

Hedging with Futures Contracts by Developing Countries: Empirical Evidence

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This paper attempts to evaluate the benefits that Less Developed Countries (LDCs), subject to price and quantity fluctuation of its exports (of one or several commodities) may derive from using futures markets. The Ivory Coast was chosen to illustrate our analysis. Three products (cocoa, coffee and cotton) are studied in order to take into account the weight of exports revenues in the whole economy, the effect of variability, the role of the Caisse de Stabilisation et de Soutien des Prix des Produits Agricoles (CSSPPA: A National Marketing Board) and the gains from using futures markets as the hedging tool relative to stabilizing policies.

I. Introduction

Less Developed Countries (LDCs) primary commodity exporting countries face fluctuating prices for their exports. Except possibly for a few large producers, these fluctuating prices translate into fluctuating revenues. For many LDC producers, particularly those in the middle range of *per capita* incomes, receipts from non-oil primary exports are the major source of foreign exchange. Many of the same countries are very heavily in debt. For such countries, a fall in export earnings forces a fall in foreign exchange expenditures. This may take the form of a fall in living standards, as imports of luxuries or even basic foodstuffs either become very expensive or are prohibited, or of a fall in investment expenditure, including maintenance. Either way the country suffers.

In the short run, commodity exporting countries face the risk of

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dramatic short-term changes running counter to long-run "normal" price patterns; these are caused usually by exceptional and inherently unpredictable events (e.g., political upheavals, bad weather, strikes, etc.). In the long run, they have uncertainty about the underlying price trend. In any time span, they have to contend with both exchange rate and interest rate fluctuations. Moreover, they need to accommodate responses to all of these forms of risk within their own seasonally fluctuating production and input patterns, and in the context of their underlying money management strategy.

First judgements about the reaction of producers to their new predicament are not very encouraging. Most developing country governments have been drawn into a chain of short-term measures whose cumulative impacts have been increasingly restrictive economic policies. The balance of payments difficulties brought on by high interest rate and heavy debt — servicing burden soon led to foreign exchange controls (or a reinforcing of existing ones). As a result, there emerged a panoply of forms of intervention that isolated domestic primary commodity prices and domestic costs borrowing from those in the world market, with inevitable distortion in economic behaviour. In international trade, frequent responses have included a search for trade agreements that avoid specific foreign exchange commitments, an increased reliance on government-sponsored export organizations and heavily subsidized incentives for increased exports.

Counter-trade, pure barter deals and long term sales contracts between countries are the three most highly publicized forms of this policy reaction. For example, barter deals and counter-trade have become increasingly important to some DC who are unable to arrange for strategic imports like petroleum, cement, grains on normal commercial terms. In a sense such arrangements can be close to the ideal of a long-term price stabilizing contracts. However, the experience with them has been far from happy. It is almost inevitable that one or the other party to a barter, counter-trade or long-term fixed price deals, will feel at some time during the contract's life that the relative prices implicit in the deal are more favourable to the other party. Lacking any means of enforcement, other than moral pressure, it is common for such deals to collapse amidst a welter of recriminations. In fact, extra-market pricing arrangements seldom work when the actual free market prices for the products being exchanged are highly visible to all involved (as in the case of commodities traded on official exchanges).

As experience grows of these piecemeal approaches to the present difficulties facing commodity exporters it becomes ever more apparent that they impose high costs upon the countries that adopt them. In many DC

large economic losses have come through commodity traders profiting from the divergences between official and informal, but available, foreign exchange rates. Less well known but equally significant trading problems have emerged when real interest rates in these countries have been kept above those paid on the world market — which has allowed commodity traders to earn more from financial transactions than from commodity trading. And counter-trade deals are notorious for the cost premium that results from the risk of large and unpredictable losses when the products offered in exchange for commodity exports are disposed of.

If developing countries have not generally been successful in adjusting to the new situation in commodity markets, there remains evidence that all is not bleak. Both multinational companies as well as primary product producers in developed economies, have had to cope with precisely the same sorts of problems. Initially, their performance was no better than that of their counterparts in the developing world; but over recent years, the multinationals have adapted their financial management strategies so as to acquire greater protection — against the new forms of uncertainty in commodity markets (both in primary product and in monetary prices). In the process, they have discovered that long-term fixed price deals across national boundaries are often impossible to enforce. They have also learnt the hard way that sudden fluctuations in interest rates, exchange rates, raw material costs and selling prices are all critical determinants of any new investment and viability.

As a result, the use of various financial instruments for managing commodity price risks has increased exponentially since the early 1970s. Increased use has allowed many possible pitfalls to be recognized early and enabled corrective action to be taken in good time, thereby engendering greater reliability of these instruments. This in turn, has encouraged others to use them while stimulating the introduction of new, tailor-made futures or options contracts, as well as a proliferation of insurance products. While many of the specific applications are new, the various tools for better trading now in common use have all been applied by specialists for the past hundred years.

Thus, although the techniques of “hedging,” “basis pricing,” “spread trading” or “rolling over futures contracts” may seem somewhat arcane to those unfamiliar with them, there is in fact a great deal of experience in how these various price risk management tools perform under wide variety of conditions. One of the more dramatic changes in the world financial system in the last few years has been the application of options and futures contracts, which were originally used in conjunction with trading primary commodities such as wheat or copper, to the “new”

monetary commodities.

This paper attempts to evaluate the benefits that LDCs, subject to price and quantity fluctuations of its exports (of one or several commodities) may derive from using futures markets. The Ivory Coast was chosen to illustrate our analysis. Three products (cocoa, coffee and cotton) are studied in order to take into account the weight of exports earnings in the whole economy, the effect of variability, the role of CSSPPA¹ and the gains from using future contracts as the hedging tool relative to stabilizing policies. By hedging, the producer uses market institutions to protect himself from variations in commodity price variability, while price stabilization is a program aimed at overriding the market — generated price distribution.

The plan of the paper is as follows: In section II we define the calendar of operations on a future market and the data used for our empirical studies are also described. Section III is an attempt to assess the relationship between futures prices and the export prices of the Ivory Coast, this is to test the informational character of futures prices in a special case of Ivory Coast. An annual index of export prices is regressed on futures prices. In Section IV, optimal positions are derived for each commodity under a "multi-product" model. Section V evaluates the impact of the production variability on optimal hedging. Finally, in Section VI we try to compare direct gains from hedging using futures contracts with those would result from price stabilizing policies.

II. Operations Calendar

A. *Formal Presentation*

Two trading dates are considered here. At time 0 (t_0), a producer decides to sell n goods at time 1 (t_1) at a vector of cash good prices p . But he knows neither which prices will prevail on cash (spot) market at t_1 nor the quantities (y) that will be available in stocks for sale. He is subject to price and quantity uncertainty.² We assume that production decisions have been made, but the output is uncertain. Besides the n physical markets, there exist n futures markets corresponding to the n products that are characterized by a deliverable goods, a delivery pace and a delivery date.

¹ Caisse de Stabilisation et de Soutien des Prix des Produits Agricoles (a National marketing board).

² Transactions costs are neglected.

For commercial reasons, the producer may choose a vector of positions (f) on the futures markets. Let f_i be the size of the long position in the i 'th futures that the producer opens at time 0. (A short position is represented if $f_i < 0$). The position f_i will be closed out at date t ($t \leq t_1$) by an offsetting trade. The offsetting transaction may be financial or physical. In t_0 , futures prices (for futures contracts which will be delivered at t_1) are quoted on futures markets and represented by the vector P_0^f .

Usually the offsetting operation are made by a financial transaction in t ($t < t_1$) consisting of a purchase of f_i (if $f_i < 0$) or a sale of f_i (if $f_i > 0$) at P_t^f . Let P_t^f be the random n column vector of the i 'th futures that prevails at time t .

A time 0 the period 1 prices are random variables \tilde{P} and \tilde{P}_1^f for which the producer has a joint subjective probability distribution. Let Σ be the variance/covariance matrix of $(\tilde{Y}, \tilde{p}, \tilde{P}_1^f)$ which we partition as,

$$\Sigma = \begin{pmatrix} \Sigma_{11} & \Sigma_{12} & \Sigma_{13} \\ \Sigma_{21} & \Sigma_{22} & \Sigma_{23} \\ \Sigma_{31} & \Sigma_{32} & \Sigma_{33} \end{pmatrix}$$

where $\Sigma_{33} = \text{Var}(\tilde{P}_1^f)$ is symmetric and positive definite.

With this notation the producer's period 1 revenue is the random variable,

$$(2.1) \quad \begin{aligned} \tilde{R} &= \tilde{p}' \tilde{Y} - (\tilde{P}_1^f - P_0^f)' f \\ &= \tilde{R}_c - (P_1^f - P_0^f)' f \text{ with } \tilde{R}_c = \tilde{p}' \tilde{Y} \end{aligned}$$

B. Data Preparation

For each product i ($i = 1, 2, 3$), R_i represents exports revenues. Export prices are represented by

$$P_i = \frac{R_i}{Y_i} \quad \text{where } Y_i \text{ is the volume of exports that occur each year.}$$

P_i is an annual export price index. Data were collected from the United Nations Statistics. In the empirical framework the set P_i , R_i and Y_i are represented by (Pcoco, Pcof, Pcot); (REVcoco, REVcof, REVcot); and (VOLcoco, VOLcof, VOLcot) respectively for cocoa, coffee and cotton.

Four contracts were chosen for each commodity, in order to cover the

annual commercial period. Contracts for delivery of March, May, July and September (October for cotton) were considered. Period corresponds to the first day of transactions of October or November in those contracts. Actually it is around this period that commodities are harvested and the main commercial decisions are taken by the Ivory Coast officials.³ Period t is the mid-point of the delivery month. Here it is assumed that the longer the hedging period the more efficient the hedge (EDERINGTON, 1979). This is because futures prices are more likely to respond to spot price changes. Futures prices are:

Delivery Month	March	May	July	Sept.	Commodity
t_0	PO3coco	PO5coco	PO7coco	PO9coco	cocoa
	PO3cof	PO5cof	PO7cof	PO9cof	coffee
	PO3cot	PO5cot	PO9cot	PO10cot	cotton
t	P33coco	P55coco	P77coco	P99coco	cocoa
	P33cof	P55cof	P77cof	P99cof	coffee
	P33cot	P55cot	P79cot	P1010cot	cotton

Data on futures prices are from New York Commodities Exchange (NYCE). They have been standardized in US\$/Kilo. Data cover the period 1967-1984 for cocoa, 1973-1984 for coffee and 1968-1984 for cotton. Each price is represented by 2 numbers; the first number represents the transaction date (0 for t_0) and the second one gives the delivery month. For example PO9coco is the price of cocoa at t_0 with delivery in September.

III. The Information Character of Futures Prices

Suppose that the Ivory Coast undertakes a package of commercial and investment policies at time 0. Commercial policy consists essentially of determining guaranteed price to producers. Decisions are usually made before exports prices are known. So uncertainty may induce sub-optimal

³ Harvests are generally done according to the following calendar

Commodity	Start	End
cocoa (main crop)	August	December
coffee	September (end)	January (end)
cotton	November	December

policies. Through this section we try to answer to the question, how can the Ivory Coast rely on information given by futures prices to predict exports prices?

A way of responding to this question is to find the relationship that links the Ivory Coast's exports prices and futures prices and to assess its consistency.

Export prices has been regressed on futures prices for all commodities according to a simple linear model

$$I_{it} = \alpha + \beta P_{it}^f + \varepsilon_{it}$$

where I_{it} is the annual exports prices index of the Ivory Coast for commodity i

P_{it}^f is the annual futures prices for commodity t .

ε_{it} is the error term.

Parameters α and β are to be estimated. They convey information on the relationship that exists between I_{it} and P_{it}^f . Coefficients were estimated by Ordinary Least Squares (OLS). Student t tests were conducted at a 5% significance level to judge the significance of the coefficients. Results on estimations and tests are reproduced in Table 1. Tests confirm the hypothesis that futures prices explain the export prices of the Ivory Coast. So futures prices have information content: they may be useful for commercial policies of the Ivory Coast. Futures prices are unbiased predictors of cotton and coffee export prices, α and β are not significant different from 0 and 1 respectively.

IV. Estimating Optimal Futures Positions

Optimal positions may be derived according to two main hypotheses:

- (i) First the producer may enter futures markets in search of insurance against export revenue risk (pure hedging)
- (ii) Second the producer may trade futures in order to maximize his expected utility by hedging his export revenues and by speculating in spot and futures prices changes (hedging under utility maximization hypothesis.)

Table 1
LINEAR REGRESSIONS OF EXPORTS PRICE OF THE
IVORY COAST ON VARIOUS FUTURE PRICES
(COCOA, COFFEE AND COTTON)

		α	β	R^2	D-W	F
COCOA	March	0.49 (2.93)	0.15 (7.18)	0.79	1.30	26.33
	May	0.48 (2.84)	0.15 (7.05)	0.78	1.29	24.82
	July	0.48 (2.75)	0.15 (6.85)	0.77	1.30	23.43
	Sept.	0.48 (2.65)	0.15 (6.64)	0.76	1.31	22.17
COFFEE	March	0.17** (0.45)	0.79* (5.36)	0.78	1.62	14.18
	May	0.15** (0.38)	0.81* (5.04)	0.76	1.62	12.67
	July	0.13** (0.32)	0.82 (4.95)	0.75	1.61	12.00
	Sept.	0.13** (3.30)	0.82* (4.82)	0.74	1.53	11.38
COTTON	March	0.17** (1.29)	0.86* (7.78)	0.82	1.80	29.61
	May	0.11** (0.88)	0.93* (8.40)	0.84	2.20	34.125
	July	0.08** (0.70)	0.96* (9.39)	0.87	2.10	43.50
	Oct.	0.04** (0.35)	1.05* (9.66)	0.88	1.31	47.67

At a 5% level:

* we cannot reject the hypothesis that they are equal to unity

** we cannot reject the hypothesis that they are equal to zero

Numbers in parentheses represent "computed t"

$$F = \frac{(T-2) R^2}{2(1-R^2)}$$

A. Hedging Effectiveness and Empirical Evidence. Special Case of Ivory Coast

In this section we consider the traditional hedging theory which con-

sider a hedger as a risk-avoider. The producer enters futures markets in order to minimize the risk usually represented by the variance of revenue. The effectiveness of his hedge may be represented by the maximum reduction of variance owing to the position he opens on futures markets. The producer's problem is then as follows: What position must he take in futures in order to minimize the variance of his revenues?

The variance of equation (2.1) is:

$$(4.1) \quad V(\tilde{R}) = V(\tilde{R}_c) + f' \Sigma_{33} f - 2 \text{Cov}(\tilde{R}_c, \tilde{P}_f' f)$$

The domain of positions that reduce $V(\tilde{R}_c)$ is given by

$$(4.2) \quad V(\tilde{R}) \leq V(\tilde{R}_c) \text{ or } V(\tilde{P}_f' f) \leq 2 \text{Cov}(\tilde{R}_c, \tilde{P}_f' f).$$

The pure hedge is equivalent to the position that minimizes $V(\tilde{R})$.

$$\text{Min}_f V(\tilde{R}) = V(\tilde{R}_c) + f' \Sigma_{33} f - 2 \text{Cov}(\tilde{R}_c, \tilde{P}_f' f)$$

whose first order conditions are given by

$$\Sigma_{33} f - \text{Cov}(\tilde{R}_c, \tilde{P}_f' f) = 0$$

Σ_{33} is a positive definite matrix, second order conditions are satisfied and we may derive the n pure hedges:

$$(4.3) \quad f_M^* = \Sigma_{33}^{-1} \cdot \text{Cov}(\tilde{R}_c, \tilde{P}_f' f)$$

f_M^* determines a minimum value of $V(\tilde{R})$. Johnson (1960) and Ederington (1979) derived the same result in a particular case ($n = 1$ and Y certain); Mckinnon (1967) found a similar result in the case of $n = 1$ and Y variable. Pure hedge may be derived by estimating the coefficients of elements of $\tilde{P}_f' f$ in the theoretical multiple regression of \tilde{R}_c on $\tilde{P}_f' f$.

Effectiveness of such a strategy can be derived by comparing the risk of an unhedged revenue $V(\tilde{R}_c)$ with the minimum risk that can be obtained by means of a pure hedge $V(R(f_c^*))$, where $V(R(f_c^*))$ is $V(\tilde{R})$ of equation (4.1) when f equal f_c^* .

Let us define the effectiveness of pure hedging (μ) by its maximum reduction in variance or in other terms by the percent reduction in variance (Johnson (1960), Ederington (1979), Overdahl (1984)). We may write:

$$(4.4) \quad \mu = \frac{V(\tilde{R}_c) - V(R(f_c^*))}{V(\tilde{R}_c)}$$

Substituting (4.3) in (4.1) we have:

$$(4.5) \quad V(R(f_c^*)) = V(\tilde{R}_c) - (\text{Cov}(\tilde{R}_c, \tilde{P}_f)) \Sigma_{33}^{-1} (\text{Cov}(\tilde{R}_c, \tilde{P}_f))$$

equation (4.4) then becomes:

$$(4.6) \quad \mu = \frac{(\text{Cov}(\tilde{R}_c, \tilde{P}_f) \Sigma_{33}^{-1} (\text{Cov}(\tilde{R}_c, \tilde{P}_f))}{V(\tilde{R}_c)}$$

As Σ_{33} is a positive definite matrix and $V(\tilde{R}_c)$ positive, one may see that μ is a positive quadratic form. This is a theoretical indication of effectiveness of the pure hedge. The greater is μ the more efficient is the pure hedge. Effectiveness eventually depends on the size of the pure hedge.

The parameter μ is the population coefficient of determination between \tilde{R}_c and \tilde{P}_f . It may be estimated by the R^2 coefficient of the theoretical multiple regression of \tilde{R}_c on \tilde{P}_f . Our μ is the 'e' of Johnson (1960) when $n = 1$ and Y nonstochastic.

Before estimating pure hedge positions and their effectiveness, it is worth reproducing here a particular result. In the case of no variable production, when the basis (future price (p_f)-spot price (p_t) at any time t) is constant or equal to zero, then $f_c^* = Y$, this case pure hedge is both a short (for it is positive) and full (for the positions on futures markets equal the positions on the spot markets) hedge. Again in this case $\mu = 1$; which means a full reduction of risk. This case corresponds to the traditional view of hedging which is defined as taking futures positions equal in magnitude but of opposite sign to the positions on the cash market (Hieronymus, 1971). The full hedge is not always optimal as is confirmed below in the empirical analysis.

B. Estimating Pure Hedges and Their Effectiveness

(i) Hedging One Commodity

For various futures, pure hedges were computed as the estimation of coefficient β of the following model:

$$(4.7) \quad R_c = \alpha + \beta P_f + \epsilon_t$$

Results are grouped in Table 2. The first feature of pure hedges is that they are all positive (short positions). Futures positions are relatively small for cocoa, high for coffee and very high for cotton. Pure hedge ratios (δ_c^*)

Table 2
RESULTS OF PURE HEDGING:
COMMODITY BY COMMODITY

	Delivery	f_c^*	δ_c^*	π	Y^*	μ	d	d^*
COCOA	March	25,164 (2.57)	12.60%	-0.411* (-0.72)		32.10% < 3.76 >	1,058* (0.15)	0.50%
	May	25,723 (2.31)	12.90%	-0.235* (-0.36)	199,613	27.7%* < 3.11 >	2,519* (0.33)	1.20%
	July	17,507* (1.75)	8.80%	-0.909* (-0.86)		18.08* < 1.76 >	3,990* (0.63)	2.00%
	Sept.	20,341* (2.00)	10.20%	-1.207* (-1.30)		22.3%* < 2.26 >	3,606* (0.54)	1.80%
COFFEE	March	110,032 (3.76)	44.20%	-0.358* (-1.14)		63.80% < 7.11 >	19,293* (1.36)	7.80%
	May	131,051 (5.36)	52.70%	-0.428* (-1.57)	248,743	78.20% < 14.18 >	16,646* (1.05)	6.70%
	July	137,344 (7.59)	55.20%	-0.354* (-1.08)		87.80% < 29.33 >	10,166* (0.62)	4.10%
	Sept.	173,682 (12.65)	69.80%	-0.417* (-1.38)		95.20% < 76.0 >	-2,702* (-0.13)	-0.011
COTTON	March	38,524 ^c (4.91)	185.20%	0.033* (0.699)		65.00% < 12.07 >	19,445 (-2.78)	-0.935
	May	42,080 (5.22)	202.30%	0.004* (0.076)	20,805	67.70% < 13.81 >	-21,594 (2.96)	-1.038
	July	39,482 ^c (4.46)	189.80%	-0.001* (-0.002)		60.50% < 9.75 >	-19,947 (-2.64)	-0.959
	Oct.	31,465 ^c (3.20)	151.20%	-0.064* (-0.55)		44.20% < 50.11 >	-16,494 (-2.21)	-0.793

At a 5% level:

* We cannot reject the hypothesis that they are equal to zero (pure hedge ratio, gain, hedge effectiveness, variability effect)

** We cannot reject the hypothesis that $\delta_c^* = 2$ (= 200%)

c We cannot reject full hedge hypothesis ($\delta_c^* = 1$) ($\delta_c^* = 100\%$)

$d^* = d/y^*$

$\pi = E(p_o^f - p_f^f)$; positive π corresponds to unity gain on futures and unity gain on futures and a loss on the country.

Numbers in parentheses are "computed t"; those in < > are F values.

were computed as the quotient of pure hedge on the expected production (of which average volume of exports (Y^*) was used as a proxy). Pure hedge ratios are significantly different from zero (except July and September cocoa futures). The full hedge hypothesis is rejected at a 5% level for all pure hedges (except March, July and October cotton futures.)

The second feature of these pure hedges is that they are effective in reducing risk of export revenues. Coefficient μ (estimated by the R^2 coefficient of (4.7)) is significantly positive for coffee and cotton. Concerning cocoa only March futures are effective. Reduction of risk ranges from 32% (cocoa), 68% (cotton) to 95% (coffee).

(ii) Hedging Several Commodities

Normally the main hypothesis of diversification, when merchandising several commodities on spot markets follows from that commodities' prices do not move together.

Let us see whether this hypothesis holds for the Ivory Coast. As one may see in Table 3 for period 1973-1984 variables P_{coco} , P_{cof} and P_{cot} moved in the same direction. Correlation between export prices of cocoa and coffee is high (0.88). Badillo and Daloz (1985) found a correlation coefficient of 0.87 for the period 1971-1983. These results suggest that diversification policy will have a weak effect on global export revenues stabilization as these two goods constitute a considerable share in export revenues.⁴ However, as correlation coefficients of export volumes were low, the correlations between export revenues were also low. The CSSPPA benefited from a diversification effect (though small).

We now derive optimal strategies for hedging several commodities for the Ivory Coast for the period 1973-1984. Optimal positions are large for cotton and coffee and small for cocoa. They are highly effective. They would have considerably reduced the variance of global export revenues of cocoa, coffee and cotton. The attitude of the Ivory Coast in not using future markets may not be justified by diversification gains on spot markets.

Two scenarios were considered. In the former March cocoa futures, March coffee futures and October cotton futures were chosen. In the latter March cocoa futures, May coffee futures and October cotton futures were selected. Pure hedges were estimated according to the following regression model:

⁴ Cocoa and coffee represented 58.6% of global exports earnings of the Ivory Coast.

Table 3
CORRELATIONS MATRIX

3.1. Correlations matrix (export prices)

	Pcoco	Pcof	Pcot
Pcoco	1.0		
Pcof	0.88	1.0	
Pcot	0.49	0.46	1.0

3.2. Correlations matrix (volume of exports)

	VOLcoco	VOLcof	VOLcot
VOLcoco	1.0		
VOLcof	-0.21	1.0	
VOLcot	0.84	-0.20	1.0

3.3 Correlations matrix (exports revenues)

	REVcoco	REVcof	REVCot
REVcoco	1.0		
REVcof	-0.54	1.0	
REVCot	0.85	0.33	1.0

$$(4.8) \quad \text{REV}_{tot} = \alpha + \beta P_f^t + \varepsilon_t$$

Where $\text{REV}_{tot} = \text{REVcoco} + \text{REVcof} + \text{REVCot}$ and P_f^t the vector of future prices in time t . Estimated β are pure hedges and μ was estimated by the R^2 coefficient of (4.8) the results are exhibited in Table 4. The suggested optimal strategy is an over-hedge for coffee, a hedge ratio of more than 70% for cotton and a small position for cocoa (not more than 5%). Such position support the prospect of reducing the global risk by 81% as index μ indicates.

C. Hedging Under Utility Maximization Hypothesis

The traditional definition of hedging (KEYNES, 1930; HICKS, 1946; HIERONYMUS, 1971) considers hedging as searching for insurance in

Table 4
SEVERAL COMMODITIES PURE HEDGES (1973-1984)
(COCOA, COFFEE, COTTON)

		f_c^*	δ_c^*	d	μ	Scenario
COCOA	March	3,969* (0.264)	1.65%	23,869 (2.779)		
COFFEE	March	517,289* (2.258)	2,069.7%*	-295,810* (-2.264)	0.81 <6.40>	I
COTTON	October	213,678 (2.592)	85.90%	-22,230* (-0.473)		
COCOA	March	9,145* (0.598)	3.80%	20,820* (2.438)		
COFFEE	May	718,798* (2.274)	2,875.90%	-420,545* (-2.832)	0.81 <6.40>	II
COTTON	October	174,306* (1.973)	70.10%	1,470* (0.298)		

Numbers in parentheses are "computed t"; those in < > are F values

At a 5% level:

* We cannot reject hypothesis that they are equal to zero.

futures markets. But such a strategy may be sub-optimal for an agent maximizing a Von-Neuman utility function. For instance the producer has no opportunity of hedging his stocks against the fall in spot prices while speculating in basis change (WORKING, 1949). A more complete view is found in ROLFO (1980) and ANDERSON and DANTHNE (1981) when the hedger is allowed to use futures as a hedging and speculating management tool.

We assume that the producer has a Von Neuman-Morgenstern utility function $U(\cdot)$ ($U' > 0, U'' < 0$). Concavity of U defines his aversion to risk. Under additional assumptions (MALINVAUD, 1969; LAFFONT, 1985), we may state that the producer chooses a position f so as to maximize a linear function $W(f)$ of the mean and variance of revenue \bar{R} given in (2.1). The problem is:

$$(4.9) \quad \text{Max}_f W(f) = E(\bar{R}) - 1/2 \alpha V(\bar{R})$$

Table 5
OPTIMAL HEDGING GAINS IN TERMS OF
AVERAGE EXPORT REVENUES OF THE IVORY COAST

Good	Futures	μ	Gr (in %)
COCOA	March	0.32	10.6
	May	0.28	9.2
	July	0.18	6.0
	September	0.22	7.3
COFFEE	March	0.64	5.6
	May	0.78	6.8
	July	0.88	7.7
	September	0.95	8.3
COTTON	March	0.65	20.4
	May	0.68	21.3
	July	0.60	18.8
	October	0.44	13.8

Results are derived under hypothesis of a utility function of BERNOULLI (1938) ($\alpha' = 1$).

where α is the Arrow — Pratt measure of absolute risk aversion coefficient. E is the expectation operator. The second part of (4.9) is the measure of risk premium at $E(\tilde{R})$ level.

Necessary conditions of a maximum are given by:

$$(4.10) \quad (P_o f - E(\tilde{P}_f)) - \alpha(\Sigma_{33} f - \text{Cov}(\tilde{R}_c, \tilde{P}_f)) = 0.$$

These necessary conditions are also sufficient given the concavity of $U(\cdot)$. As Σ_{33} is a positive definite matrix we may derive optimal positions:

$$(4.11) \quad f^* = 1/\alpha \Sigma_{33}^{-1} (P_o f - E(\tilde{P}_f)) + \Sigma_{33}^{-1} (\text{Cov}(\tilde{R}_c, \tilde{P}_f))$$

Optimal hedge f^* is formed by two parts:

- a) $1/\alpha \Sigma_{33}^{-1} (E(\tilde{P}_f) - P_o f)$ is the optimal position of an operator whose physical position equals zero ($Y = 0$). Such an operator is called a "Speculator."

This position depends on the subjective futures price probability distribution and on risk aversion. It tends to zero as the absolute risk aversion coefficient tends to infinity. It vanishes when the vector of gains on futures:

$\pi = E(E(\bar{P}_f) - P_o f)$ is equal to zero.

- b) $\Sigma_{33}^{-1} (\text{Cov}(\bar{R}_c, \bar{P}_f))$ is the pure hedge position f_c^* of (4.3). This part is a function of the subjective probability distribution of spot revenue and futures prices. However it does not depend on risk aversion.

One may see that $f_c^* = \lim_{\alpha \rightarrow \infty} f^*$ and that $(E(\bar{P}_f) - P_o f) = 0$ implies $f^* = f_c^*$.

In summary, the optimum position on the futures market is the sum of a pure hedge and a pure speculation when the operator maximizes his expected utility function.

Sensitivity analysis was conducted in function of various values of α to see the values of f^* (α). Results showed that the introduction of a finite risk aversion coefficient does not change the pure hedge position significantly in the case of the Ivory Coast. This comes from the fact that speculation gains (π) are statistically insignificant as it shown in Table 2. For the Ivory Coast for the periods covered by the study, $f^* = f_c^*$. All the results obtained under pure hedge strategies are thus valid under expected utility Maximization hypothesis. This is in accordance with overdahl (1984).

V. Optimal Hedge Estimation under Production Uncertainty

Production uncertainty is considered as an impediment for commodity exporting LDC's in using futures markets. ROLFO (1980) states that production variability may be responsible for the limited usage of futures markets by LDC's exporting agricultural products. In this section we identify the effect of production variability not on the full hedge, but on the optimal hedge.⁵ Then the problem is the following: When does production variability reduce the optimal hedge? Does it always have an effect on optimal production?

Proposition 1

Suppose that the commodity producer enters a futures market by choosing a position that maximizes his expected utility, then production variability will reduce his optimal hedging if and only if

$$(5.1) \quad \Sigma_{33}^{-1} (\Sigma_{23} Y - \text{Cov}(\bar{R}_c, \bar{P}_f)) > 0.$$

⁵ As full hedge is not always optimal.

Proof:

- a) According to (4.11) the optimal hedge when production is known is given by quantities

$$(5.2) \quad f^*_1 = \Sigma_{33}^{-1} (1/\alpha (P_o f) - E(\bar{P}_f f) + \text{Cov}((\bar{P}' Y, \bar{P}_f f)))$$

- b) When production is stochastic, optimal positions are given by f^* of (4.11).

Let d be the difference between optimal positions of non-variable and variable productions. We then have:

$$(5.3) \quad d = f^*_1 - f^*$$

Substituting f^*_1 and f^* by their respective values of (5.2) and (4.11) in (5.3) we get

$$(5.4) \quad d = \Sigma_{33}^{-1} (\Sigma_{23} (Y) - \text{Cov}(\bar{R}_c, \bar{P}_f f))$$

Thus we may claim that production variability reduces optimal positions (5.2) if and only if $d > 0$ which means:

$$\Sigma_{33}^{-1} (\Sigma_{23} Y - \text{Cov}(\bar{R}_c, \bar{P}_f f)) > 0.$$

Vector d is the measure of the absolute effect of production variability on optimal positions. It is worth observing that the pure speculation terms of (4.11) and (5.2) vanished. *So d is only the difference of pure hedges.* This result is intuitive for speculation components and are independent of production Y . Production variability may exercise its effect only on a pure hedges. Such an effect may be negative as well as positive depending on the probability distribution of prices and quantities. However production will not always have an effect on optimal hedge as is stated by the following proposition:

Proposition 2

When production Y is variable but independent of futures and spot prices, its variability has no effect on optimal position ($d = 0$). This is derived from the statistical statement that

$$(5.5) \quad \text{Cov}(x y, z) = \text{Cov}(xE(y), z)$$

When y is independent of x and z . In fact when this assumption holds we have $f(x, y, z) = f(x, z) \cdot f(y)$ or $\text{Prob}(x, y, z) = \text{Prob}(x, z) \cdot \text{Prob}(y)$ for a continuous or a discrete joint distribution of x , y and z . A full proof is given in the appendix.

In the case of the Ivory Coast we tested the hypothesis whether production variability would explain the policy of not using futures markets. Deviations from optimal positions (d) were estimated as follows:

$$(5.6) \quad \text{DREV} = \alpha + dP_f + U$$

where $\text{DREV} = P' (E(Y) - Y)$. In the empirical framework, Y^* (the vector of average volume of exports) was used as a proxy of $E(Y)$. Results are displayed in Table 2 and 4. Estimated deviations (d) are generally positive for cocoa and coffee; they are negative for cotton. This result confirms the idea of (5.1) that production variability may have negative as well as positive effect on optimal hedge. The reduction effect hypothesis is then proved.

At a 5% level, test showed that the estimated α was not significant. Thus production uncertainty should influence the choice of an optimal position by Ivory Coast on futures markets. Moreover this country would have benefited from using futures markets as is shown in the following section.

VI. Hedging by Futures Contracts & Stabilization Compared

In this section we try to compare the potential gains from using futures markets with the proposed gains from a price stabilizing scheme. In the first part potential gains from futures markets are derived. In the second part we compare them to price stabilization benefits.

A. Gains from Using Future Markets

Intuitively a hedger will enter futures markets if such a strategy dominates his sole strategy on spot markets. By choosing his optimal position on futures markets he expects to increase his utility relative to the one he derives from the spot markets only.

More formally, if the producer chooses f^* his utility is $W(f^*)$. If he only operates on spot markets, his utility may be represented by $W(O)$.

He gains from using futures markets if and only if

$$(6.1) \quad W(f^*) > W(O)$$

in virtue of strict monotonicity of $u(\cdot)$. This approach is compatible with the theory of choice by a risk-averse agent under uncertainty (STIGLITZ, 1981). This is the same as stating that $R(f^*)$ dominates R_c for a risk-averse agent.

From (4.9) we may write:

$$(6.2) \quad W(O) = E(\tilde{R}_c) - \frac{\alpha V(\tilde{R}_c)}{2} \quad (\text{without using futures})$$

$$W(f^*) = E(\tilde{R}) - \frac{\alpha V(\tilde{R}(f^*))}{2} \quad (\text{using futures})$$

where second terms are risk premia.

The gains from using futures markets are $G = W(f^*) - W(O)$ and

$$(6.3) \quad G = (E(\tilde{p}_f) - p_0^f)' f^* + \frac{\alpha(V(\tilde{R}_c) - V(\tilde{R}(f^*)))}{2}$$

B. Gains from Price Stabilization Policies

Here we adopt a measure of computing gains from price stabilization policies as derived by NEWBERY and STIGLITZ (1981). The method consists in finding a sum of money a producer would be willing to pay for a stabilization scheme to be introduced. Efficiency or risk benefit to the producer is

$$(6.4) \quad Br = 1/2 R \Delta \sigma_y^2$$

where R = the relative risk-aversion coefficient

$\Delta \sigma_y^2$ = change in the square of coefficient of variation of the revenue.

Risk benefits were computed for various countries (and commodities) for period 1951-1975. Results are reproduced in Table 6. The *risk benefits (cocoa and coffee) for Ivory Coast are small.*

Table 6
PRODUCER BENEFITS OF COMPLETE PRICE
STABILIZATION PERCENTAGES

Crop/Country	Share of world exports, %	Risk benefit $1/2 \Delta \sigma_y^2$	Transfer benefit	Net producer benefit
(1)	(1)	(2)	(3)	(4)
Cocoa from				
Ghana	32	0		
Nigeria	22	-0.5		
Ivory Coast	13	7		
Brazil	9	7		
weighted average	76	2.1	-2.9	-0.8
Coffee from				
Colombia	15	1		
Ivory Coast	5	2		
Mexico	3	1.5		
Brazil	31	0.5		
weighted average	54	0.7	-1.4	-0.7
Cotton from				
Egypt	14	1		
Mexico	7	-1.5		
Sudan	6	2.5		
Brazil	5	3.5		
weighted average	32	1.2	-2.7	-1.5
Jute from				
Bangladesh	69	2		
Thailand	19	6		
weighted average	88	2.9	-1.0	1.9
Rubber from				
Malaysia	53	2		
Nigeria	4	3.5		
Thailand	10	3		
Sri Lanka	6	2		
weighted average	73	2.3	-1.6	0.7
Sugar from				
Mauritius	3	19		
Philippines	8	19		
Brazil	11	4.5		
weighted average	22	11.8	-6.1	5.7

Key: Benefits measured as percentage of average revenue from crop assuming risk aversion $R = 1$ (col. (4) = col. (3) + col. (2)).

Source: NEWBERY and STIGLITZ (1981) p. 296.

C. Comparing Gains

To analyse the futures performance for the Ivory Coast in terms of $E(\bar{R}_c)$ we computed G for various commodities. We first show that G is similar to the NEWBERY and STIGLITZ Br, and second we compare computed G and Br.

We can write (6.3) as follow:

$$(6.5) \quad G = \frac{\alpha(V(\bar{R}_c) - V(\bar{R}(f^*)))}{2}$$

$$(6.7) \quad G = \frac{R^* \alpha(V(\bar{R}_c) - V(\bar{R}(f^*)))}{2R^*} = \frac{\alpha' \Delta V}{2R^*}$$

R^* = Average income, proxy of $E(\bar{R}_c)$

α' = (αR^*) = relative risk-aversion coefficient (level R^*)

ΔV = absolute reduction of variance by optimal hedging
 $f^* (V(\bar{R}_c) - V(\bar{R}(f^*)))$ of \bar{R}_c

$$(6.8) \quad G = \frac{\alpha' \Delta V R^{*2}}{R^* 2R^{*2}} = \frac{\alpha' \Delta v^2 R^*}{2}$$

with $\Delta v^2 = (\Delta V / R^{*2})$ = absolute change in the square of coefficient of variation of \bar{R}_c .

$$(6.9) \quad Gr = \frac{G}{R^*} = \frac{\alpha' \Delta v^2}{2}$$

which corresponds to Br of (6.4) the risk benefit as derived by NEWBERY and STIGLITZ. In fact both Br and Gr express the same reality and become comparable. They may be defined as the net prime of risk or the maximum amount (in terms of expected revenue) a risk-avoider producer is willing to pay for risk reduction (by a stabilization scheme or by hedging on futures markets).

Effectiveness of pure hedge or maximum reduction of variance of R_c by hedging was computed as:

$$\mu = (\Delta V / V(\bar{R}_c)) \text{ in (4.4)}$$

Substituting (4.4) in (6.9) we get:

$$(6.10) \quad Gr = \frac{\alpha' \Delta v^2}{2} = \frac{\alpha' \mu V(\bar{R}_c)}{2R^{*2}}$$

The higher is risk reduction (μ) the greater are relative gains (Gr.) Results of Gr are presented in Table 5. For cocoa Br and Gr are small and roughly equal.⁶

For coffee, gains from hedging in futures, though small, are likely to be greater than gains from stabilization policies. Gains rise from 2% to 8.3% (Table 5: Coffee September futures).

We may summarize this section by recording that although we have found a small difference between stabilization policies and hedging strategies, it is extremely difficult in some circumstances for certain countries to make an unambiguous judgment as to which is superior in terms of risk reduction. This is because there are two opposing tendencies. On the one hand, stabilization is superior because, unlike hedging, it gives the stabilized price on unanticipated production as well as anticipated production; on the other hand, stabilization forces a common degree of stabilization on all producers whereas under hedging, each producer can adopt his own preferred position. Which of these tendencies will be more important in a particular instance will depend on the characteristics of the various producers and the intentions of the intervention authority.

From our comparative studies, we have found that gains from hedging by using future contracts are slightly greater than the gains from stabilization policies in the special case of Ivory Coast and in fact the proper use of futures markets can greatly extend the risk management possibilities for LDCs. But optimal use requires understanding of how futures contracts work, how to balance risk and return in a hedged position, and how to implement the hedging strategies that futures trading make possible. In practice, however, LDC producers are not major or even substantial users of futures markets. Among explanations offered for the lack of LDC use of futures markets are:

- (i) LDC producers and governments lack familiarity with futures markets, and in many cases are prejudiced against use of speculative markets. Hedging on futures is a complicated activity. The producer must decide what quantity he wishes to hedge over what period; where there is more than one exchange, he must select the exchange which offers him the least uncertainty in geographical basis and the least exchange rate risk; he may consider it necessary to take a curren-

⁶ Comparison is to be done carefully. Periods under studies are different. Results are to be interpreted as only indicative.

- cy hedge in addition to the commodity hedge; he must decide in which month or months to take a position and when to roll forward; and he must be alert to movements in the temporal basis which will make maintenance of the hedge disadvantageous. Few LDC producers will have employees with these skills, and if they are to exploit the potential of the futures exchanges they must either invest in training or recruit skilled traders in the developed economies. In general, they will be well advised to do both of these, but this may require encouragement by the exchanges and other sympathetic organization.
- (ii) LDC producers and governments frequently lack the financial and management expertise necessary to exploit futures trading opportunities. It is obviously true that individual farmers of peasant products will be unable or unwilling to acquire the required level of expertise, but problems may also exist at the level of the state trade corporation or export ministry. However, experience in a number of commodities suggests that, it is unnecessary for producers to acquire the expertise. The predominant marketing arrangement in these trades is for producers to sell to commodity dealers than to hedge their positions on the futures markets. This form of marketing arrangement is a great deal simpler for management in the producer country, and can yield all the disadvantages of direct futures markets trading.
- (iii) LDC producers may be discouraged from taking futures positions because of the difficulty in obtaining finance, and in particular foreign exchange, to cover the payment of variation margins.

VII. Conclusion

This paper shows how producing LDC's subject to price and quantity fluctuations may use futures prices to predict its export prices and hedge its exports revenues on futures markets. The Ivory Coast was chosen for the study. First it appears to be a suitable representative of commodity exporting LDC's whose economies are sensitive to changes in export earnings. Indeed the Ivory Coast founded its development on exports. The information performance of futures markets was tested. The result is that futures prices predict rather well exports prices of the Ivory Coast.

Optimal positions were derived and estimated for cocoa, coffee and cotton under hypothesis of risk minimization (pure hedge) and expected utility maximization. Generally the full hedge hypothesis was rejected at a 5% level. Optimal hedge ratios are considerable and such hedges are effective. (except for cocoa). Risk of exports revenues could be reduced by

68% for cotton and 95% for coffee.

The effect of production variability to optimal hedge positions was analyzed. The main theoretical result is that it is not always negative; it may be positive depending on the joint probability distribution of production, futures and spot prices.

Two routes are open in international commodity policy. The traditional route is to negotiate international commodity agreements which override the market price distribution in an attempt to generate a price distribution which gives LDC commodity producers less variables and perhaps also higher revenue. The second route, which is currently attracting considerable attention is to encourage LDC primary producers to make use of existing, and in many cases rapidly developing, markets institutions to hedge their revenues. One of our purposes in this paper has been the comparison of these routes.

The comparison between these two routes is relatively complicated. This is firstly because economic theory cannot tell us a priori whether particular countries are likely to obtain greater risk reduction from hedging than from stabilization and secondly because there are practical problems associated with both routes. The theoretical difficulty arises because there are two factors at work which push in opposite directions. Stabilization offers a greater degree of risk reduction than the comparable hedging program because, at best, the producer can hedge in relation to his anticipated or planned output, and therefore any deviations from planned output will be unhedged; stabilization, on the other hand, gives him the stabilized price for his entire output. This factor favors intervention, but the intervention approach is inefficient relative to hedging in that a single stabilization range (or factor of proportionality) must be chosen, while in general different producers will benefit from different ranges (or factors). Stabilization must therefore rely on a compromise, and this compromise may be quite unsuited to some market participants.

From our studies, gains from optimal hedging strategies were derived and computed for all commodities. They were compared with gains from price stabilization. In general for the Ivory Coast the former seems greater than the latter; and this shows the possible use of futures markets by LDC to reduce the risk exposure of their export revenues. However, LDC primary producers in the practical case are not major users of futures exchanges. This does not appear to be the result of unsuitability of the contracts currently traded to LDC requirements. It is possible to argue that ignorance and suspicion, are important factors, but the major reason for the absence of LDCs as substantial users of commodity futures exchanges is that efficient hedging requires access to substantial credit. This is because

hedging is only likely to be available on attractive (i.e. efficiently priced) terms if the contracts are fungible.

Appendix

DEMONSTRATION of: If Y is independent of P and P^f_t , then $d = 0$.
 Let us prove proposition 2 for the case $n = 1$ and replace variables P , Y and P^f_t respectively by x , y and z .

Variable y is independent of x and z if and only if

$$(A.1) \quad f(x,y,z) = f(x,z) f(y) \text{ where } f(\cdot) \text{ is the joint density function of } x, y \text{ and } z$$

$$\text{Cov}(xE(y), z) = E(y)\text{Cov}(x,z)$$

We have to prove that $\text{Cov}(xy,z) = E(y) \text{Cov}(x,z)$

$$(A.2) \quad \text{Cov}(xy,z) = \int_{xy,z} (xy - E(xy))(z - E(z)) f(x,z) \cdot f(y) dx dy dz$$

$$= \int_y y \left(\int_{xz} x(z - E(z)) f(x,z) dx dz \right) f(y) dy$$

$$- E(xy) \int_y \left(\int_{xz} (z - E(z)) f(x,z) dx dz \right) f(y) dy$$

with $\int_{xz} (z - E(z)) f(x,z) dx dz = 0$

Then

$$\text{Cov}(xy,z) = \int_y y \left(\int_{xz} (x - E(x) + E(x))(z - E(z)) f(x,z) dx dz \right) f(y) dy$$

$$= \int_y y \left[\int_{xz} (x - E(x))(z - E(z)) f(x,z) dx dz + E(x) \int_{xz} (z - E(z)) f(x,z) dx dz \right] f(y) dy$$

Then

$$\text{Cov}(xy,z) = \int_y y (\text{Cov}(x,z)) f(y) dy$$

$$= \text{Cov}(x,z) \int_y y f(y) dy$$

$$= \text{Cov}(x,z) E(y)$$

and finally

$$\text{Cov}(xy,z) = \text{Cov}(xE(y),z) \text{ for } y \text{ independent of } x \text{ and } z$$

So $d = (\text{Cov}(PE(Y), P^f_t) - \text{Cov}(PY, P^f_t)) = 0$ for Y independent of P and P^f_t .

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