Potential Use of Futures Markets for International Marketing of Côte d'Ivoire Coffee

Korotoumou Ouattara
Ted C. Schroeder
L. Orlo Sorenson

INTRODUCTION

Coffee is one of the oldest primary commodities traded on the futures markets and yet the participation in the coffee futures markets by less developed countries (LDCs), the major producers, has been very limited. Numerous factors may contribute to the lack of participation of LDCs in futures markets in general and in coffee futures in particular including mistrust, ignorance, costs (financial requirements and margin costs), basis risk, and exchange rate risk (see Thompson and Bond (1985)). However, the potentials for LDCs to use futures markets to reduce export price risks have been well established (see McKinnon (1967), Newbery and Stiglitz (1981), Petzel (1985), and Thompson (1985)).

Coffee markets have exhibited large fluctuations in prices and quantities over the years, resulting in substantial risks for major producers. All Robusta coffee producing countries are developing countries that rely heavily on coffee revenues to fulfill economic development needs. As a result, effective marketing of Robusta coffee by exporting countries is of high priority. One benefit of participation by LDCs in the coffee futures market would be a reduction in export revenue instability. During the early years of the International Coffee Agreement (1964–1972) coffee prices were fairly stable. However, in 1973 coffee prices rapidly rose and the quota system collapsed. In 1975, prices again rose and pressure was present to instill greater flexibility in export quotas. Prevailing marketing strategies such as quotas and buffer stocks have been relatively unsuccessful in reducing price instability. Cooperative efforts through the International

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Korotoumou Ouattara was a Graduate Research Assistant in the Department of Agricultural Economics at Kansas State University.

Ted C. Schroeder is an Assistant Professor in the Department of Agricultural Economics at Kansas State University.

L. Orlo Sorenson is a Professor in the Department of Agricultural Economics at Kansas State University.

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Coffee Organization (ICO) (1986–87) have achieved some success in reducing year-to-year and cyclical variations in coffee prices, but substantial risk remains for short-term anticipated or actual inventory holders. Over the 1975 through 1987 period, within-year variations in coffee price have been as high as 25 percent. The price risk facing short-term inventory holders may be reduced through the use of the coffee futures markets (see Scheu (1973)). Anticipatory hedging has been shown to be a risk reducing strategy for risk averse producers (see Gray and Rutledge (1971)). In the presence of production uncertainty, partial hedging may be optimal for risk averse producers (see Rolfo (1980), Alexander, Musser, and Mason (1986), Sheales and Tomek (1987)).

The purpose of this article is to derive and examine optimal hedge ratios for a coffee producing country facing both price and production uncertainty. Côte d'Ivoire is the case study country. The study utilizes the methodology for export country hedging developed by Rolfo (1980) and extends research done by The World Bank (1983) and Gordon and Rausser (1984).

Côte d'Ivoire, formerly the Ivory Coast, is the third largest coffee producer in the world accounting for 6 percent of total world coffee production. Côte d'Ivoire is the largest producer of Robusta coffee in Africa. It produces approximately 240 million kilograms of coffee annually of which about 95 percent is exported. Côte d'Ivoire markets coffee through a Stabilization Fund which is in some respects similar to a marketing board. Unlike marketing boards in other countries, the Ivorian Stabilization Fund does not necessarily take physical possession of the product. It is a parastatal company that supervises the marketing operation, guarantees a fixed price to producers each year, and guarantees a CIF (Cost, Insurance, and Freight) price to local licensed exporters. Recently, the Fund has become progressively more involved in the sale of large quantities of coffee to the largest volume buyers. Under these circumstances, the exporter simply serves as an intermediary between the Fund and the buyer. Therefore, the Fund is exposed to coffee price fluctuations between the time when it sets purchase prices for producers and the time it sells the coffee abroad. It is during this period of exposure to price changes that coffee hedging could help the Fund stabilize export revenues.

HEDGING MODEL

A mean-variance (E-V) model is proposed here to examine the optimal anticipatory hedge ratios for a coffee exporter facing price and production risks. The E-V model is based on the expected utility hypothesis. From this hypothesis, Markowitz (1959) shows that utility can be maximized by trading between a higher mean return and a weighted lower variance. This model implicitly assumes that the hedger possesses a quadratic utility function (implying increasing absolute risk aversion) or that returns are normally distributed. Because of these restrictions, E-V analysis has been criticized. However, several studies have found that the E-V approach is quite robust to violations of the normality assumption (see Levy and Markowitz (1979), Kroll, Levy, and Markowitz (1984)). In addition, Epstein (1985) suggests that the E-V criterion is the only consistent rule for most definitions of the preferred assumption of decreasing absolute risk aversion. This partly explains why the E-V model has been used extensively in portfolio problems (see Newberry and Stiglitz (1981), Rolfo (1980), Chavas and Pope (1982), and Sheales and Tomek (1987)).

The optimal hedging level for a risk-averse, coffee producing country facing both quantity and price uncertainties can be derived in the following manner. Assume that the coffee producing country maximizes the expected utility of income by choosing the optimal hedging level in the presence of price and production uncertainties. Utility is examined in a mean-variance framework.[1] The objective function is:

$$\text{Max } Z = E(y) - \lambda \text{ Var}(y) \tag{1}$$

where E refers to expectation, Z is the objective value, y is the exporter income, and λ is a risk aversion parameter.

The exporting fund's income for selling on the cash market is:

$$y = (P - \overline{P})Q \tag{2}$$

where P is the cash coffee price at harvest, $\overline{P}$ is the guaranteed minimum price to producers, and Q is the quantity of coffee produced and available for export. By hedging with n futures contracts, the exporting country can modify its income to be:

$$R = y + n(PP - PF) \tag{3}$$

where PP is the futures price at the time a short hedge is placed, PF is the futures price at the time the hedge is lifted (at time of export), and R is the cash market revenue plus the income from the hedge. Prior to harvest, output and price are unknown and random.

With hedging, the producer's objective funciton becomes:

$$\underset{n}{\text{Max}}\ Z = E(y) + n(PP - E(PF)) - \lambda[\text{Var}(y) + n^2 \text{ Var}(PF) - 2n \text{ Cov}(y, PF)] \tag{4}$$

The optimal futures position, n^*, is determined by maximizing eq. (4) by choosing n. The first order condition for the optimal futures position is:

$$PP - E(PF) - \lambda[2n \text{ Var}(PF) - 2 \text{ Cov}(y, PF)] = 0 \tag{5}$$

Rearranging eq. (5) gives the optimal hedge ratio with deterministic production as:

$$n^* = \frac{\text{Cov}(y, PF)}{\text{Var}(PF)} + \frac{PP - E(PF)}{2\lambda \text{ Var}(PF)} \tag{6}$$

The optimal hedge in eq. (6) is comprised of hedging and speculative components. The first term is the hedging component, which indicates the level of futures holdings that minimize the variance of returns. The second term is the speculative component, which reflects the effects of hedging on the level of returns. It is inversely related to the hedger's risk parameter and disappears if the hedger is infinitely risk averse ($\lambda \rightarrow \infty$), or if the current futures price is an unbiased estimate of the futures price at the time the hedge is lifted, i.e., $PP = E(PF)$.

Coffee production patterns change over time depending upon the average age of trees, technological progress, tree diseases, weather, etc. Knowledge of the state of these factors provides information before harvest that can be used to forecast production. With this information, expectational data, rather than historical data can be used to measure price and production uncertainty. Equation (6) can be modified to incorporate expectations regarding prices and production.

[1]As stated the model has the objectives of stabilizing export revenue within the year. This should also be a longer-time horizon stabilizing factor since hedges cannot likely be placed beyond a year in advance due to low liquidity in the market, long-term storage of significant amounts of coffee is not economically feasible, and coffee revenues were found to be uncorrelated across time. Thus, a single-period model should be fairly consistent with a multi-year solution.

Price and production uncertainties can be measured by the difference between realized and forecast prices and quantities (see Rolfo (1980)). Thus, ignoring basis risk, the following price and production forecast errors are defined:
Cash price forecast error (e_p) is given by:

$$e_p = [P - PP]/PP$$

Futures price forecast error (e_f) is given by:

$$e_f = [PF - PP]/PP$$

Production forecast error (e_q) is given by:

$$e_q = [Q - QF]/QF$$

where QF is forecast production.

Thus, revenue forecast error (e_y) from cash marketing is:

$$e_y = e_p + e_q + e_p e_q$$

Rearranging the forecast errors so that P, PF, and Q are functions of predetermined variables gives:

$$P = PP(1 + e_p)$$

$$PF = PP(1 + e_f)$$

$$Q = QF(1 + e_q)$$

Substituting these relations into eq. (6) and simplifying (see Appendix for derivation) gives the optimal hedge ratio under price and production uncertainty expressed as proportions of forecast production and price:

$$\frac{n^*}{QF} = \frac{\text{Cov}[(1 + e_p)(1 + e_q), e_f]}{\text{Var}(e_f)} - \frac{\overline{P}\ \text{Cov}[(1 + e_q), (e_f)]}{PP\ \text{Var}(e_f)} - \frac{E(e_f)}{2\lambda PP \cdot QF \cdot \text{Var}(e_f)} \tag{7}$$

This hedge ratio is dynamic because it changes each year to reflect changes in: the futures price at the time the hedge is placed, the minimum price guaranteed to producers, and the forecasted production estimates relative to the parameters of the equation.

EMPIRICAL DATA

The coffee harvest time in Côte d'Ivoire is from November to April. Historical and expectational data used to derive the forecast errors were collected for 14 years (1973/74 to 1986/87) using the coffee "C" contract on the New York Sugar, Coffee, and Cocoa Exchange. The May closing futures prices reported on the last day of October (PP) and the May closing futures prices reported on the first active trading day of May (PF) were collected from the *The Wall Street Journal* (1973–1987). May was chosen as the futures delivery month because it most closely matches the end of the Ivorian coffee harvest. The May Robusta coffee cash prices were obtained form USDA (United States Department of Agriculture, 1973–1987).

The Arabica coffee futures prices quoted on the New York Coffee Exchange were used to cross hedge Côte d'Ivoire Robusta coffee. The New York exchange was chosen over the London Robusta coffee futures market because it trades the highest volume of coffee futures and because the U.S. is the most important North American buyer of Ivorian coffee, accounting for one-fourth of overall coffee sales. Using the U.S. coffee futures market reduces exchange rate risks with the major coffee buyer. The futures price (Arabica) and the spot price (Robusta) probably will not be equal at delivery. Arabica is generally higher priced than Robusta reflecting differences in coffee quality.

The forecast output (QF) was obtained from USDA October forecasts covering 14 seasons from 1973–1974 to 1986–1987. The USDA forecasts accurately approximated the realized output (Q) published by the ICO. From the time the hedge is placed in October to when the hedge is lifted at harvest in May, Côte d'Ivoire has seven months of possible hedging involvement in futures markets.

EMPIRICAL RESULTS

The means and standard deviations of the forecast errors used in the E-V model are reported in Table I. The mean, futures, price forecast error (e_f) is positive and significantly different from zero at the .10 level of significance, implying that the optimal hedge ratio (n^*/QF) is an increasing function of the risk parameter in eq. (7). The mean cash price (e_p) and quantity (e_q) forecast errors are both negative, although not significantly different from zero. The covariance and correlations among the forecast errors are presented in Table II. The covariance between production and cash price forecast errors is positive, implying that Côte d'Ivoire may have incentives to (cross) hedge quantities greater than the expected output (see Miller (1986)).

To examine the impact of various levels of risk aversion, risk parameters were chosen within the range [0.000001, ∞] which are consistent with those used by Rolfo (1980). The larger values of the risk aversion parameter correspond to risk averse agents with a value of infinite implying a risk minimizer. Optimal hedging levels and the associated mean and standard deviations of revenues for various risk aversion levels are reported in Table III. The Stabilization Fund's average revenue above the guaranteed price to producers over the 1973/74 through 1986/87 period (assuming all production was exported at harvest) with no hedging would have been $490 million with a standard deviation of $338 million. To minimize risk, a routine hedge using an average hedge ratio of 1.248

Table I
SUMMARY OF MEANS AND OTHER STATISTICS OF FORECAST ERRORS, 1973 TO 1986

	Future Price Forecast Error (e_f)	Cash Price Forecast Error (e_p)	Production Forecast Error (e_q)	Revenue Forecast Error (e_y)
Mean	0.12349	−0.01008	−0.00731	−0.00098
Standard Deviation	0.26614	0.26839	0.25990	0.48123
Minimum Value	−0.29608	−0.37620	−0.60000	0.56886
Maximum Value	0.67461	0.58921	0.48485	1.35974
STD Error of Mean	0.07113	0.07173	0.06946	0.12861

Table II
COVARIANCES AND CORRELATIONS AMONG PRICE, PRODUCTION, AND REVENUE FORECAST ERRORS, 1973 TO 1986

	Future Price Forecast Error (e_f)	Cash Price Forecast Error (e_p)	Production Forecast Error (e_q)	Revenue Forecast Error (e_y)
e_f	.0708313	.0600163	.0238638	.0964475
	(1.00000)[a]	(0.84022)*	(0.34500)	(0.75305)*
e_p		.0720325	.0175891	0.103859
		(1.00000)	(0.25216)	(0.80412)*
e_q			.0675469	0.096101
			(1.00000)	(0.76836)*
e_y				0.231587
				(1.00000)

[a]Correlation coefficients are in parentheses.
*Indicates significantly different from zero at the .05 level.

Table III
OPTIMAL CÔTE D'IVOIRE COFFEE HEDGE RATIOS AND ASSOCIATED MEANS AND STANDARD DEVIATIONS OF REVENUES FOR SELECTED RISK AVERSION LEVELS, 1973/74 TO 1986/87

Risk Aversion Parameter	Average Optimal Hedge Ratio n^*/QF	Standard Deviation of Hedge Ratio	Average Revenue (mil. U.S. $)	Standard Deviation of Revenues (mil. U.S. $)
∞	1.248	0.277	384.0	240.2
1,000	1.248	0.304	384.0	240.2
100	1.248	0.304	384.0	240.2
10	1.248	0.304	384.0	240.2
1	1.248	0.304	384.0	240.2
0.1	1.248	0.304	384.0	240.2
0.01	1.247	0.304	384.1	240.2
0.001	1.235	0.307	385.1	240.3
0.0001	1.120	0.343	394.8	241.6
0.00001	−0.035	0.787	491.6	336.0
0.000001	−11.584	5.268	1,460.6	2,335.5

would have resulted in an average revenue of $384.0 million with a standard deviation of $240.2 million. Thus, routine hedging would have reduced the standard deviation of revenue by about 29% and the average revenue by approximately 22% relative to cash marketing. It is important to note that the hedge ratios reported in Table III are averages over the 14 seasons. The hedge ratio may change each year because of changes in PP, $\overline{P}$, and QF in eq. (7).

For λ between .01 and ∞, the optimal hedge ratios and associated revenues and standard errors of revenues were relatively constant indicating that the speculative component is inconsequential for these values of the risk parameter. However, changes occurred for values of λ smaller than .01. For less risk averse agents, optimal hedging diminished and eventually became negative for values of λ less than or equal to 0.0001. For agents that were less risk averse, the speculative component eventually became greater than the hedging component and, thus, the hedger was net long in the futures market. As expected, the averages and standard deviations of revenue were greater for the less risk averse hedgers than for the more risk averse.

CONCLUSION

Côte d'Ivoire, as well as other developing countries, relies heavily on coffee revenues for development needs. However, violent fluctuations in international coffee prices have made the country's development planning process very uncertain. By using the coffee futures market to hedge coffee exports, Côte d'Ivoire could have reduced the standard deviation of revenues by nearly 29% and reduced average revenue by about 22% relative to using only the cash market. Thus, these results suggest that Côte d'Ivoire's coffee export earnings could be stabilized through judicious use of marketing strategies involving coffee futures. The results indicate that when hedging in the New York Coffee futures market to minimize risk, Côte d'Ivoire could have assumed an average futures position equal to approximately 125 percent of it's expected production during the 1973/74 through 1986/87 crop years.

In terms of application, the results may be considered for analyses of policies that could be implemented by the Ivorian Stabilization Fund, provided it continues to play an active role in the sale of coffee abroad. This study did not incorporate financial and exchange rate risks considerations which might restrain a country from participating in the futures market.

Appendix

DERIVATION OF THE OPTIMAL HEDGE n^* USING EXPECTED FORECAST ERRORS

Revenue (R) can be defined as:

$$R = (P - \overline{P})Q + n(PP - Pf) \qquad (1A)$$

where P is the cash price at harvest, $\overline{P}$ is the guaranteed price to producers, Q is the quantity produced, n is the hedging level, PP is the futures price at the time a hedge is placed, and PF is the futures price at the time the hedge is lifted. The variance of income is:

$$\begin{aligned}\mathrm{Var}(R) = {} & \mathrm{Var}(PQ) + \overline{P}^2\,\mathrm{Var}(Q) + n^2\,\mathrm{Var}(PF) - 2n\,\mathrm{Cov}(PQ, PF) \\ & + 2n\overline{P}\,\mathrm{Cov}(Q, PF) - 2\overline{P}\,\mathrm{Cov}(PQ, Q)\end{aligned} \qquad (2A)$$

Given

$$P = PP(1 + e_p) \qquad (3A)$$

$$Q = QF(1 + e_q) \qquad (4A)$$

$$PF = PP(1 + e_f) \qquad (5A)$$

where e_p, e_q, and e_f are the forecast errors associated with forecasts of cash price, production, and the ending futures price, respectively, as defined in the text.

Then $E(R) = E[PP(1 + e_p)QF(1 + e_q) - \overline{P}QF(1 + e_q) + nPP - nPP(1 + e_f)]$ (6A)

$$\begin{aligned}\text{Var}(R) = {} & \text{Var}[PP(1 + e_p), QF(1 + e_q)) + \overline{P}^2 \text{Var}(QF(1 + e_q)) \\ & + n^2 \text{Var}(PP(1 + e_f)) - 2n \text{Cov}(PP(1 + e_p)QF(1 + e_q), \\ & PP(1 + e_f)) + 2n\overline{P} \text{Cov}(QF(1 + e_q), PP(1 + e_f)) \\ & - 2\overline{P}\, Cov(PP(1 + e_p)QF(1 + e_q), QF(1 + e_q))\end{aligned} \tag{7A}$$

where E refers to expectation.
Given the agents objective to maximize the following:

$$\text{Max } Z = E(R) - \lambda \text{ Var}(R) \tag{8A}$$

then the first order condition is:

$$\begin{aligned}\frac{dZ}{dn} = {} & PP - E[PP(1 + e_f)] - \lambda\Big[2n \text{ Var}(PP(1 + e_f)) \\ & - 2 \text{ Cov}[PP(1 + e_p)QF(1 + e_q), PP(1 + e_f)] \\ & + 2\overline{P} \text{ Cov}[QF(1 + e_q), PP(1 + e_f)]\Big] = 0\end{aligned} \tag{9A}$$

Given that:

$$Var[PP(1 + e_f)] = \text{Var}(PP + e_f PP) = PP^2 \text{ Var}(e_f)$$

and

$$E[PP(1 + e_f)] = E(PP) + PPE(e_f) = PP + PPE(e_f)$$

then

$$\begin{aligned}\frac{dZ}{dn} = {} & -PPE(e_f) - \lambda\Big[2nPP^2 \text{ Var}(e_f) \\ & - 2\text{Cov}[PP(1 + e_p)QF(1 + e_q), PP(1 + e_f)] \\ & + 2\overline{P} \text{ Cov}[QF(1 + e_q), PP(1 + e_f)]\Big] = 0\end{aligned} \tag{10A}$$

Solving for the optimal hedge (n^*) gives:

$$\begin{aligned}n^* = {} & \frac{\text{Cov}[PP(1 + e_p)QF(1 + e_q), PP(1 + e_f)]}{PP^2 \text{ Var}(e_f)} \\ & - \frac{\overline{P} \text{ Cov}[QF(1 + e_q), PP(1 + e_f)]}{PP^2 \text{ Var}(e_f)} - \frac{PPE(e_f)}{2\lambda PP^2 \text{ Var}(e_f)}\end{aligned} \tag{11A}$$

Dividing by QF gives the optimal hedge ratio:

$$\frac{n^*}{QF} = \frac{\text{Cov}[(1 + e_p)(1 + e_q), (e_f)]}{\text{Var}(e_f)} - \frac{\overline{P} \text{ Cov}[(1 + e_q), (e_f)]}{PP \text{ Var}(e_f)} - \frac{E(e_f)}{2\lambda PPQF \text{ Var}(e_f)} \tag{12A}$$

Bibliography

Alexander, V. J., Musser, W. N., and Mason, G. (1986): "Futures Markets and Firm Decision under Price, Production, and Financial Uncertainty," *Southern Journal of Agricultural Economics*, 18:39–49.

Chavas, J.-P., and Pope R. (1982): "Hedging and Production Decisions under a Linear Mean-Variance Preference Function," *Western Journal of Agricultural Economics*, 7:99–110.

Epstein, L. G. (1985): "Decreasing Risk Averison and Mean-Variance Analysis," *Econometrica*, 53:945–961.

Gordon, K. M., and Rausser, G. C. (1984): "Country Hedging for Real Income Stabilization: A Case Study of Korea and Egypt," *Journal of Futures Markets*, 4:449–464.

Gray, R. W., and Rutledge, D. J. S. (1971): "The Economics of Commodity Futures Markets: A Survey," *Review of Marketing and Agricultural Economics*, 39:57–108.

International Coffee Organization (ICO) (1986–1987): *Quarterly Statistical Bulletin*, London, Various Issues.

Kroll, Y., Levy, H., and Markowitz, H. M. (1984): "Mean-Variance Versus Direct Utility Maximization," *The Journal of Finance*, 39:47–61.

Levy, H., and Markowitz, H. M. (1979): "Approximating Expected Utility by a Function of Mean and Variance," *American Economic Review*, 69:308–317.

Markowitz, H. M. (1959): *Portfolio Selection*, New York: John Wiley & Sons.

McKinnon, R. T. (1967): "Futures Markets, Buffer Stocks and Income Stability for Primary Producers," *Journal of Political Economy*. 75:844–861.

Miller, S. E. (1986): "Forward Contracting Versus Hedging under Price and Yield Uncertainty," *Southern Journal of Agricultural Economics*, 18:139–146.

Newbery, D. M. G., and Stiglitz, J. E. (1981): *The Theory of Commodity Price Stabilization: A Study in the Economics of Risk*, Oxford, England.

Petzel, T. E. (1985): "International Use of U.S. Futures Markets," *American Journal of Agricultural Economics*, 67:999–1001.

Rolfo, J. (1980): "Optimal Hedging under Price and Quantity Uncertainty: The Case of a Cocoa Producer," Journal of Political Economy, 88:100–116.

Scheu, J. J. (1973): "Hedging: Reducing the Risks of Trading in Actual Coffee," *Tea and Coffee Trade Journal*, 145:20–27.

Sheales, T. C., and Tomek, W. G. (1987): "Hedging Australian Wheat Export Using Futures Markets," *Journal of Futures Markets*, 7:519–553.

The Wall Street Journal. (1973–1987): New York: Dow Jones and Company, Inc., Various Issues.

The World Bank (1983): "The Use of Futures Markets by Less Developed Countries for Commodity Exporting," Agrep. Div. Working Paper, Washington, D.C.

Thompson, S. (1985): "Use of Futures Markets for Exports by Less Developed Countries," *American Journal of Agricultural Economics*, 67:986–991.

Thompson, S. R., and Bond, G. E. (1985): "Basis and Exchange Rate Risk in Offshore Futures Trading," *American Journal of Agricultural Economics*, 67:980–985.

U.S. Department of Agriculture: *World Coffee Situation*, Foreign Agricultural Service: Washington, D.C., Various Circulars 1973–1987.