are given in table 4.8. The within sample results do not indicate a significant change in revenue mean or variance with hedging. In the post sample tests, hedging at the optimal ratios for risk parameter value 0.0001 reduced the revenue variance by 41 and 29 percent for Nigeria and the Ivory Coast respectively. Hedging at the optimal ratios for the risk parameter values of 0.00001 lowered revenue variance by 35 and 23 percent of the same two countries respectively. The reductions in the revenue variance for Ghana were 35% and 31% at the two risk parameter levels respectively. The revenue trade-offs in all those cases were less than 10
Table 4.8

REVENUE MEAN AND VARIANCE BY COUNTRY FOR UTILITY MAXIMIZATION HEDGE: LONDON

<table>
<thead>
<tr>
<th>RISK</th>
<th>COUNTRY</th>
<th>WITHIN BASE</th>
<th>OUTSIDE BASE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MEAN</td>
<td>VARIANCE</td>
</tr>
<tr>
<td>m=0.0001</td>
<td>GHANA</td>
<td>555 (99)</td>
<td>355481 (97)</td>
</tr>
<tr>
<td></td>
<td>NIGERIA</td>
<td>556 (99)</td>
<td>359074 (98)</td>
</tr>
<tr>
<td></td>
<td>IV.COAST</td>
<td>551 (98)</td>
<td>343266 (94)</td>
</tr>
<tr>
<td></td>
<td>CASH</td>
<td>563 (100)</td>
<td>365167 (100)</td>
</tr>
<tr>
<td>m=0.00001</td>
<td>GHANA</td>
<td>556 (99)</td>
<td>354057 (97)</td>
</tr>
<tr>
<td></td>
<td>NIGERIA</td>
<td>557 (99)</td>
<td>356244 (98)</td>
</tr>
<tr>
<td></td>
<td>IV.COAST</td>
<td>555 (99)</td>
<td>344798 (94)</td>
</tr>
<tr>
<td></td>
<td>CASH</td>
<td>563 (100)</td>
<td>365167 (100)</td>
</tr>
</tbody>
</table>

Units for London are Pounds Sterling per metric ton
Numbers within parenthesis indicate percentage of cash position
percent. As the risk aversion of the producer decreased the variance reduction ability of the optimal hedges were lower as expected.

The New York market results in table 4.9 indicate very low reductions in revenue variance for all countries with a 2% trade off in revenue. The mean revenues were less affected by hedging compared to cash sales and the risk reduction benefits were marginally better for all the countries in the New York sample.

Simulations outside the data base again produced a sizeable reduction in the variance of revenue with very little trade-off in revenue for the countries in the New York sample. The variance reductions were similar to post sample tests in the London sample but the revenue trade offs were less. Ivory Coast and Nigeria received 41 and 48 percent reductions in variance with 2 and 3 percent trade offs in revenue. Compared to the London sample, the weight of the years with high volatilities in the price and revenue is greater within the data base of the New York sample. The variance reduction within the data base is marginally greater in the New York sample.

The optimal hedge ratios produced remarkably good results in the post sample tests compared to the within sample tests. Revenue trade offs were relatively small at each level of risk reduction.
### Table 4.9

**Revenue Mean and Variance by Country for Utility Maximization Hedge: New York**

<table>
<thead>
<tr>
<th>Risk</th>
<th>Country</th>
<th>Within Base</th>
<th></th>
<th></th>
<th>Outside Base</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>Variance</td>
<td>Mean</td>
<td>Variance</td>
<td>Mean</td>
<td>Variance</td>
</tr>
<tr>
<td>$m=0.00001$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GHANA</td>
<td>1384 (98)</td>
<td>1346049(89)</td>
<td>2260 (100)</td>
<td>82348 (62)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NIGERIA</td>
<td>1388 (98)</td>
<td>1369776(91)</td>
<td>2198 (97)</td>
<td>68495 (52)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IV.COAST</td>
<td>1382 (98)</td>
<td>1332543(88)</td>
<td>2210 (98)</td>
<td>77745 (59)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CAMEROUN</td>
<td>1379 (98)</td>
<td>1318015(88)</td>
<td>2230 (99)</td>
<td>84797 (64)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CASH</td>
<td>1412 (100)</td>
<td>1504960(100)</td>
<td>2262 (100)</td>
<td>131809 (100)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$m=0.000001$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GHANA</td>
<td>1389 (98)</td>
<td>1362562(91)</td>
<td>2260 (100)</td>
<td>84014 (64)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NIGERIA</td>
<td>1395 (99)</td>
<td>1393808(93)</td>
<td>2217 (98)</td>
<td>72648 (55)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IV.COAST</td>
<td>1393 (99)</td>
<td>1374220(91)</td>
<td>2228 (99)</td>
<td>85759 (65)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CAMEROUN</td>
<td>1385 (98)</td>
<td>1339163(89)</td>
<td>2236 (99)</td>
<td>87943 (67)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CASH</td>
<td>1412 (100)</td>
<td>1504960(100)</td>
<td>2262 (100)</td>
<td>131809 (100)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Units for New York are Dollars per metric ton

Numbers within parenthesis indicate percentage of cash position
Five-Year Moving Average Method

This procedure simulated a hedging strategy based on the 5 year moving average computed excluding the two extreme prices. The longest possible span for the each hedge was one year, from March in the previous year (t-1) to March in the contract year (t). Hedges were initiated anytime during the one year span depending on the fulfillment of the hedging objective, the expected price level. Price levels set at 10 and 15 percent above the computed average were used as lower borders for the placement of hedges. The results of the hedge simulations are presented in the table 4.10.

Scheme 1 was based on a 10 percent price level above the average. In simulating this procedure for the 22 year period within the sample, the countries were hedged 64 percent of the time. Fifty percent of the hedges in fact were spread over a full one-year duration as March opened with the price already above the limit. The hedging operations were profitable 57 percent of the time. This procedure obtained a 20 percent reduction in revenue variance for Ivory Coast and Cameroun and a 19 percent reduction for Ghana with only 9, 10 and 8 percent drops in the mean revenue in the within sample tests.

Scheme 2 was based on a 15 percent increment in the average for placing the hedges. This method caused 60 percent of the countries to hedge within the one year duration and 70 percent of them to end up in a net profit situation from hedging. The simulation results within the sample
Table 4.10

REVENUE MEAN AND VARIANCE BY COUNTRY FOR 5-YEAR MOVING AVERAGE

<table>
<thead>
<tr>
<th>SCHEME</th>
<th>COUNTRY</th>
<th>WITHIN BASE</th>
<th>OUTSIDE BASE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MEAN</td>
<td>VARIANCE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10% LIMIT</td>
<td>15% LIMIT</td>
</tr>
<tr>
<td>SCHEME I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GHANA</td>
<td>1297 (92)</td>
<td>1225002 (81)</td>
<td>2808 (124)</td>
</tr>
<tr>
<td>NIGERIA</td>
<td>1285 (91)</td>
<td>1219818 (87)</td>
<td>2460 (109)</td>
</tr>
<tr>
<td>IV.COAST</td>
<td>1283 (91)</td>
<td>1201681 (80)</td>
<td>2873 (127)</td>
</tr>
<tr>
<td>CAMEROUN</td>
<td>1264 (90)</td>
<td>1210420 (80)</td>
<td>2743 (121)</td>
</tr>
<tr>
<td>CASH</td>
<td>1412 (100)</td>
<td>1504960 (100)</td>
<td>2262 (100)</td>
</tr>
<tr>
<td>SCHEME II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GHANA</td>
<td>1308 (93)</td>
<td>1237870 (82)</td>
<td>2736 (121)</td>
</tr>
<tr>
<td>NIGERIA</td>
<td>1296 (92)</td>
<td>1230231 (82)</td>
<td>2462 (109)</td>
</tr>
<tr>
<td>IV.COAST</td>
<td>1294 (92)</td>
<td>1212279 (81)</td>
<td>2809 (124)</td>
</tr>
<tr>
<td>CAMEROUN</td>
<td>1275 (90)</td>
<td>1218271 (81)</td>
<td>2678 (118)</td>
</tr>
<tr>
<td>CASH</td>
<td>1412 (100)</td>
<td>1504960 (100)</td>
<td>2262 (100)</td>
</tr>
</tbody>
</table>

Units for London are Pounds Sterling per metric ton and for New York Dollars per metric ton

Numbers within parenthesis indicate percentage of cash position
were similar to scheme one with Ghana and Nigeria receiving 18 percent and Ivory Coast and Cameroun receiving 19 percent reductions in variance with about the same trade offs in revenue (Table 4.10). All the countries received profit levels slightly higher than with scheme 1.

In the post sample tests, the results altered significantly causing the average revenues of the countries to increase by 10 to over 20 percent, but in the same time causing the variance in revenue to increase substantially. Variance increased over 6 times that of cash sales even in the cases the variance was reduced significantly within the sample period. Nigeria decreased the revenue variance by following both schemes 1 and 2 and the increases in its revenue were comparatively lower. Crop predictions played a major role in determining the amounts hedged during the months before September as most hedges were initiated before that month. The countries were over or under-hedged by greater margins in the hedges initiated one year before in the post sample period due to large errors in the production prediction. Therefore, the very high variance in revenue is due to the large changes in the profitability of hedging due to these variable crop predictions.

**Hedging One Year Ahead**

This strategy simulated two situations with hedges originating in March of the previous year \((t-1)\) for the crops harvested in the current \((t)\) year. The first situation assumed a naive approach where the hedges
were placed on the first market day in March in year t-1 in an amount equal to the forecast output based on the trend equations discussed earlier. The hedge was lifted in March of year t. In the second approach, all the hedges were re-examined in September when the first output forecast become available and adjusted upwards or downwards by selling or buying back a quantity equal to the shortfall or excess in the March estimate.

Table 4.11 shows the results of this model. A hedge held undisturbed from March to March increased the revenue for all four countries by approximately 10 percent but failed in securing any reduction in the variance. This was again due to the errors in the production estimations obtained using the prediction equations. The variance in revenue was increased by over 200 percent compared to cash in Ghana and Cameroun. A hedge re-examined and adjusted in September performed much better than the naive approach. Nigeria and Cameroun received 17 percent reductions in revenue variance for a trade-off of 10 percent of the income in the pre-sample tests. Post-sample tests strengthened these results. The naive approach of hedging in March in the previous year and holding the same position throughout gave very high variability in revenue. However when the hedge position was adjusted in the fall, a lower revenue variance resulted. Variance was lowered 36 percent compared to cash revenue in the case of Ghana and 42 percent in Camerouns.

These results show the importance of making an accurate crop estimate as soon as possible in order to determine the appropriate amount to hedge. The mean revenue appears to be robust across various techniques for
Table 4.11

REVENUE MEAN AND VARIANCE BY COUNTRY FOR HEDGING 1 YEAR AHEAD

<table>
<thead>
<tr>
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Units for London are Pounds Sterling per metric ton and for New York Dollars per metric ton

Numbers within parenthesis indicate percentage of cash position
hedging but the variance is very sensitive compared to the mean. The production predictions used in this study are not very good. The range of errors in prediction was spread between a high of 188 metric tons for Ghana to 45 metric tons for Camerouns which are about 50 percent of the actual crop. Using these estimates led to high variability in revenue which was avoided when the hedge was adjusted to reflect new crop forecasts.

**Dual Moving Average Cross-over System**

The "optimal" 14-46 dual moving average (MA) system of Irwin and Uhrig (1983) was combined with a third leading moving average to confirm buy and sell signals. A linearly weighted 3-day moving average performed best as a leading average in confirming the signals given by the 14 and 46 MA. The simulation results are summarized in the table 4.12.

Within sample tests provided an average of 2.91 sales per year for the 22 year period. Twenty six or 40.6% of those sales produced profits. Net profits averaged 67.7 $ per metric ton. In the tests outside the sample there were 3.25 sales per year. Five of the sales (38.5%) were profitable and 3 out of 4 years produced gains averaging 76 $ per tonne for the whole period. Compared to the conventional 14-46 dual moving average system, there were 18% less sales and 166 $ more profits in using the third leading indicator.
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Units for London are Pounds Sterling per metric ton and for New York Dollars per metric ton.

Numbers within parenthesis indicate percentage of cash position.
The results of the simulations of this strategy in a hedging program spreading over one year duration starting in March in the previous year are presented in table 4.12. In the within sample tests both the revenue mean as well as the revenue variance of the countries was increased by adopting this strategy. Post sample tests gave greatly reduced revenue variances along with increased revenue means for all countries except Nigeria. The revenue variance was reduced by nearly two thirds in all cases. These were the largest reductions in revenue variance obtained for any strategy in the post sample tests.

MARKET VERSUS HEDGE VOLUME

The market volume for a sample of the days on which the hedges would have been placed following various strategies were compared to the volumes for each country trading on that day. A comparison of market volumes at the peak of sales and the volumes that would have been hedged by the four major producers following ratios of output for variance minimization indicated that the hedge levels would often exceed the maximum market volume for the March contract by over 20 times. The market volumes and the open positions were relatively small compared to the output of even the smallest hedger. It was evident that even at a time of very high market volume, the quantities traded by the countries are so large in proportion it will undoubtedly depress the market price. Under these circumstances, a more practical approach would be to spread out the hedges over several
contracts and to roll-over the futures positions as the contracts expire. This problem could not be addressed in the present study but would need to be investigated before any country entered into a hedging program. Also it should be mentioned that once countries start to trade in the futures markets, the market would probably attract enough speculative activity to strengthen the volume to required levels. The lack of interest of the producers in the futures markets is probably one reason for the present low volume attraction in the market.

**MARGIN REQUIREMENTS**

Table 4.13 shows the margin requirements estimated for some of the hedging strategies examined earlier. The maximum payment required to meet the margin calls and the average payment over the length of the hedging period are reported for each strategy for one contract (10 metric tons). The figures only represent the cash outlays necessary to meet the margin calls and do not include margin deposits and commissions. Due to the difficulty of obtaining complete data on margin deposits and commissions it was decided to exclude them from calculations. The commission fee for trading cocoa is currently less than 1 percent of the contract value and is negligible (Personal communication, Dun Hargitt and Co.). Initial margin deposits on the other hand can be sizable and vary as the price level changes. An accurate estimate of margin deposits is therefore
<table>
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not possible without data on margin deposits and the statistics reported in the table 4.13 underestimate the financial requirements for hedging.

The DMAC system has the lowest mean and maximum margin requirements both within and outside the data bases. The margin requirements for the selective hedges extending over 1 year duration are higher relative to the short duration hedges except for the DMAC system. As the total requirement of margin money is a multiple of the quantities hedged the actual financial outlays necessary for hedging would not be directly comparable. The short duration hedges based on variance minimization and utility maximization hedges would have lower margin needs than the longer duration hedging strategies except the DMAC method. The average margin requirement range between 6 to 26 percent of the mean crop value within the data base and 6 to 12 percent of the mean crop value outside. It seems quite possible for the producers to use the potential production as collateral in financing the margin payments if suitable infrastructure is available.

**COMPARISON ACROSS VARIOUS HEDGING STRATEGIES**

Figures 4-1 to 4-4 show the relative risk-return positions of the various hedging strategies within the data base for the New York market for the four countries. The various strategies are identified by numbers 1 to 8 as follows:
FIGURE 4.1 Relative-Risk Return, Within Data Base-Ghana
FIGURE 4.2 Relative-Risk Return, Within Data Base—Nigeria
FIGURE 4.3 Relative-Risk Return, Within Data Base—Ivory Coast
FIGURE 4.4  Relative-Risk Return, Within Data Base-
Cameroon
1 = variance minimization hedge,
2 = utility maximization at m=0.00001,
3 = utility maximization at m=0.000001,
4 = 1 year ahead hedge-scheme I,
5 = 1 year ahead hedge-scheme II,
6 = 5-year average method-scheme I,
7 = 5-year average method-scheme II,
8 = dual moving average method,
C = cash position.

Cash or unhedged strategy had a higher variance relative to the most hedging strategies studied. Mean revenue of cash was above all the strategies except for the dual moving average method (8). However, following a risk return combination none of the hedging strategies could be declared inferior to cash (unhedged) strategy. Strategies 6 and 7 will be preferred by those countries more averse to risk. Strategy 8 has a higher return that might attract some less risk averse countries to it.

If a country's dependency on the revenue from cocoa is assumed proportional to the risk averse behavior of countries, Ghana and the Ivory Coast whose dependency on cocoa revenue is comparatively high would be more inclined to prefer strategies such as 1-3, 6 and 7 than Nigeria and Cameroun. Similarly strategies 1 and 2 would be more acceptable to the latter two countries than strategies 6 and 7. It can also be seen that some of the selective hedging strategies can obtain a lower variance in revenue for the producer countries without much trade-off in revenue. Selective
strategies are found to be as competitive or better choices for those countries that are more risk averse than the others.

Figures 4-5 to 4-8 show the the relative risk-return position of the same strategies when tested outside the data base. Strategies 4, 6 and 7 are excluded from the plots as they have extremely high variances. Strategies 1, 2, 3, 5 and 8 has lower variance than the cash (unhedged) position. Strategies 5 and 8 are clearly superior to all the other strategies in all countries except Nigeria. Variance minimization (1) and utility maximizing hedges at a risk parameter level of 0.0001 (2) are better choices than hedging 1 year ahead with subsequent modifications in September (5) for Nigeria. But, for the other countries selective strategies 5 and 8 are found to be better in the risk-return than the three optimum ratio hedges.

Combined with the information on the margin requirements strategy based on the dual moving average become a very competitive strategy for hedging by those countries concerned with the high margin payment requirements.
FIGURE 4.5 Relative-Risk Return, Outside Data Base - Ghana
FIGURE 4.6 Relative-Risk Return, Outside Data Base - Nigeria
FIGURE 4.7 Relative-Risk Return, Outside Data Base-

Ivory Coast
FIGURE 4.8 Relative-Risk Return, Outside Data Base-Cameroun
CHAPTER 5
SUMMARY AND CONCLUSIONS

SUMMARY

The justification for this research was the need to find market solutions to the problem of stabilizing revenue from commodity exports of developing countries. The conventional approaches relying on commodity agreements which interfere with the market have been ineffective. The failure of the conventional approaches to provide a satisfactory solution has drawn a lot of attention to the futures markets as an alternative solution. The present study was conducted to investigate the possibility of using the futures markets for this purpose by the cocoa exporting countries. The specific objectives of the research were

1. to investigate the possibility of using the futures markets by selected cocoa producing countries to reduce export income instability, and

2. to estimate the financial outlays necessary for successful participation in the futures trading.

The relevant literature was reviewed in the Chapter 2 in order to assess the importance of commodity stabilization to the developing coun-
tries, understand the strengths and weaknesses of the buffer stock based stabilization schemes and to evaluate the futures markets as a potential solution. Also some theoretical and empirical studies relating to the futures markets were reviewed in order to develop a framework for analysis.

In chapter 3 the specification and estimation of the various models was presented and the data sources discussed. Two models based on optimum hedge ratios and three selective hedging strategies were considered in the empirical models. Data were analysed using futures prices from the New York and London futures exchanges.

The solutions to the empirical models are presented and compared in the chapter 4. The various strategies were tested within and outside the data base and evaluated on the basis of revenue mean and variances. It was found that most of the strategies tested would obtain a reduction in the revenue variance for the four countries in the study. However, they were associated with different degrees of revenue trade-offs. Some of the selective strategies employed in the study obtained higher net revenues for hedging but were inconsistent with the primary objective as they led to increased variance in revenue. An estimation of cash outlays for margin payments indicated that some strategies spreading over longer duration may require access to more liquid resources to meet the margin payments whereas a selective strategy based on moving averages require the lowest margin financing.
CONCLUSIONS

The results of the study lead to the following general conclusions.

1. Futures markets are found to be an alternative to commodity stabilization using buffer stocks as they are found to be capable of reducing the variance of revenue substantially with a little reduction in revenue.

2. The countries subject to both quantity and price variability in their outputs should only hedge a portion of their expected output in the futures markets. Even when the countries are infinitely averse to risk, only two thirds to three fourths of the output should be hedged. When the variability in the output is higher, the optimal hedge decreases further.

3. Those countries that depend on the revenue from cocoa to provide a major portion of income may consider use of DMAC strategy as trading based on this strategy produce large reductions in the variance of revenue without a loss in the mean revenue and also require lower margin payments compared to the other strategies.

4. Countries who depend less on cocoa to provide a portion of its revenue may adopt some of the selective strategies with little trade-off in mean revenue and receive substantially lower variances than cash
marketing because these countries can adopt selective hedging strategies that require more financial resources for margin payments than those countries that depend on cocoa income more.

5. The ability to make better crop forecasts would substantially increase the returns to longer duration hedging. The ability to adjust the hedge positions early would lower cost of hedging by reducing some losses due to errors in matching the hedged amounts. Therefore a program to obtain better crop information should be considered along with any hedging program by the producer countries.

6. Hedging in the New York market allows producer countries to obtain lower variance in revenue at a less trade-off of revenue compared to the London market. Both the variance minimization and utility maximization hedges simulated in the New York market gives greater reductions in the variance especially outside the data base and the revenue trade-offs are comparable or less than in London.

7. The low market volume in the cocoa futures markets at present is found to be a factor of concern at least initially in hedging large output such as country production. Distributing the volume over several contracts and rolling-over the futures position can be used to prevent price drops due to large volume selling. Experience with the futures markets have shown that when hedge volume increases, speculators are frequently drawn into that market. It is expected that the market
might attract enough speculators to provide the required volumes within a short time.
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APPENDIX TABLE I

DETAILS OF REGRESSION EQUATIONS ESTIMATED FOR PRODUCTION PREDICTION IN MARCH


\[ PDGH = 273.30 - 6.375 \text{ LTR} + 0.23 \text{ WM3GH} \quad R^2 = 0.58 \]

where,
- \( PDGH \) = Production of Ghana for the crop year
- \( \text{LTR} \) = Linear time trend
- \( \text{WM3GH} \) = Linearly weighted 3 period moving average of production

IVORY COAST: 1958 - 1981

\[ PDIC = 62.89 + 5.48 \text{ LTR} + 0.002 \text{ M3IC2} \quad R^2 = 0.95 \]

where,
- \( PDIC \) = Production of Ivory Coast for the crop year
- \( \text{LTR} \) = Linear time trend
- \( \text{M3IC2} \) = Simple 3 period moving average of production squared


\[ PDCM = 42.59 + 1.07 \text{ LTR} + 0.46 \text{ M3CM} \quad R^2 = 0.67 \]

where,
- \( PDCM \) = Production of Cameroon for the crop year
- \( \text{LTR} \) = Linear time trend
- \( \text{M3CM} \) = Simple 3 period moving average

NIGERIA: I. 1958 - 1973

\[ PDNI = 130.12 + 2.75 \text{ LTR} - 0.97 \text{ LTR}^2 \quad R^2 = 0.64 \]

where,
- \( PDNI \) = Production of Nigeria for the crop year
- \( \text{LTR} \) = Linear time trend
- \( \text{LTR}^2 \) = Linear time trend squared
II. 1974 - 1981

\[ \text{PDNI} = 955.47 - 27.05 \text{ LTR} - 1.29 \text{ M3NI} \quad R^2 = 0.77 \]
\[ (2.30) \quad (-2.23) \quad (-1.39) \]

where,

\[ \text{M3NI} = \text{Simple 3 period moving average production} \]

Numbers within parenthesis beneath the coefficients indicate the value
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