International Risk Management: Optimal Hedging for the Government Export Agency in the Ivory Coast

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Abstract: A risk management model based on portfolio theory, which accounts jointly for price, quantity, interest rate, and exchange rate risks, is developed and applied to cocoa and coffee production and exports in the Ivory Coast. Using commodity and financial futures markets jointly, the results show that a government export agency can reduce risks from 27 to 86 percent by following a multicommodity hedging programme. The model and technique developed are applicable to many international risk management situations.

Introduction

Economic development in a number of countries depends heavily on the export sector. This is particularly true for developing countries where the export sector usually represents a substantial part of the economy. Fluctuations in the export revenues of these countries may cause adverse effects on the economy as the whole. To guard against these effects, most developing countries have taken steps to stabilize their export proceeds by acting at two levels. First, at the domestic level, these countries have isolated farmers from fluctuations in the world markets by guaranteeing them fixed prices for their products. Second, these countries have acted at the international level in concert with other countries to reduce world price fluctuations. This second effort has consisted mainly of managing buffer stocks and/or allocating export quotas to maintain world prices within agreed on ranges.

The stabilization efforts at the domestic level have been, for the most part, effective (Denis, 1982; and Blandford, 1974), but, at the international level, they have been less successful. Factors cited as difficulties encountered by many international stabilization schemes range from the inability of the producing and consuming countries to reach agreements on export quotas and price ranges (MacBean, 1966; and Ernst, 1982) to more fundamental economic ones. For example, Newbery and Stiglitz (1981) argue that the effectiveness of these schemes is limited because they do not take into account existing stabilization tools such as the futures markets. In addition, these schemes fail to incorporate two major sources of export revenue fluctuations, exchange rate and interest rate variations.

The objective of this paper is to present a risk management model, based on modern risk management concepts, which takes into account not only price and quantity risks but also interest rate and exchange rate risks. Specifically, this paper uses portfolio theory to demonstrate how the futures markets can be used to manage simultaneously quantity, price, interest rate, and exchange rate risks associated with the marketing of cocoa and coffee by the Ivory Coast. The approach developed here can be applied to many international trading situations.

Revenue Risks from Ivory Coast Exports

In the Ivory Coast, cocoa and coffee are the two major export crops, despite the diversification policy promoted by the government since the 1960s. About 60 percent of the total export revenue is generated by the sale of these two commodities. Fluctuations in cocoa and coffee export proceeds can be detrimental to Ivory Coast's economy. To protect farmers against world price fluctuations, the government, through its marketing agency (Caisse), guarantees farmers a fixed price at the start of each season. Caisse, which does not take physical possession of the products, regulates the actions of private exporters who buy the commodities from the farmers at the guaranteed price and sells them in the world market. These private exporters are also guaranteed a fixed price, which reflects the cost of transporting and handling the commodities from the farm gate to the ports. Any positive

margin between the world price and the exporter fixed price is collected by Caisse. When the margin is negative, Caisse pays the difference to the exporters. Over the years, the typical situation has been for the world price to be higher than the domestic price (Delaporte, 1976). The margin collected by Caisse can be invested in the international financial market or used to finance development projects. In the 1985 government investment budget, the receipts from Caisse represented about 19 percent of total receipts and 30 percent of total domestic receipts. The revenue generated by Caisse depends on the quantity of cocoa and coffee produced, the world cocoa and coffee prices, the interest rate in international financial markets, and the exchange rate between the US dollar and the CFA franc. Most of the world cocoa and coffee transactions are in US dollars or dollar-related currencies.

Over the years, cocoa and coffee production in the Ivory Coast have fluctuated widely. For example, from 1975 to 1986, their coefficients of variation were 36 and 26 percent, respectively. During the same period, world cocoa and coffee prices varied an average of 54 and 53 percent around their respective means. Similarly, the US dollar/CFA franc exchange rate and US interest rate had coefficients of variation of 30 and 36 percent, respectively.

Hedging Model

Portfolio theory, as developed by Markowitz (1952) and applied to hedging in the futures market by Johnson (1960) and Stein (1961), is the basis of the risk management model presented here. The Johnson-Stein minimum variance hedge ratio model was expanded by Rolfo (1980) to an optimal hedge ratio based on utility maximization, which includes a speculative component along with the minimum variance ratio. Rolfo applied this framework to cocoa exporting countries, including the Ivory Coast. Anderson and Danthine (1980) expanded the framework to multiple risks and showed specifically the speculative and the pure hedge components of optimal hedges. A model similar to the Anderson and Danthine paradigm is outlined here, with the goal to apply it empirically.

Using the mean-variance framework, the objective of Caisse is assumed to be to maximize expected revenue subject to a certain level of risk, where risk is measured by the variance of the revenue. The objective function to be maximized can be formalized as follows:

$$(1)\quad \Omega = E_t(Y_{t+1}) - \delta V_t(Y),$$

where, Y_{t+1} is the revenue in period $t + 1$, E_t is the expectation operator, V_t is the variance operator, and δ is the risk aversion parameter $(\delta \geq 0)$.

The revenue in $t + 1$ is a function of the action undertaken by Caisse before harvest and at harvest, both in the cash and the futures markets. At harvest, Caisse, through private exporters, buys quantities Q_{cc} and Q_{co} of cocoa and coffee at fixed domestic prices P^d_{cc} and P^d_{co}, respectively. These quantities are sold in the world markets at prices $P_{cc}X$ and $P_{co}X$, respectively (the dollar prices are converted back to CFA francs by exchange rate X). The proceeds are then invested at a one-period rate of interest r. The total revenue of the cash cocoa and coffee activities are designated as R_{cc} and R_{co}, respectively.

Before harvest, Caisse sells a quantity H_{cc} and H_{co} of cocoa and coffee forward in the futures market at price f^t_{cc} and f^t_{co}, respectively. At harvest, Caisse buys back these quantities at price f^{t+1}_{cc} and f^{t+1}_{co}, respectively. In local currency, the returns from these activities in the cocoa and coffee futures markets are R^f_{cc} and R^f_{co}, respectively.

Before harvest, Caisse also sells quantity C of foreign currency futures at price X^t_f to be bought back at time $t + 1$ at price X^{t+1}_f. The return from this action is R^f_c.

Before harvest, Caisse buys quantity I of futures contracts at futures interest rates paying a rate r^t_f to be sold back at harvest $t + 1$ at rate r^{t+1}_f. The return from this investment is R^f_r.

In the risk management context, the unknowns to be solved by Caisse are the levels of the commodity hedges, H_{cc} and H_{co}, the amount of currency hedge, C, and the level of interest rate hedge, I.

The net income generated by Caisse is:

$$(2)\quad Y_{t+1} = K'R,$$

where K is a (6×1) vector of ones and futures positions, $K' = [1\ 1\ H_{cc}\ H_{co}\ C\ I]$; and R is a (6×1) vector of cash and futures returns, $R' = [R_{cc}\ R_{co}\ R^f_{cc}\ R^f_{co}\ R^f_c\ R^f_r]$.

The objective function (1) becomes:

$$(3)\quad \Omega = K'E(R) - \delta[K'RR'K].$$

The above function is concave; consequently, the maximum is obtained at point where the first derivatives with respect to H_{cc}, H_{co}, C, and I are equal to zero. Following the derivatives in Sarassoro (1988), the optimal hedges are given by the following equation:

$$(4)\quad K_1 = P^{-1}[(1/\delta E)(R_1)-S],$$

where $K_1' = [H_{cc}\ H_{co}\ C\ I]$; $P = [a_{ij}]$ $(i=3,\ 6$ and $j=3,\ 6)$ is a (4×4) matrix of simple regression coefficients of i on j, where $i = j = 1,\ 6$ represent R_{cc}, R_{co}, R^f_{cc}, R^f_{co}, R^f_c, and R^f_r, respectively; $R_1' = [R^f_{cc}\ R^f_{co}\ R^f_c\ R^f_r]$; and $S = [a_{i1} + a_{i2}]$, $i = 3,\ 6$.

Equation (4) will be used to estimate the optimal hedges for H_{cc}, H_{co}, C, and I for selected values of the risk parameter δ in the interval 10^{-5} to 10^5, where 10^{-5} indicates very low risk aversion and 10^5 signifies high risk aversion. For highly risk averse decision makers or when δ is large, the optimal hedge coincides with the risk minimization strategy. Consequently, the proportion of risk reduction, $e = [1\text{-}var(Y_h)]/[var(Y_u)]$, due to hedging can be used to evaluate the hedging strategy. $Var(Y_h)$ and $var(Y_u)$ are the variance of the hedged and the unhedged portfolios, respectively.

Empirical Findings

Cocoa and coffee are harvested continuously from October to September of the following year, with the bulk of the harvested occurring from December to March. In this paper, the cocoa and coffee seasons are divided into the four periods: October-December, January-March, April-June, and July-September.

The optimal hedging strategy proposed here assumes that just before each period (in September, December, March, and June), Caisse take a position in the cocoa, coffee, currency, and interest rate futures markets, to be reversed at the end of the period (December, March, June, and September) when the cash commodities are sold in the spot markets and the proceeds invested. No futures market exists for the CFA franc, and the French franc, to which the CFA franc is tied, has no active futures market. Consequently, an alternative futures currency, the pound sterling, is used to cross hedge the CFA franc.

The basic data needed to calculate the commodity and financial optimal hedges are the monthly average futures prices for those months futures contracts are bought and sold and the total quantities of cocoa and coffee exported by the Ivory Coast during the quarter. The US 90-day Treasury bill futures is used to hedge the interest rate risk. The proceeds are invested in three-month Treasury bills. Finally, the domestic prices for cocoa and coffee are fixed for each year. This analysis covers the period from 1976 to 1986.

Table 1 gives the ratios of the futures returns to their respective variances for the four periods being studied. In most cases (except for the currency futures returns), these ratios are close to zero, suggesting that little speculative opportunity exists.

Actual estimation of the optimal hedge for values of δ varying from 10^{-5} to 10^5 show that the optimal hedges do not vary significantly. Consequently, only the results

corresponding to the risk minimization strategy ($\delta = 10^{-5}$) are reported. The hedging model can then be evaluated using the hedging efficiency criteria, $e = [1\text{-}var(Y_h)]/[var(Y_u)]$.

Table 2 reports the optimal cocoa, coffee, currency, and interest rate hedge ratios and the proportion of total risk eliminated by the hedging strategy. The hedge ratios range from buying futures contracts larger than the cash position (currency in September-December) to small futures positions (coffee in September-December) to selling more futures positions (coffee in September-December) to selling more futures contracts than the size of the cash position (cocoa in June-September). Most importantly, the hedging effectiveness column indicates that the commodity and financial futures markets are useful risk management tools, since Caisse can reduce between 27 and 87 percent of the risk associated with cocoa and coffee export revenue. These represent substantial reductions in risks.

Table 1—Ratios of the Expected Futures Returns to Variances for the Cocoa, Coffee, Currency, and Interest Rate Futures Markets

	Cocoa	Coffee	Currency	Interest Rate
Dec.-Mar.	1.86×10^{-4}	-2.94×10^{-4}	5.39	-0.007
Mar.-June	-0.16×10^{-4}	2.02×10^{-7}	1.23	-0.28
June-Sept.	-1.25×10^{-7}	1.53×10^{-7}	-1.18	0.09
Sept.-Dec.	1×10^{-4}	-11×10^{-7}	-1.18	-0.0039

Table 2—Optimal Commodity and Financial Hedge Ratios and Hedging Effectiveness (in percent)

	Optimal Hedges				
	Cocoa	Coffee	Currency	Interest Rate	Hedging Effectiveness
Sept.-Dec.	111	8	-491	127	67
Dec.-Mar.	68	-54	275	-147	26
Mar.-June	17	-234	75	135	85
June-Sept.	301	17	51	-10	47

Several observations can be drawn from the above results. First, across the four quarters, the average risk reduction is 56 percent, which is noteworthy. The results obtained in this analysis also suggest that, contrary to traditional hedging theory, taking futures positions greater and smaller than the cash position may be consistent with optimal hedging decisions. Sometimes these results show the futures position to be on the same side rather than the opposite side of the cash position. Gemmill (1980) found that long positions in futures were consistent with risk minimization. Also, Rolfo (1980) found that, for low risk aversion, long positions in the futures were optimal.

Second, considerable variability exists in the hedge positions from quarter to quarter. This means that a government agency needs to be flexible in establishing futures positions and willing to alter them in the next quarter. This need for flexibility may suggest why many stabilization schemes fail where countries are locked into specific trading scenarios for a whole year.

Third, some of the results of this paper may be difficult to implement because political leaders in many developing countries believe that participation in futures markets is speculation. Therefore, one may have difficulty convincing the decision makers at Caisse to take futures positions at all, let alone futures positions that are greater than the cash positions. Consequently, upper and lower bounds corresponding to the expected cash position and zero, respectively, can be put on the different hedges. For example, when the hedge is found to be negative, set it equal to zero. Similarly, a futures position greater than the corresponding expected cash position is set to that expected cash position. Experimentation with this constrained risk minimization strategy reduced the hedging effectiveness for all four periods on average from 56 percent to 28 percent, making these results, based on constrained trading positions, less interesting and less appealing.

Conclusion

This paper demonstrates how a marketing agency faced with multiple (quantity, price exchange rate, and interest rate) international risks may use commodity and futures markets jointly as management tools. In particular, this paper develops a multicommodity hedging model based on portfolio theory and applies it to Ivory Coast cocoa and coffee exports.

When the average of past returns is used as an expectation model, the cocoa, coffee, pound sterling, and three-month US Treasury bill futures markets offer little speculative opportunity. However, when the objective of the decision maker is to minimize risk, the cocoa, coffee, exchange rate, and interest rate futures markets provide substantial risk reduction opportunity. In particular, Ivory Coast's government export agency may reduce 27 to 86 percent of the risk it faces in marketing cocoa and coffee. The futures positions have considerable range, and, on occasion, risk minimization would require futures positions greater than the expected cash positions and on the same side as the cash positions. A policy using such trading strategies may be politically difficult to implement in many developing countries; however, this study demonstrates the potential for substantial risk reduction when managing several risks simultaneously.

Note

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DISCUSSION OPENING—*Parr Rosson* (Clemson University)

The effects of export-led economic development on GDP growth are well documented by Krueger and others. Little doubt exists that the export sector and agriculture are both critical if successful economic development is to occur in most developing nations. The paper by Sarassoro and Leuthold makes a solid contribution towards enhancing the research base in such a critical area. Further, the authors treat a difficult topic with a useful model that provides strong evidence of the benefits to effective management of export risk. Therefore, this brief comment is designed to stimulate discussion about the implications of the results and to explore one possible caveat to the theoretical base on which this research is built.

First, as the authors point out, the ratio of currency futures returns to variance were relatively high, suggesting some degree of speculative market opportunity. How might this research be extended to include the use of currency options? Although historical data on options are limited, they afford a viable alternative for risk management. In concept, a currency option would allow the exporter to hedge against an appreciating currency yet take full advantage of a decline in currency values. The use of currency options seems an important alternative, which deserves further attention.

Second, Sarassoro and Leuthold's study assumes that export revenue stability and economic growth are positively correlated. However, as Newbery and Stiglitz point out, this need not always occur. Economic signals sent via the international market to producers would be distorted under this scheme. Alternatives that appear logical in a static framework can have severe economic consequences as adjustment occurs. Linkages to employment, capital markets, and investment are crucial. Artificial stability may lead to resource misalignment, overinvestment, and higher input prices. Further, spillover effects into the rest of the economy from reduced domestic investment in critical sectors could adversely affect economic growth patterns. From a policy perspective, these questions are crucial for the Ivory Coast or any other developing nation seeking effectively to manage economic development and are worthy of further discussion.

GENERAL DISCUSSION—*T. Haque, Rapporteur* (Indian Agricultural Research Institute)

One participant asked that, assuming that high risk was involved in the export of coffee and cocoa due to price fluctuations and exchange rate variations, could we explore the possibility of farmers and government sharing the risk? The authors replied that exploring such a possibility was needed.

Another participant asked if the inclusion of transaction costs would influence the results of the study in a significant manner? The authors felt that transaction costs could be included in the optimal hedging plan and the implications studied.

Participants in the discussion included G.C.W. Ames and S.K. Ehui.