THE EFFECTS OF TRANSACTION COSTS ON THE OPTIMAL PRICE AND PRODUCTION RISK MANAGEMENT FOR COCOA-EXPORTING COUNTRIES

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ABSTRACT

This paper derives and estimates empirically the role of transactions costs for the optimal price-risk hedge ratios for four cocoa producing SSA countries (Cameroon, Ghana, Nigeria and Cote d'Ivoire). Using monthly data from 1966 to 2009, transaction costs are introduced in two commonly used approaches for finding optimal hedge ratios under both price and production risk; the mean-variance approach and the logarithmic utility based approach. For the mean variance the optimal hedge ratios for cocoa are around 0.93 and 1.0 for all countries and different transaction costs and levels of risk aversion. For the logarithmic utility approach, which is supposed to be a more realistic approach

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the hedge ratios are lower than unity, differ more across countries and are reduced by higher transaction costs. Therefore developing appropriate market regulations where transaction cost on intermediaries are kept to minimal is relevant for these countries.

Keywords: Futures markets, optimal hedge ratio, cocoa.

JEL Classification: G13, C52, Q11

INTRODUCTION

The effects of revenue flow limitations from commodity export price uncertainty continue to be a feature in the development economics literature, as seen in examples like Funke et al. (2008), Malone (2005), Larson et al. (2004) and Ramey and Ramey (1995). Some researchers see uncertainty in commodity export revenue due to export price volatility as responsible for the deterioration of the distribution of income and as a factor that increases the likelihood of default on sovereign debt among commodity exporting countries (see IMF (2003), Prem Notes (1999) and Larson et al. (1998)). Evidence are abound in the literature how risk management is a challenge and an almost out-of-control task for developing countries due to the uncertainties in production and prices (see Gilbert (1999), Crouhy et al., (2000), Jorion (2006), Hillson (2007), Rejda (2008), and Kotler and Calione (2009)).

For commodity-exporting countries in Sub-Saharan Africa (SSA), for which the revenues of a few primary agricultural products represent a substantial portion of total government income, volatilities in prices could compromise the public balances of these governments and destabilize the economies. These countries commodity production and trade directly affects the livelihood of millions of people, the governments' fiscal revenues and public expenditures, as well as the country's trade balance, foreign reserves and the strength of their local currencies.

For instance Ghana, Cote d'Ivoire, Nigeria and Cameroon together account for seventy percent of world cocoa beans exports (Gibson, 2007). Furthermore, until recently when Ghana strike oil, a third of the total Ghanaian export revenue and almost half of Cote d'Ivoire export's revenue originated from cocoa exports. Cocoa prices move with cycles in growth rates, capital stock, real exchange rates, terms of trade, cocoa production, and output (Bogetic et al., 2007). At a more disaggregated level, the risks being faced by these individual countries can be reduced by using available market instruments. It is in this context that an optimal hedge via the futures markets can play an important role, which in turn may also have stabilizing effects on the economy.

In a pioneering paper, Rolfo (1980) analyzed hedging ratios for cocoa-exporting countries subject to both price and quantity uncertainties. Rolfo (1980) derived the joint optimal and output risk hedge ratios, under both logarithmic and quadratic utility functions, for Cote d'Ivoire, Ghana, Nigeria and Brazil. He found that a minimal use of futures markets or no hedging at all would be superior to a full hedge. A potential limitation of Rolfo's work is that it ignores transaction costs. In the finance literature, transaction costs are often considered to be negligible because markets are usually highly competitive and actual costs are seen as small in comparison to the costs of the assets traded. Hedging costs, typically dismissed in hedging models for being seemingly negligible, can be important determinants of hedging behavior as suggested by Lence (1996). Armah (2008), following Lence (1996), used a constant relative risk aversion (CRRA) utility function, incorporated transaction costs in the optimal hedge ratio for Cocoa producers in Ghana but restricted his investigation to price risk only. He concluded that transactions costs decrease the optimal hedge ratio and do not seem to affect the hedge ratio until it reaches high levels. According to Armah (2008) the combination of high transaction costs and high alternative investments decrease optimal hedging ratios drastically.

In this paper, we introduce transaction costs into the models developed by Rolfo (1980) in order to derive and estimate empirically the cocoa price risk optimal hedge ratios for Cameroon, Ghana, Nigeria and Cote d'Ivoire. In this way we are able to analyse the potential importance of transaction costs for optimal hedge ratios under the presence of volatile prices and output. We presume that the estimates from models that account for transaction cost better reflect reality than those that do not.

REVIEW OF THE LITERATURE

Most of the literature focuses on the mean-variance framework to estimate hedge ratios that minimizes risk measured by the variance. The approach is often used because it is relatively simple and easy to compute. The approach originates from Johnson (1960), which was extended to financial futures by Ederington (1979) and later adopted in a variety of contexts by many other scholars, such as Brown (1985), Bond et al. (1987) and Myers and Thompson (1989). However, some researchers are of the view that, the assumption that all investors seek to minimize risk is not realistic because weakly risk-averse investors would adopt hedge ratios that differ from those by strongly risk-averse investors. This position is recognized in the literature and addressed by Stein (1961), Peck (1975), Rolfo (1980), Kahl (1983), and Cicchetti et al. (1988).

Therefore, in order to circumvent the deficiencies associated with the risk minimization hedging, other researchers have resorted to utility functions. This approach allows hedgers to find the hedge ratio that maximizes utility, not merely the hedge ratio that minimizes risk (Kolb and Okunev, 1993). Utility maximization hedging strategies require the specification of a utility function, and the most commonly proposed utility functions have been quadratic, logarithmic, and exponential functions. No matter what type of function is chosen, there is always the concern that the proposed function will not accurately describe the preferences of the hedgers. Benninga et al. (1984) demonstrated the conditions under which the minimum variance hedge would also be consistent with the expected utility-maximizing hedge ratios. According to Benninga et al. (1984), there is no reason to believe that utility will be maximized when the variance of the spot minus futures position is minimized.

Tomek (1987) argues that hedge ratios are overestimated due to the omittance of important costs such as yield risk and transaction costs from the farmers' objective function. Lence (1995, 1996) derived the optimal hedge ratio when transaction costs and investments in other securities were also incorporated in the model. Using a Constant Absolute Risk Aversion (CARA) utility function, Lence found that under certain circumstances, the optimal hedge ratio is zero; that is, the optimal hedging strategy is not to hedge at all.

For cocoa producing countries Rolfo (1980) was the first to estimate optimal hedge ratios. .One important contribution in Rolfo's paper was that he studied uncertainty in both production and prices, which has also been the approach of Chavas and Pope (1982), Lapan and Moschini (1994). Subsequently Sy (1990), instead of using the mean variance approach, adopted the Constant Absolute Risk Aversion (CARA) utility function to investigate the relative costs and benefits from hedging the price and output risks of cocoa, coffee and cotton for Cote d'Ivoire. Sy (1990) agrees with Rolfo (1980) in that the hedge ratio for cocoa price risk alone is positive and smaller than unity for March contracts, but disagree with Rolfo when production risk is introduced. Sy (1990) concluded that the effects of production risk on the hedge ratio are not always negative.

Ouattara et al. (1990) used the mean variance approach and investigated the hypothesis of using futures markets to hedge against revenue risk by the Cote d'Ivoire Marketing Board's for Coffee Export. Using data from New York Coffee, Sugar and Cocoa Exchange (CSCE) for the period 1973/74 to 1986/87 crop seasons, they concluded that Cote d'Ivoire could reduce revenue risk if they hedged more than 100 percent of their production. Different from Rolfo, Ouattara et al. (1990) came out with different hedge horizon. They used the futures forecast prices in May on the last trading day of October and the futures prices at expiration in the May futures reported on the first trading day of May.

METHODOLOGICAL FRAMEWORK

The basic framework is portfolio analysis, which we hypothesize by the assumption that utility is a function of mean and variance. This is the same assumption as in Peck (1975), Rutledge (1972) and Rolfo (1980). We narrow the innovation of the model to transaction cost (brokerage fee) only since there is no signs of a significant risk premium in the cocoa futures market (Ohemeng, Sjö and Danquah, 2012). Our study adopts both the minimum variance and the utility maximization techniques similar to Rolfo (1980) since we investigate four different marketing boards (countries) in the SSA and each of these boards might have different risk utility. Both models include transaction costs, a risk-aversion parameter in the hedge ratio formula as well as the producer' expectations of futures prices movements.

Consider a cocoa exporting producing country that faces both price and quantity risk on her production. Assume that the cocoa producing country is subject to output uncertainty from such unexpected factors as pest and disease infection or bad climatic conditions between the time the production decision is made and the beginning of the marketing season. The uncertainty is captured by the standard error of estimates based on historical data. In order for the uncertainty axiom to be effective, we assume that there is no buffer stock or that the yearly variations in stocks are not significant.

Following Rolfo (1980), the basic model consists of a risk-averse cocoa exporting country with a constant absolute risk aversion (CARA) utility function, $U(.)$, $U'>0$ and $U''<0$ whose arguments are a function of expected wealth and variance of wealth. Constrained by their landholdings and their credit lines SSA cocoa producers choose futures holdings to maximize the expected utility of their income. In line with Armah (2008), and contrary to Rolfo (1980), the hedge horizon is identified as pre-harvest (July) to harvest (December) in conformity to realism. At the pre-harvest, that is ex-ante ($t = 0$), the decision maker engages in an activity that produces $Q \geq 0$ random commodity for sale at harvest, that is ex-post ($t = 1$), at the random price S_p, so that in the absence of hedging, the decision maker's income will be QS_p The cocoa exporting country can hedge her inventory, since there exists futures markets for the product. At the pre-harvest ($t = 0$), she can as well sell n commodity units in the futures markets at price f and at harvest future price $F_{p.}$ The net cash flow from the futures transaction occurs at the end of the contract, at which time the producer must pay a transaction fee of T dollars per commodity unit. The pre-harvest distributions of price and quantity are empirically determined and are based on the difference between a price forecast before harvest and the realized price. Holding n futures contracts enables the decision maker's end-of-period wealth distribution to be specified as:

$$W = S_p Q + n(f - F_n - T), \tag{1}$$

where is the production distribution and f is the futures price that is quoted before the harvest ($t = 0$)[1]. MVHs will usually be inconsistent with expected-utility maximization. However, Benninga et al. (1983), demonstrated that under certain conditions MVHs are also expected-utility, that is, maximization hedge ratios. The conditions assumed by Benninga et al. (1983) are as follows:

1 Futures prices are determined according to individual preferences and risk aversion in a market equilibrium setting.

i. the decision maker is prohibited to borrow, lend, or invest in alternative activities;
ii. there are neither initial margin deposits nor futures brokerage fees;
iii. production is deterministic;
iv. random cash prices can be expressed as a linear function of futures prices plus an independent error term; and
v. current futures are unbiased.

In order to accommodate more realism in the estimation of the MVH, two of these standard assumptions made by Benninga et al. (1983) are relaxed. Thus, there is a transaction costs or futures brokerage fee of T dollars per commodity unit and production Q is assumed to be non-deterministic. The objective function of the mean variance framework assumes that the Boards' expected utility is a function of expected income and variance of income. This can be expressed as:

$$E(U) = E(W) - \lambda Var(W) \tag{2}$$

where *E(.)* denotes the expected value operator, *W* is the end-of-period wealth position and λ is the risk parameter of the Board. Regardless of the utility function and distribution of incomes, the maximization of mean-variance objective function may provide a reasonable approximation to the maximization of the true objective function (Levy and Markowitz, 1979). Writing out the variance of income in full gives:

$$Var(W) = Var(S_pQ) + n^2Var(f - F_p - T) + 2nCov[S_pQ, (f - F_p - T)]. \tag{3}$$

The three terms in the variance equation (3) are the variance from the crop, the variance from futures, and the covariance of crop and futures.

The transaction cost is normalized by the initial futures price f as defined as $\delta = {}^{T}/_{f}$[2]. The normalization is necessary because T is the brokerage per contract so normalizing by the initial futures price removes inflationary effects. To determine the optimal hedge n^* we first solve for the first-order condition ${}^{\partial E(U)}/_{\partial n} = 0$:

$$0 = E[S_pQ + n(f - F_p - f\delta)] - \lambda Var(S_pQ) - n^2\lambda Var(f - F_p - f\delta)$$
$$- 2n\lambda Cov[S_pQ(f - F_p - f\delta)],$$

$$n^* = \frac{Cov(S_pQ, F_p) + Cov(S_pQ, f\delta)}{Var(F_p + f\delta)} - \frac{f - E(F_p) - fE(\delta)}{2\lambda Var(F_p - f\delta)}. \tag{4}$$

The first part of the MVHs optimal hedge is proportional to the covariance between revenue and futures price and covariance between revenue and the transactional cost.

2 The values of $({}^{T}/_{f})$ to be used in this study are representative of typical brokerage fees for agricultural commodities such as oats, barley, corn, wheat, and soybeans.

The second part is proportional to the bias in the futures prices and indirectly to the risk of aversion. This represents a pure speculation position according to Ouattara et al. (1990), that is, the difference between the future price and the expected futures spot price after taking into consideration the expected brokerage fees.

Three price series are used at the same time in the investigation. Similar to Rolfo (1980), pre-harvest price date is chosen as on the closing prices of the last day of July (futures date), the harvest price date as the closing prices on the first Friday of December (futures at settlement date) while the shipment prices dated on the last day of December (spot prices). Comparing the variances of cash and futures, the forecast errors are derived by;

$$eS_p(t) = \frac{S_p(t) - f(t)}{f(t)}, \quad t = 1, \ldots, 43 \tag{5}$$

and

$$F_p(t) = \frac{F_p(t) - f(t)}{f(t)}, \quad t = 1, \ldots, 43 \tag{6}$$

where $f(t)$ is the price forecast as at the pre-harvest, $S_p(t)$ the shipment price or the spot price, and $F_p(t)$ the futures price at settlement.

The estimation of production uncertainty is derived by similar procedure as that of the price forecast. That is the variance between the last forecast available at the pre-harvest and the actual production at the harvest and this is calculated for each country. The forecasts are assumed to incorporate all available information before harvest as at the last day of July. Let the forecasted output of individual country for the season be $Q^e(t)$ and the realized output be $Q(t)$. Output variability is measured by the forecast error $e^Q(t)$, defined as the difference between realized and forecast production divided by forecast production;

$$e^Q(t) = \frac{Q(t) - Q^e(t)}{Q^e(t)}, \quad t = 1, \ldots, 43.[3] \tag{7}$$

The mean variance hypothesis

Deriving $S_p = f(1 + eS_p)$, $Q = Q^e(1 + e^Q)$ and $F_p = f(1 + eF_p)$ from equations (5), (6), and (7) respectively and substituting them into the optimal hedge ratio in equation (4) to derive individual country's mean-variance framework as;

$$\frac{n_i^*}{Q^e} = \frac{Cov[(1+eS_p)(1+e^Q), eF_p] + Cov[(1+eS_p)(1+e^Q), \delta]}{Var(eF_p+\delta)} - \frac{E(eF_p+\delta)}{2\lambda f Q_i^e Var(eF_p+\delta)}. \tag{8}$$

In Equation (8) the optimal hedge ratio $\left(\frac{n_1^*}{Q^e}\right)$ is an explicit function of the quantity and price distributions, transaction costs and of the output forecast.

3 Time t varies from 1 for the seasons 1966 to 43 for 2009.

The logarithmic (Bernoulli) utility function

Though the mean-variance approach is popular in the finance literature it is not always the best way to describe expected utility from hedging. According to Chen et al (2003), the mean-variance framework is not consistent with the expected utility maximization principle unless either the utility function is quadratic or the returns are jointly normally distributed. Therefore, in order to make the hedge ratio consistent with the expected utility maximization principle, we need to derive a hedge ratio that produces results consistent with the expected utility.

Following Rolfo (1980) we can derive a hedge ratio that maximizes the expected utility where the utility function is assumed to be the logarithmic of terminal wealth. Unlike the mean-variance framework which requires restrictive assumptions (example CARA), the logarithmic utility function allows for the more realistic assumption of decreasing absolute risk aversion and constant relative risk aversion. Both of these preference structures have been criticized as unrealistic. They are, however, tractable and easy to compute. The optimal holding of futures contracts, and which now incorporates transaction costs is defined by;

$$E\left[\frac{F_p-f-T}{S_pQ+n_1^*(f-F_p-T)}\right]=0. \tag{9}$$

Drawing from Equations (5), (6), (7) and substituting into Equation (9) provides the optimal hedge for a representative SSA country with a logarithmic utility function as;

$$E\left[\frac{eF_p-\delta}{(1+eS_p)(1+e^Q)-\frac{n_1^*}{Q^e}(eF_p+\delta)}\right]=0. \tag{10}$$

In order to estimate $\frac{n_i^*}{Q_i^e}$ it is assumed that the set of observations $[eS_p(t), eF_p(t), e_i^Q(t)]$ for t = 1,…,43, are independently drawn from the distributions (eS_p, eF_p, e_i^Q), respectively. Equation (10) then approximates to;

$$\sum_{t=1}^{43}\frac{eF_p-\delta}{\left\{[1+eS_p(t)][1+e^Q(t)]-[eF_p(t)+\delta]\frac{n_i^*}{Q_i^e}\right\}}=0. \tag{11}$$

DATA AND ESTIMATION

The basic data on cocoa yields both forecasted and realized come from International Cocoa Organization (ICCO), while the cash and futures data are obtained from Coffee, Sugar and Cocoa Exchange (CSCE) for the period January 3, 1966 to August 21, 2009. The before harvest date is selected on the last day of July futures contract while the harvest date is selected as the closing prices on the first Friday of December for the December futures contracts. We also selected the shipment prices on the last day of December. The 5-month July-December hedge horizon for our analysis was identified based on the smallest comparing evidence of variances of cash and futures prices for different horizon.

Production and revenues

Table 1 shows the summary statistics of cocoa futures and spot prices as well as the corresponding forecasted returns. The theory of storage suggests that futures and spot prices do not converge at maturity, that is, the futures prices are particularly lower. It is striking to note that overall cocoa futures prices tend to underestimate both the futures prices at settlement and the spot price by 6.75 percent and 6.24 percent respectively on averages. On the contrary, the mean returns of the cash price outperform the futures prices by 54.51 percent. Cash and futures returns have negative skewness implying the distributions have a long left tail. The Jarque-Bera test of normality rejects the null hypotheses of normal distributions at 5 percent for cash and futures returns. As is well known, the returns on financial returns often deviate from a normal distribution, display skewness and have “fat tails”. Table 1 shows that this is also true of cocoa, cocoa futures returns are negatively skewed. In addition, the commodity displays relatively high kurtosis indicating more realizations in the tails than would be expected based on a normal distribution.

Table 1: Summary statistics for cash and futures prices

	Futures prices	**Forecast error on futures**	**Cash price**	**Forecast error on cash**
Mean	3703.63	0.0073	3453.54	0.0161
Median	1885.00	0.0064	1969.00	0.0015
Maximum	24200	0.6762	17880	0.5998
Minimum	816	-0.8154	703	-0.8177
Std. Dev.	4692.45	0.2458	4229.04	0.2441
Skewness	2.6705	-0.0162	2.4248	-0.1837
Kurtosis	10.4542	5.7794	7.7634	5.6082
Jarque-Bera	150.66	13.8422	82.7924	12.4304
Observation	43	43	43	43

Source: CSCE and author’s computations

This confirms Roumasset (1979) assertion that the distribution of the yield of agriculture products deviate substantially from normality and, specifically, fertilizer is probably the main contributing factor in explaining the skewness or the deviations in conformity to the farmers’ actual behavior. This implies that any model assuming a normal distribution of income will be at best impractical. The results contradict those of Armah (2008) which could not reject normality for the cash and futures returns.

Correlation between cash and futures prices

Table 2 displays the variance-covariance and correlation matrix of cash and futures returns. The data show high correlation between cash and futures returns as envisaged (0.9783), however the covariance between the variables is low (0.0573).

From the variance-covariance matrix, the variance for the futures returns is 0.059025; therefore, the mean variance hypothesis hedge is therefore approximately equal to 0.057328/0.059025 = 0.9712494.

Table 2: Correlation and covariance of cocoa futures and cash returns

Correlation	**Cocoa futures returns**	**Cocoa cash returns**
Cocoa futures returns	1	0.9783
Cocoa cash returns	0.9783	1
Covariance		
Cocoa futures returns	0.0590	0.0573
Cocoa cash returns	0.0573	0.0582

Source: CSCE and author's computations

Correlation matrix of production uncertainty

Table 3 reports the variance-covariance matrix of production uncertainty between producing countries. The data displays some correlation among these uncertainties. The correlation coefficients of -0.34 between Ghana and Cameroon, 0.23 between Ghana and Cote d'Ivoire and -0.21 between Nigeria and Cameroon, indicate a weak correlation between countries within the same climatic region. It is generally expected that countries within the same region would observe common characteristics in terms of climatic condition, common farming practice and others and hence have strong correlation coefficients.

The fact that the correlation is not stronger is likely due to the supply of cocoa beans being a function of not only climatic conditions but also on the new land under cultivation, the yield patterns of the cocoa tree itself, pest and disease control as well as collective attention extended to the farms. It is also important to note that the common cocoa diseases affecting countries within the study area emanate from virus which can be controlled by constant weeding and spraying collectively or individual farms and it should be timely. This confirms the fact that the factors explaining the uncertainty of cocoa production are to a large extent country specific. Therefore the correlation is relatively weak between the measured production uncertainties across the countries. The results are different to those of Rolfo (1980) who founds that production uncertainties were more strongly correlated within the West African region.

Table 3: Variance-covariance and correlation matrix of production uncertainty in cocoa

	Cameroon	**Ghana**	**Nigeria**	**Cote d'Ivoire**
Cameroon	0.00548*	-0.00288	-0.00183	0.00051
	1.00000†	-0.34290	-0.20697	0.06557
Ghana	-0.00288	0.01284	0.00210	0.00269
	-0.34290	1.00000	0.15447	0.22790
Nigeria	-0.00183	0.00210	0.01432	-0.00030
	-0.20697	0.15447	1.00000	-0.02370
Cote d'Ivoire	0.00051	0.00269	-0.00030	0.01081
	0.06557	0.22790	-0.02370	1.00000

Source: ICCO and author's computations

*Variance-covariance
†Correlation

Correlation matrix between production uncertainties and price uncertainties

The correlation between production and price uncertainties is close to zero within countries. There is a weak negative correlation between production and prices, except for Nigeria where there is a positive sign. This is so because farmers on their own cannot influence prices, hence farmers expect output to be correlated with the output of all farmers. The lack of a strong negative correlation between prices and output stresses that the two factors need to be considered in a joint hedging model.

Table 4 below reports the covariances and correlations between production errors and price uncertainty. The model assumes silently that supply is the source of uncertainty and that determines the price. Given that the countries in this study account for about seventy per cent of the world production, one would have expected large and negative correlations, but this is not the case. With the exception of Nigeria, Table 4 reports of low and negative correlation coefficients for the study countries. The results collaborate with the earlier conclusion drawn on Table 3. Thus, factors influencing production uncertainty are country specific, which motivates that hedging and transaction costs should be studied for individual countries.

Table 4: Covariance and correlation between production uncertainty and shipment price uncertainty

	Cameroon	**Ghana**	**Nigeria**	**Cote d'Ivoire**
Covariance	-0.00278	-0.00128	0.00395	-0.00284
Correlation	-0.15573	-0.04672	0.13683	-0.11304

Source: ICCO and author's computations

Correlation between forecast errors on revenues and prices uncertainty

The reports of the correlations between forecast errors on revenues[3] for each country and prices uncertainty for market of actual are shown in Table 5 below. The result shows a strong positive correlation between the revenue uncertainty and price uncertainty; approximately 0.9 for all the four countries. The highest correlation between revenue and price uncertainties stands in the name of Cameroon, whiles the lowest is registered by Nigeria. This presents us with the pictures of the extent to which these countries depend on the commodity.

Table 5: Correlation matrix between forecast errors on revenues and prices uncertainty

	Cameroon	**Ghana**	**Nigeria**	**Cote d'Ivoire**	**Price**
Cameroon	1.00000	0.78896	0.79897	0.81139	0.93870
Ghana	0.78896	1.00000	0.85034	0.86805	0.90088
Nigeria	0.79897	0.85034	1.00000	0.81806	0.89396
Cote d'Ivoire	0.81139	0.86805	0.81806	1.00000	0.91806
Price	0.93870	0.90088	0.89396	0.91806	1.00000

Source: CSCE, ICCO and author's computations

The results imply that higher prices tend to be related to higher country revenues and vice-visa irrespective of the difference between realized and forecasted output. The results explain the earlier assertion of heterogeneity in factors affecting production error correlation among the countries. As explained earlier, it is expected that the co-movements of production would have had significant influence on the prices since the four countries accounts for more than 70 percent of the world output. Their total production together would have had signified lower correlation between revenue and price uncertainties. But contrary to the a priori information, the regional revenues uncertainty are strongly correlated with the other country's output uncertainty within

3 The revenue error is calculated as the sum of the quantity, the actual price errors and their cross-product.

the region. The highest correlation is between Ghana and Cote d'Ivoire (0.87) who incidentally share common boarder and are the two leading producers in the world.

The optimal hedge ratios

Finally, we present the findings for the hedge ratios for a mean variance representation and the logarithmic utility function.

In order to assess the impact of the brokerage fees, ratios of brokerage fees to current futures prices (δ) are initially set to zero and increased slightly and gradually to 0.005, 0.01, 0.02, 0.03, 0.04, 0.05, 0.1, 0.2 and 0.5. With the assumed constant absolute risk aversion (CARA) of the MVH and following Rolfo (1980) we proceeded with the simulations of the four producing countries for values of the risk aversion parameter (λ) between infinity and 0.00001. Using the definition of Lence (1996), risk aversion parameters of 0.0001, 0.0001, 0.001, 0.01, 0.1 and 1 are considered to be low; values $1 < \lambda < 9$ are considered to be moderate and values of 10 and above are considered to be extremely high. Results for λ=10 reflect implausibly high risk aversion (Levy and Markowitz, 1979). These exceptionally high risk aversion parameters are presented for completeness rather than realism and should therefore be interpreted with care.

As per the correlations between price and quantity distributions (Cameroon -0.15573, Ghana -0.04672, Nigeria 0.13683 and Cote d'Ivoire -0.11304) it is not surprising therefore to notice that the hedge ratios for these countries are large. When price and quantity distributions are statistically independent, a mean variance model according to McKinnon (1967) means an optimal hedge ratio of one. Table 6 reports the optimal hedge ratios of the four study countries. The range of which the hedge ratios are displayed for all the countries are by far higher than that exhibited by Rolfo's (1980) and Armah's (2008). For risk aversion parameter $\lambda = \infty$ the second term of equation (8) turns to zero, and the hedge ratios for the respective countries when the brokerage fees are set from zero to 0.5 are as follows: Cameroon 0.9397, Ghana 0.9765, Nigeria 1.0143 and Cote d'Ivoire 0.9367.

What comes out of Table 6 is that the commodity hedge ratios are close to unity (0.9136 to 1.0155) and that the ratios changes very slightly across various values of risk aversion and brokerage fees.

Table 6: Optimal hedge mean variance hypothesis

Risk aversion parameter (λ)	**Brokerage Fees (δ)**	**Cameroon**	**Ghana**	**Nigeria**	**Cote d'Ivoire**
	0				
0.00001		0.9390	0.9668	1.0141	0.9355
0.0001		0.9396	0.9675	1.0143	0.9360
0.001		0.9397	0.9734	1.0143	0.9364
0.01		0.9397	0.9735	1.0143	0.9366
0.1		0.9397	0.9736	1.0143	0.9367
1		0.9397	0.9736	1.0143	0.9367
10		0.9397	0.9736	1.0143	0.9367
100		0.9397	0.9736	1.0143	0.9367
1000		0.9397	0.9736	1.0143	0.9367
∞		0.9397	0.9765	1.0143	0.9367
	0.005				
0.00001		0.9388	0.9664	1.0139	0.9353
0.0001		0.9395	0.9672	1.0140	0.9359
0.001		0.9395	0.9733	1.0143	0.9363
0.01		0.9396	0.9735	1.0143	0.9365
0.1		0.9397	0.9736	1.0143	0.9367
1		0.9397	0.9736	1.0143	0.9367
10		0.9397	0.9736	1.0143	0.9367
100		0.9397	0.9736	1.0143	0.9367
1000		0.9397	0.9736	1.0143	0.9367
∞		0.9397	0.9765	1.0143	0.9367
	0.01				
0.00001		0.9386	0.9661	1.0135	0.934
0.0001		0.9394	0.9669	1.0140	0.9356
0.001		0.9394	0.9732	1.0143	0.9362
0.01		0.9396	0.9735	1.0143	0.9365
0.1		0.9397	0.9736	1.0143	0.9367
1		0.9397	0.9736	1.0143	0.9367
10		0.9397	0.9736	1.0143	0.9367
100		0.9397	0.9736	1.0143	0.9367
1000		0.9397	0.9736	1.0143	0.9367

∞		0.9397	0.9765	1.0143	0.9367
	0.02				
0.00001		0.9384	0.9660	1.0134	0.9346
0.0001		0.9391	0.9667	1.0142	0.9354
0.001		0.9393	0.9732	1.0143	0.9360
0.01		0.9395	0.9734	1.0143	0.9363
0.1		0.9397	0.9735	1.0143	0.9366
1		0.9397	0.9736	1.0143	0.9367
10		0.9397	0.9736	1.0143	0.9367
100		0.9397	0.9736	1.0143	0.9367
1000		0.9397	0.9736	1.0143	0.9367
∞		0.9397	0.9765	1.0143	0.9367
	0.03				
0.00001		0.9379	0.9659	1.0133	0.934
0.0001		0.9388	0.9665	1.0142	0.9351
0.001		0.9389	0.9729	1.0143	0.9359
0.01		0.9394	0.9734	1.0143	0.9364
0.1		0.9396	0.9735	1.0143	0.9366
1		0.9397	0.9736	1.0143	0.9367
10		0.9397	0.9736	1.0143	0.9367
100		0.9397	0.9736	1.0143	0.9367
1000		0.9397	0.9736	1.0143	0.9367
∞		0.9397	0.9765	1.0143	0.9367
	0.04				
0.00001		0.9378	0.9658	1.0132	0.9340
0.0001		0.9386	0.9663	1.0142	0.9348
0.001		0.9388	0.9727	1.0143	0.9354
0.01		0.9390	0.9733	1.0143	0.9357
0.1		0.9396	0.9737	1.0143	0.9360
1		0.9397	0.9736	1.0143	0.9367
10		0.9397	0.9736	1.0143	0.9367
100		0.9397	0.9736	1.0143	0.9367
1000		0.9397	0.9736	1.0143	0.9367
∞		0.9397	0.9765	1.0143	0.9367
	0.05				
0.00001		0.9374	0.9656	1.0132	0.9338

0.0001		0.9379	0.9660	1.0143	0.9346
0.001		0.9385	0.9726	1.0143	0.9350
0.01		0.9389	0.9733	1.0143	0.9352
0.1		0.9395	0.9737	1.0143	0.9358
1		0.9397	0.9736	1.0143	0.9367
10		0.9397	0.9736	1.0143	0.9367
100		0.9397	0.9736	1.0143	0.9367
1000		0.9397	0.9736	1.0143	0.9367
∞		0.9397	0.9765	1.0143	0.9367
	0.1				
0.00001		0.9367	0.9654	1.0132	0.9328
0.0001		0.9377	0.9659	1.0143	0.9333
0.001		0.9383	0.9726	1.0143	0.9337
0.01		0.9388	0.9732	1.0143	0.9349
0.1		0.9393	0.9736	1.0143	0.9353
1		0.9397	0.9736	1.0143	0.9367
10		0.9397	0.9736	1.0143	0.9367
100		0.9397	0.9736	1.0143	0.9367
1000		0.9397	0.9736	1.0143	0.9367
∞		0.9397	0.9765	1.0143	0.9367
	0.2				
0.00001		0.9340	0.9652	1.0132	0.9258
0.0001		0.9361	0.9657	1.0143	0.9269
0.001		0.9374	0.9724	1.0143	0.9285
0.01		0.9387	0.9731	1.0143	0.9344
0.1		0.9391	0.9736	1.0143	0.9351
1		0.9397	0.9736	1.0143	0.9367
10		0.9397	0.9736	1.0143	0.9367
100		0.9397	0.9736	1.0143	0.9367
1000		0.9397	0.9736	1.0143	0.9367
∞		0.9397	0.9765	1.0143	0.9367
	0.5				
0.00001		0.9201	0.9650	1.0130	0.9136
0.0001		0.9206	0.9654	1.0141	0.9168
0.001		0.9242	0.9723	1.0142	0.9205
0.01		0.9338	0.9730	1.0143	0.9302

0.1		0.9343	0.9736	1.0143	0.9344
1		0.9397	0.9736	1.0143	0.9367
10		0.9397	0.9736	1.0143	0.9367
100		0.9397	0.9736	1.0143	0.9367
1000		0.9397	0.9765	1.0143	0.9367
∞		0.9397	0.9765	1.0143	0.9367

Source: Author's computations

Rolfo found much lower hedge ratios. Without transaction costs and for standard values for risk aversion, Rolfo found hedge ratios around 0.609 (Ghana), 0.654 (Nigeria) and 0,778 (Cote d'Ivoire). Our results indicate that transaction costs matter.

The logarithmic utility function

The proportion of the expected output to be hedged $(\frac{n_1^*}{Q^e})$ for a cocoa producer with a logarithmic utility function confronted with both price and output uncertainty is a solution of equation (11). A MATLAB software program is used to solve equation (11), and as before the simulations are executed for various transaction costs (brokerage fees). Table 7 reports the optimal hedge ratios of the logarithmic utility function.

Table 7: Optimal hedge ratio – Logarithmic Utility Function

Brokerage Fees λ	**Cameroon**	**Ghana**	**Nigeria**	**Cote d'Ivoire**
0	0.6601	0.7468	0.8041	0.7355
0.005	0.5385	0.6864	0.7743	0.6453
0.01	0.5086	0.6612	0.7155	0.6381
0.02	0.5044	0.6305	0.7045	0.6236
0.03	0.5019	0.6259	0.7007	0.6150
0.04	0.4998	0.6158	0.6815	0.6034
0.05	0.4879	0.5956	0.6752	0.5938
0.1	0.4860	0.5654	0.6655	0.5828
0.2	0.4646	0.5602	0.6568	0.5758
0.5	0.4205	0.5508	0.6196	0.5536

Source: CSCE, ICCO and author's computations

The hedge ratios in Table 7 are well below unity. It can be seen that the fraction of outputs to be hedged varies with the changing brokerage fees. In other words, a brokerage fee has significant impact on the amount of output to be hedged. As the brokerage fees increased from zero through 0.5, the hedged ratios reduced significantly for all the sampled countries. The results suggest that, for weakly risk aversion investors, hedge ratios tend to increase monotonically as risk aversion level increases. For strongly risk averse investors, the hedge ratios are generally similar.

Again our results differs from Rolfo (1980) who found 0.151 (Ghana), 0.134 (Nigeria) and 0.303 (Cote d'Ivoire). The results confirms the conclusion in Lence (1996) that transaction costs typically dismissed in hedging models for being seemingly negligible are actually important determinants of hedge ratios.

CONCLUSIONS

This paper aims at analyzing futures hedging strategies for SSA cocoa producing countries faced with both price and output risks. The sample data is from 1996 to 2009 for Cameroon, Ghana, Nigeria and Cote d'Ivoire. Our work extends on earlier work by foremost Rolfo (1980) and Armah (2008). To the best of our knowledge, all of the derivations of the optimal hedge ratios under both price and output risks do not incorporate transaction costs. We anticipated that relaxing these conventional assumption may produce hedge ratio that may be quite different from the one obtained from the conventional assumptions. This research therefore evaluates the effect of incorporating transactions cost into the hedge ratio for cocoa producing countries that are confronted with uncertainty in both the price and the output.

The optimal hedge ratios prescribed in this study show no significant differences among the countries. For the mean variance approach hedge ratios are close to unity. Using the assumed more realistic logarithmic utility function leads to clearly lower (below unity) ratios. In comparison with earlier published results, the results in this study suggest that transaction costs are important in that they change the level of the hedging ratios under both the mean-variance and logarithmic utility frameworks. Also, for the logarithmic utility function, higher levels of transactions cost play a nontrivial role in hedge ratios selection. Therefore developing appropriate market regulations where transaction cost on intermediaries are kept to minimal is relevant for these countries.

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