WPS 1328

POLICY RESEARCH WORKING PAPER 1328

The Use of New York Cotton Futures Contracts to Hedge Cotton Price Risk in Developing Countries

New York cotton futures and options contracts provide an effective way to reduce cotton price volatility, despite relatively high basis risk.

Panos Varangis
Elton Thigpen
Sudhakar Satyanarayan

The World Bank
International Economics Department
International Trade Division
July 1994

Summary findings

Cotton exports account for a significant share of commodity exports for some developing countries, especially in West Africa and Central Asia. In these countries, dependency on cotton for export revenues has increased in the past 20 years. These countries therefore have a high exposure to cotton price volatility.

Cotton-producing developing countries and economies in transition make little use of hedging mechanisms to reduce their risk from the volatility of cotton export revenues. Countries in Francophone West Africa use forward sales to hedge but only for a small share of the crop.

These countries could use cotton futures and options contracts to hedge against short- to medium-term price volatility, making cotton export revenues more predictable. Cotton futures and options contracts could also make cotton-related commercial transactions more flexible. (Futures could be sold when there are no buyers in the physical market, for example.) In West Africa, futures and options could complement the existing system of forward sales.

Varangis, Thigpen, and Satyanarayan examine the feasibility of using New York cotton futures and options contracts as hedging instruments. They base their analysis on a portfolio selection problem in which the hedger selects the optimal proportions of unhedged and hedged output to minimize risk.

The results suggest that despite the existence of relatively high basis risk (that is, a relatively low correlation between spot and future prices), hedging reduces cotton price volatility by 30 to 70 percent.

Moreover, for all varieties of cotton examined, the hedge ratio (the percentage of exports hedged) was below one. Using a hedge ratio of one (naive hedge), at times, increases rather than decreases risk.

The results also show that hedging, while reducing risk, also reduces expected returns. Attitudes toward risk — that is, the degree of risk aversion — determine how much of this risk-return tradeoff is acceptable. For a risk-averse agent, the main benefit of hedging lies in risk reduction rather than in the potential for increased returns.

This paper — a product of the International Trade Division, International Economics Department — is part of a larger effort in the department to examine the benefits of using market-based risk management instruments in developing countries and economies in transition. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Dawn Gustafson, room R2-092, extension 33714 (28 pages). July 1994.

THE USE OF N.Y. COTTON FUTURES CONTRACTS TO HEDGE COTTON PRICE RISK IN DEVELOPING COUNTRIES

by

Panos Varangis, Elton Thigpen and Sudhakar Satyanarayan

International Trade Division
The World Bank

Washington, D.C.

New York Cotton futures/options contracts provide an effective way to reduce cotton price volatility, despite the existence of relatively high basis risk.

INTRODUCTION *

Cotton is an important crop for many developing countries. Table 1 shows the share of cotton in total agricultural exports for major cotton producing countries. The countries with the highest reliance are in Francophone Africa (FPA). In Benin and Burkino Faso, for example, cotton accounts for about two-thirds of agricultural export revenues.[1] Other countries in which cotton has a high share in total agricultural exports include the countries in the Former Soviet Union (FSU) and Pakistan. Table 1 also shows that the share of cotton in total agriculture exports has increased for many countries/regions over the last twenty years. The significant share of cotton in agricultural (and total) exports suggests a high exposure to cotton price volatility. Presently, cotton producing developing countries make very limited use of risk management instruments to hedge this exposure. The main reasons for this are the government intervention that reduces the incentive to hedge (by setting minimum or fixed prices and thus absorb the price risk) and the lack of technical know-how in using risk management instruments.[2] Another reason could be the cost of hedging which is defined in this context as the risk-return trade off.

---

*We would like to thank Ronald Duncan for valuable comments.

[1]See also Satyanarayan, et. al., 1993.

[2]For a detailed discussion on the impediments to the use of risk management instruments in developing countries see Claessens and Varangis (1994).

Table 1: Cotton's Share in Total Agricultural Export Revenues in Selected Countries

	1971	1981	1991
	(%)		
Francophone Africa	7.3	9.7	23.5
FSU	24.2	49.7	46.4
Pakistan	34.2	41.7	40.7
Turkey	18.1	26.9	11.5
China	2.0	1.1	0.7
World	5.1	3.1	2.5

Source: IECIT estimates using data obtained from FAO International Trade Tapes.

The recent marketing liberalization efforts in many cotton producing developing countries are likely to expose participants to market forces and make hedging instruments such as futures and options attractive in reducing intertemporal price volatility. However, even without liberalization, there is scope for using hedging instruments. In most cases where government intervention is prevalent, the government effectively internalizes (assumes) the cotton price risk. For example, governments in China and Uzbekistan and cotton parastatals in Turkey and the FPA countries could make good use of hedging instruments in reducing cotton price volatility. FPA countries use forward sales for this purpose, but this instrument only provides limited coverage (see Satyanaryan, et. al., 1993).

The usual arguments for hedging are that by doing so market participants can increase the predictability of future cash flows, lock-in profit margins, and reduce the price uncertainty of investment projects. Where available, futures and options provide the most efficient way for dealing with short-term (mainly intra-year) price uncertainty. In addition, futures and options contracts can add to the flexibility of selling decisions, for example, by giving flexibility to buyers to "call-in" their purchasing price.[3]

The present paper examines the feasibility of using N.Y. cotton futures contracts to hedge cotton price risk in developing countries. The paper concentrates on five countries/regions. They are: Uzbekistan, Pakistan, China, Turkey and the FPA. These countries/regions were chosen because they account for about 60% of cotton production and 40% of cotton exports from developing countries, and, with the exception of China, cotton exports account for a significant part of agricultural export revenues in each of these countries/regions.[4] The paper is structured as follows: Section I of the paper quantifies the basis risk; i.e., one minus the correlation coefficient between spot cotton prices from

---

[3]For commodity related hedging applications in developing countries see Gemmill (1985), Quattara et. al. (1992), Rolfo (1980), Varangis et. al. (1993), Claessens and Varangis (1993), and Larson (1993).

[4]In 1991 cotton exports accounted for about 24% of total agricultural exports for FPA, 46% for the Central Asian Republics of FSU, 41% for Pakistan, 12% for Turkey, but only 0.7% for China. Overall, for the World, cotton exports account for about 2.5% of total agricultural export revenues.

developing countries and N.Y. cotton futures contract prices.[5] Section II performs simulations to show to what extent cotton price volatility is reduced by using N.Y. cotton futures contracts. The analysis is based on a portfolio selection framework in which hedgers select the optimal proportions of unhedged and hedged output. Section III summarizes and concludes.

---

[5]In general, basis risk measures how closely futures and spot prices move together. A high (low) basis risk means a low (high) correlation between the spot and futures. Basis risk is the unhedgeable part of the spot price risk when using futures contracts to hedge.

I. HEDGING THROUGH NEW YORK COTTON FUTURES

Cotton prices have fluctuated significantly, especially in the latter half of the 1980s. Table 2 shows the average monthly export price, its standard deviation and its coefficient for variation of each of the cottons examined. The coefficient of variation, our measure of volatility, is shown to vary between 17.2% and 21.2%, although the 17.2% for Punjab SG 1505 is for a much shorter time period. Thus, for the cotton prices examined, over the period 1985-92/93, the coefficient of variation is around 20% compared with 17% which is the volatility of the World Bank's commodity price index over the same period.

The only market that trades in cotton futures is the New York Cotton Exchange (NYCE). The New York No. 2 cotton contract is based on grade 41, staple 34 (strict low middling 1-1/16 inch) cotton. The quality of the cottons from the countries covered here is similar (middling 1-3/32 inch) but not identical. Provided that the characteristics of the cash commodity are identical to the quality specified in the futures contract, the traditional recommendation is to hedge all of the cash commodity in the futures market. (This type of a hedge is termed a "direct hedge"). However, in cases where the cash and futures prices are for related but not identical commodities, the appropriateness of the futures contract

Table 2: Cotton Price Volatility

Cotton Type	Period	Average Monthly Export Price	Standard Deviation	Coefficient of Variation a/
		------US¢-------	----US¢----	--------%-------
Central Asian	Aug 85 - Jan 93	66.12	14.05	21.2%
Punjab SG 1505	Aug 88 - Jun 93	69.10	11.77	17.2%
Chinese 329	May 85 - Jan 93	70.14	14.30	20.4%
Turkish Izmirant	Jan 85 - Apr 92	74.99	14.59	19.5%
FPA	May 85 - Jan 93	66.64	12.78	19.2%

a/ Ratio of standard deviation to the mean.

for "cross-hedging" needs to be determined.[6] A simple method, based on price correlation, can be used to determine how closely the cotton futures price and the cotton export prices move together. In general, the higher the correlation the greater the effectiveness of a hedge. Table 3 shows the results of an OLS (Ordinary Least Squares) regression in which (nearby) futures price changes are regressed on cotton cash price changes.[7] The R-square measures indicate that 30-44% of the variance of cash price changes is explained by futures price changes, except for the Turkish cotton for which the R-square is very low (5%). The percentage of the variation in cash price changes which is unexplained (1-R square) is an estimate of the basis risk.[8] Thus, the basis risk is high but this is to be expected because the underlying cash and futures prices are for different grades of cotton, and US policy has to some extent insulated US markets from the world cotton market. A cross-hedge in this situation is still feasible, but the optimal quantity to be hedged as a percentage of the cash commodity

---

[6]A typical cross-hedge in cotton is to hedge the price of one quality by using a futures contract based on a marginally different quality, such as West African Cotlock A index cotton (middling 1-3/32 inch quality) being hedged with a New York number 2 futures contact based on strict low middling 1-1/16 inch quality. The futures contract would be liquidated simultaneously with the sale of the physical cotton.

[7] Note that the OLS regression uses price changes rather than price levels because cash and futures prices of most commodities are non-stationary (Milonas and Vora, 1987). A simple transformation such as using differenced data, as we have done, controls for non-stationarity of prices in levels.

[8]Since options are options on futures contracts, the analysis to determine the basis risk is applicable to the use of options on these futures contracts.

- i.e., the optimal hedge ratio - is less than one and needs to be empirically determined. The optimal hedge ratio will depend upon the hedger's level of risk-aversion. Hedging is rational if the reduction in risk more than compensates for the reduction in returns.

Before a determination of the optimal hedge ratio is made, it is of interest to check the relationship between spot cotton prices and the Cotlook A Index. This is because a recently introduced cotton futures contract based on the Cotlook A index may be a more appropriate hedging instrument than the New York No. 2 futures contract.[9] Table 3 reports the results of regressing Cotlook A Index price changes on spot cotton price changes from developing countries.[10] The R Square indicates that with the exception of the Turkish cotton, 70-85% of the variation in the cotton prices examined is explained by changes in the Cotlook A Index. This reasonably good fit is not surprising given that the spot cotton prices examined are part of the fourteen components of the Cotlook A index. The fact that the cotton prices examined and the Cotlook A index were significantly correlated implies that the Cotlook futures contract may prove a better hedging instrument for these cotton than the New York No.2 cotton futures contract. Moreover,

[9]For the definition of the Cotlook A index see note under Table 1.

[10]We use spot-to-spot regression rather than spot-to-futures because there is not sufficient data on Cotlook A futures prices. We, therefore, assume a close relationship between the Cotlook Index and Cotlook futures contract prices.

Table 3: QUANTIFICATION OF BASIS RISK

Cotton Type	Period	Hedge Ratio	R^2	Basis Risk
Using N.Y. No. 2 Cotton Futures Contract				
Central Asian	Aug 85-Jan 93	.38	.30	.70
Punjab SG 1505	Aug 88-Jan 93	.66	.44	.56
Chinese 329	May 85-Jan 93	.42	.39	.61
Turkish Izmirant	Jan 85-Apr 92	.20	.05	.95
FPA	May 85-Jan 93	.34	.30	.70
Using Cotlook A Index				
Central Asian	Aug 85-Jan 93	.98	.85	.15
Punjab SG 1505	Aug 88-Jan 93	1.01	.73	.27
Chinese 329	May 85-Jan 93	.79	.68	.32
Turkish Izmirant	Jan 85-Apr 92	.39	.34	.66
FPA	May 85-Jan 93	.80	.80	.20

Note: The Cotlook A Index is published daily by Cotlook Limited, a cotton information service in the United Kingdom. The A index is an average of the 5 lower quotes in US¢/lb for cotton being offered in significant quantities from 14 cotton growing regions in 13 producing countries. The Index is based on cotton comparable to middling 1-3/32 inch quality by the "Liverpool" concept, delivered C.I.F. North Europe, cash against documents on arrival of vessel, including profit and agent's commission. The Index is presented as an indication of the competitive level of offering prices.

the New York Cotton Exchange has added additional serial months to the Cotlook World Cotton Futures contract--for which settlement is based on the Cotlook A Index--to increase the trading and hedging opportunities for market users. In addition to the regular cycle months of March, May, August, October, and December, two spot or serial months from the January, February, April, September, and November cycle will also be available. The Exchange anticipates that the addition of rolling spot months will increase the contract's liquidity and afford hedgers and speculators a more viable trading vehicle. However, the present very low level of liquidity of the contract is likely to discourage use of this contract for hedging purposes.

II RISK MINIMIZATION (EX-ANTE RISK-MINIMIZING HEDGES)

We turn now to analyzing the risk management prospects for cottons from selected developing countries. We assume throughout the paper that the objective of the hedger is simply to minimize risk regardless of the risk-reduction tradeoff (i.e., the hedger is highly risk averse).

The cotton hedging decision can be thought of as a portfolio selection problem in which the hedger selects the optimal proportions of unhedged (spot) and hedged (futures) output.[11] The portfolio can then be represented as:

$$ER_p = Q_u\, E(S_{t+1} - S_t) + Q_h\, E(F_{t+1} - F_t) \quad \text{..............(1)}$$

where:

ER_p = Expected return on the hedged portfolio

Q_u = Unhedged output

$E(S_{t+1} - S_t)$ = Expected change in the cotton spot price from time t to time t+1

Q_h = Hedged output

$E(F_{t+1} - F_t)$ = Expected change in the futures price from time t to time t+1

[11] In terms of conventional portfolio theory, hedged output can be thought of as a riskless asset and unhedged output as a risky asset.

Note that $(Q_u + Q_h) = Q_e$, the amount of output available for export. At time period t, the values of S_{t+1} and F_{t+1} are unknown. These are, therefore, random variables. In a hedge, Q_u and Q_h have opposite signs. For instance, in a short hedge, a long position in the spot market ($Q_u > 0$) is offset by a short position in the futures market ($Q_h < 0$). Rewriting equation 1 for a long cash/short futures position we have:

$$ER_p = Q_u \, [\, E(S_{t+1} - S_t) - (Q_h / Q_u)\, E(F_{t+1} - F_t)] \,.........(2)$$

Let $h = (Q_h / Q_u)$. If the value of Q_u is set equal to 1, then h can be interpreted as the hedge ratio - the percentage of the spot or cash position that is hedged in the futures market. Thus,

$$ER_p = E(S_{t+1} - S_t) - h\, E(F_{t+1} - F_t) \,.................(3)$$

If the portfolio is completely hedged, that is, each unit in the spot market is hedged with a unit of futures, then h = 1. (This type of a hedge is called a "naive hedge".) If h = 0, then there is no hedging and the expected return on the portfolio is simply equal to the return on the spot market.

The variance of the portfolio is a measure of the risk of the portfolio. The variance of the portfolio (Var(P)) is given by:

$$Var(P) = Var(S) + h^2\, Var(F) - 2\, h\, cov(S,F) \,............(4)$$

where:

Var(S), Var(F) = variance of spot and futures price changes

cov(S,F) = covariance between spot and futures price changes

Recall that we are assuming that the objective of the cotton producing countries is simply to minimize risk. The problem then is to identify a h, such that Var(P) is minimized. This can be done by differentiating Var(P) with respect to h as follows:

$$\partial \, Var(P) / \partial h = 2 \, h \, Var(F) - 2 \, cov(S,F) = 0$$

Solving for h from the above results in:

$$h^* = cov(S,F) \, / \, Var(F) \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

It can be shown that h^* (the risk-minimizing hedge ratio) is simply the slope coefficient of an OLS linear regression of futures price changes on spot price changes (see Ederington, 1979). h^* signifies how much of the output needs to be hedged in order to minimize risk. A hedge ratio of 1 shows that all output needs to be hedged to achieve risk minimization. Furthermore, for cotton, in order to hedge 50,000 lbs of cotton, one needs to purchase one N.Y. No. 2 cotton futures/options contracts which has an underlying quantity of 50,000 lbs.

For the construction of hedges we need to determine when the hedge is placed and how long it will last. We assume that the hedges are placed during the planting (sowing) season in order to guarantee profits to growers and cover the fixed minimum price offered to growers by the parastal marketing agency or the government. The sowing season for FPA cotton ends around July-August. Thus, we assume that the hedge for FPA cotton is placed in August of each year by buying the July No. 2 contract and lifted at the end of June before the contract expires. The timing of the hedge, therefore, approximately coincides with the cotton season in FPA countries. Hedges for 1987 through 1991 are constructed in this manner.[12] For the other cottons we assume the hedges are placed around the planting season, in April of each year, by buying next year's March contract and lifting it the end of February before the contract expires.[13] Thus, the commitment in the futures market is equal to a period of 11 months from the time the hedge is placed to the time it is lifted. Hedges are constructed for those years for which data are available.

---

[12]The estimated ex-ante, risk-minimizing hedge ratios appear to be very similar for each of these periods. This indicates the robustness of the estimated hedge ratio over the various periods (see Tables 3 through 7).

[13]The results do not change significantly if we pick another month for simulations. Compare, for instance, Table 5 in Satyanarayan et. al. (1993) and Table 7 in this paper. The timing of the hedges for FPA cotton in these tables is different, but the risk-reduction results are quite similar.

The risk-minimizing hedge ratios for each year are calculated by using information available at the time the hedge was placed. Thus, the hedge ratio for the August 1989 hedge for FPA cotton was estimated using data between May 1985 and July 1989; the hedge ratio for the August 1990 hedge was estimated using data between May 1985 and July 1990, and so on. These hedges are thus ex-ante hedges.

Tables 4 through 8 report the estimated risk-minimizing hedge ratios and contrasts the performance of four portfolios - Unhedged, Naive, ex-ante Risk-Minimizing and ex-post - over the life of the hedges. By definition, an ex-post hedge provides the maximum amount of information to the hedger and, as a result, yields the maximum amount of risk reduction. It can, thus, be thought of as a benchmark against which to compare the performance of other hedges.[14] It is apparent from the results that in every one of these hedges the risk of the unhedged position exceeded the risk of the hedged position. Notice also that if a policy of covering all of the spot positions in the futures market had been followed, the risk of the Naive portfolio would have been less than the Unhedged portfolio in twelve of the hedges but more than the Unhedged in five of the hedges. This is not surprising given that Naive hedges work well only when the spot commodity and the futures commodity are almost identical.

---

[14]It should be remembered that the risk-minimizing portfolio is ex-ante. The ex-post risk-minimizing portfolio may be quite different.

Table 4: Performance of Hedged and Unhedged Portfolios for Uzbekistan Cotton

Period	Portfolio	Hedge Ratio	Return	Risk	Risk Reduction
April 1987 Hedge					
Aug 85 - Mar 87	Unhedged	h = 0	.50	25.41	-
	Naive	h = 1	.39	1.85	92.7%
	Ex-Ante Hedged	h = .17	.48	18.38	28%
Apr 87 - Feb 88	Ex-Post Hedged	h = 1.07	.38	1.74	93%
April 1988					
Aug 85 - Mar 88	Unhedged	h = 0	-1.01	22.92	-
	Naive	h = 1	-1.19	3.27	86%
	Ex-Ante Hedged	h = .28	-1.06	14.62	36%
Apr 88 - Feb 89	Ex-Post Hedged	h = 1.23	-1.23	2.56	89%
April 1989					
Aug 85 - Mar 89	Unhedged	h = 0	.63	5.09	-
	Naive	h = 1	.35	1.17	77%
	Ex-Ante Hedged	h = .35	.53	1.64	68%
Apr 89 - Feb 90	Ex-Post Hedged	h = .71	.43	.39	92%
April 1991					
Aug 85 - Mar 91	Unhedged	h = 0	-2.73	2.52	-
	Naive	h = 1	-.97	2.58	-2%
	Ex-Ante Hedged	h = .36	-2.08	1.32	48%
Apr 91 - Feb 92	Ex-Post Hedged	h = .49	-1.86	1.24	51%

Note: We were unable to construct a hedge for April 1990 due to missing observations. A negative sign for risk reduction means that the hedge is risk-increasing rather than risk-reducing.

Table 5: Performance of Hedged and Unhedged Portfolios for Chinese Cotton

Period	Portfolio	Hedge Ratio	Return	Risk	Risk-Reduction
April 1987 Hedge					
May 85 - Mar 87	Unhedged	h = 0	.77	23.81	-
	Naive	h = 1	.66	2.04	91%
	Ex-Ante Hedged	h = .27	.74	14.00	41%
Apr 87 - Feb 88	Ex-Post Hedged	h = 1.03	.66	2.02	92%
April 1988 Hedge					
May 85 - Mar 88	Unhedged	h = 0	-.16	10.46	-
	Naive	h = 1	-.34	6.48	38%
	Ex-Ante Hedged	h = .35	-.22	5.98	43%
Apr 88 - Feb 89	Ex-Post Hedged	h = .65	-.27	4.81	54%
April 1989 Hedge					
May 85 - Mar 89	Unhedged	h = 0	-.07	5.40	-
	Naive	h = 1	.41	2.39	56%
	Ex-Ante Hedged	h = .37	.11	2.38	56%
Apr 89 - Feb 90	Ex-Post Hedged	h = .69	.26	1.58	71%
April 1990 Hedge					
May 85 - Mar 90	Unhedged	h = 0	.77	1.03	-
	Naive	h = 1	-1.27	3.47	-237%
	Ex-Ante Hedged	h = .38	-.01	.48	53%
Apr 90 - Feb 91	Ex-Post Hedged	h = .31	.44	.14	57%
April 1991 Hedge					
May 85 - Mar 91	Unhedged	h = 0	-2.98	4.65	-
	Naive	h = 1	-.[illegible]	2.53	45.6%
	Ex-Ante Hedged	h = .38	-2.07	3.36	28%
Apr 91 - Feb 92	Ex-Post Hedged	h = 1.02	-.53	2.52	46%

Note: A negative sign for risk-reduction means that the hedge is risk-increasing rather than risk-reducing.

Table 6: Performance of Hedged and Unhedged Portfolios for Turkish Cotton

Period	Portfolio	Hedge Ratio	Return	Risk	Risk-Reduction
April 1987 Hedge					
Jan 85 - Mar 87	Unhedged	h = 0	-.17	20.73	-
	Naive	h = 1	1.00	25.57	-23%
	Ex-Ante Hedged	h = .17	.03	19.67	5%
Apr 87 - Feb 88	Ex-Post Hedged	h = .32	.20	19.37	7%
April 1988 Hedge					
Jan 85 - Mar 88	Unhedged	h = 0	-.76	23.96	-
	Naive	h = 1	-.94	26.28	-10%
	Ex-Ante Hedged	h = .18	-.80	22.39	7%
Apr 88 - Feb 89	Ex-Post Hedged	h = .41	-.84	21.66	10%
April 1989 Hedge					
Jan 85 - Mar 89	Unhedged	h = 0	.21	7.01	-
	Naive	h = 1	1.60	3.34	52%
	Ex-Ante Hedged	h = .18	.46	5.32	24%
Apr 89 - Feb 90	Ex-Post Hedged	h = .76	1.26	2.94	58%
April 1991 Hedge					
Jan 85 - Mar 91	Unhedged	h = 0	-1.39	20.43	-
	Naive	h = 1	.37	14.68	28%
	Ex-Ante Hedged	h = .19	-1.05	18.53	9%
Apr 91 - Feb 92	Ex-Post Hedged	h = 1.05	.46	14.66	28%

Note: We were unable to construct a hedge for April 1990 due to missing observations. A negative sign for risk-reduction means that the hedge is risk-increasing rather than risk-reducing.

Table 7: Performance of Hedged and Unhedged Portfolios for Pakistan Cotton.

April 1991 Hedge					
Period	Portfolio	Hedge Ratio	Return	Risk	Risk-Reduction
Aug 88 - Mar 91	Unhedged	h = 0	-2.05	5.30	-
	Naive	h = 1	-.47	.32	94%
	Ex-Ante Hedged	h = .43	-1.37	1.64	69%
Apr 91 - Feb 92	Ex-Post Hedged	h = .90	-.63	.26	95%

Note: We were unable to construct hedges for other years due to missing observations.

Table 8: Performance of Hedged and Unhedged Portfolios for FPA Cotton.

August 1987					
Period	Portfolio	Hedge Ratios	Return	Variance	Risk Reduction
May 85 - July 87	Unhedged	h = 0	-1.70	7.27	-
	Naive	h = 1	-.51	2.51	65%
	Ex-Ante Hedged	h = .23	-1.43	4.82	34%
Aug 87 - June 88	Ex-Post Hedged	h = .80	-.74	2.21	70%
August 1988					
Period	Portfolio	Hedge Ratios	Return	Variance	Risk Reduction
May 85 - July 88	Unhedged	h = 0	-.48	6.61	-
	Naive	h = 1	.07	3.81	42%
	Ex-Ante Hedged	h = .27	1.10	5.55	16%
Aug 88 - June 89	Ex-Post Hedged	h = 1.40	-.50	3.56	46%
August 1989 Hedge					
Period	Portfolio	Hedge Ratios	Return	Variance	Risk Reduction
May 85 - July 89	Unhedged	h = 0	.32	4.54	-
	Naive	h = 1	-.25	2.32	49%
	Ex-Ante Hedged	h* = .3	.14	1.81	60%
Aug 89 - June 90	Ex-Post Hedged	h = .61	-.03	0.87	81%
August 1990 Hedge					
Period	Portfolio	Hedge Ratios	Return	Variance	Risk Reduction
May 85 - July 90	Unhedged	h = 0	-.53	3.35	-
	Naive	h = 1	-1.50	7.24	-116%
	Ex-Ante Hedged	h* = .32	-.84	1.65	50%
Aug 90 - June 91	Ex-Post Hedged	h = .36	-.88	1.63	51%
August 1991 Hedge					
Period	Portfolio	Hedge Ratios	Return	Variance	Risk Reduction
May 85 - July 91	Unhedged	h = 0	-1.11	6.06	-
	Naive	h = 1	-.25	3.62	40%
	Ex-Ante Hedged	h* = .32	-.84	4 07	33%
Aug 91 - June 92	Ex-Post Hedged	h = .72	-.49	3.17	48%

We can also calculate the risk reduction benefits of hedging as the percentage of the unhedged variance that the risk-minimizing or Naive hedge eliminates. Thus,

% Reduction in Risk = 1 - [Var(Hedged)/Var(UnHedged)]

The risk reduction and portfolio returns of the different portfolio constructed for hedging are as follows:

For Uzbeki cotton (Table 4), the ex-ante portfolio was better than the Naive in only one of four years. However, the year that the Naive portfolio did worst it lead to an increase rather than a decrease in risk. The risk reduction of the ex-ante hedge ranged from 28% to 68%, and that of the Naive portfolio from -2% to 93%. The Naive portfolio risk reduction was quite close to the maximum possible risk reduction as indicated by the ex-post portfolio. In three out of four years, the Unhedged portfolio gave a higher return than either the ex-ante or ex-post portfolios. Hedging carries a cost in terms of foregone returns, and whether the hedger considers these costs reasonable or not depends upon attitudes to risk (i.e. degree of risk-aversion).[15]

---

[15]Additional costs include the brokerage fee (usually 1 thousandth of the contract value) and the opportunity cost of holding a margin account--i.e., the difference between the interest bearing notes of the margin account and investing somewhere else. These costs are very small.

For Chinese cotton (Table 5), the ex-ante portfolio was better than the Naive in two out of five years and in one year they had the same risk reduction. For 1990, though, the Naive hedge resulted in a very significant risk increase rather than risk reduction. The range of risk reduction by the ex-ante portfolio was between 28% and 56% and that of the Naive portfolio between -237% and 91%. With the exception of 1991 and 1989, the returns of the Unhedged portfolio were higher than the rest, indicating that there is a cost in hedging (reduced returns for reduced volatility).

For the Turkish cotton (Table 6), the ex-ante portfolio reduced risk in two out of four cases in the range of 5-24%. Naive hedges led to risk increases in 1987 and 1988 (23% and 10% respectively) but for 1989 and 1991 did significantly better than ex-ante hedges. It is worth noting that the ex-post hedges led to rather small risk reductions (7-28%) with the exception of 1989 (58% risk reduction). The return of the unhedged portfolio was higher than the others for only one year, 1988.

For Pakistani cotton (Table 7) simulations were possible only for one year, 1991, because of the unavailability of data for the other years. Thus, for 1991, ex-ante hedges reduced volatility less than the Naive while the Naive hedge gave results almost identical to the maximum risk reduction possible as indicated by the ex-post hedge. The Naive hedge gave the highest return and the

Unhedged position the lowest return.

For FPA cotton (Table 8) risk reduction benefits range from 65% for the August 1989 Naive hedge to -116% for the Naive hedge of August 1990. The negative sign in 1990 implies that by hedging all output, the risk of the naive portfolio increases over that of the Unhedged portfolio. For 1989 and 1990, ex-ante hedges did better than Naive hedges. For the rest of the years, Naive hedges did better than ex-ante. However, given the fact that Naive hedges could lead to significant risk increases (1990), they are considered unsuitable for hedging FPA cotton prices. The range of ex-ante portfolio risk reduction range between 16% and 60%, which is also similar to the other cottons examined. With regard to hedging returns for 1988 and 1989, the Unhedged portfolio gave a higher (positive) return than the ex-ante or Naive portfolios. For the rest of the years, the ex-ante, Naive, and Unhedged positions all lost money.[16]

To sum up, we have assumed in this paper that cotton producing developing countries are risk-minimizers, and we have been able to show that hedging can reduce risk. While there were some years in which the Naive hedges led to a significant increase, rather than reduction, of risk, overall the Naive hedges contributed to

---

[16]For the case of FPA cotton, Satyanarayan et. al. (1993) have extended the analysis to quantify the risk-return trade-offs from hedging FPA cotton and estimated the optimal hedge ratios at different levels of risk aversion.

significant risk reductions. In several cases the Naive hedges performed at least as well as the ex-ante hedges. However, the possibility of increasing risk, rather than reducing it, as manifested in 5 out of 19 cases, makes the use of Naive hedges unwise for hedging the cottons we examined. At times Naive hedges increase risk significantly. It is also worth mentioning that, in every case, higher risk reduction resulted in lower portfolio return, highlighting the notion that hedging carries a cost.[17] The attitude toward risk will determine whether this cost is reasonable or not.

Introducing risk aversion in the portfolio model of hedging developed earlier requires some modifications.[18] Hedges now have to maximize an expected utility function that is:

$$EU = ER_p - \lambda \, Var\,(P) \qquad (6)$$

where λ is the risk aversion parameters and ER_p and Var (P) are defined in equations 3 and 4 respectively. A high (low) value of λ imply high (low) levels of risk aversion. The model above is a mean-variance model and implicitly assumes that the hedger has a quadratic utility function or that returns are normally distributed. The optimization problem is to select the hedge ratio (h) which maximizes EU. The optimizing hedge ratio is inversely related to λ and positively related to the "bias" between the

---

[17]Cost is defined as the risk-return trade-off.

[18]For details see Satyanarayan et. al., 1993. They apply this approach to the FPA cotton.

current and the expected futures price. For very high values of λ (i.e., high risk aversion) or assuming no bias in futures prices, the optimal hedge ratio derived from (6) is the same as in equation 5 earlier. A problem associated with this type of analysis is the existence of the "bias" in futures prices. A posteriori, we could calculate the "bias", but a priori, when the decision to hedge needs to be taken, it is hard to predict what the "bias" will be. Also, the "bias" tend to change over time and that affects the optimizing hedge ratio.

In summary, there is a risk-return trade-off in hedging. A risk averse agent will always choose to hedge. However, how much will be hedged (i.e., the hedge ratio) will depend on altitudes towards risk and the "bias" in futures prices. Furthermore, for a risk-averse hedger, the benefits of hedging lie not so much in the potential for increased returns as in the reduction of variance.

III. CONCLUSIONS

Cotton exports are a significant part of agricultural and total export revenues for many developing countries. In several cases the share of cotton exports has in fact increased, which means that several developing countries have increased their exposure to cotton price volatility.

In many cotton producing developing countries, the major part of the cotton price risk has been borne by the parastatal marketing authorities and ultimately by the government. This was mainly because of the government-controlled fixed or minimum prices paid to producers. Administrative prices or price support schemes have created severe fiscal problems during periods of persistent cotton price declines. Recent marketing reforms have lessened some of the governments' exposure to cotton price volatility by introducing flexibility into their cotton pricing systems.

To see the benefits which could be gained from using futures contracts to cotton price risk, this paper investigated the risk reduction possibilities for cotton from Uzbekistan, Pakistan, Turkey, China and the FPA countries, using portfolio analysis. A portfolio model of hedging was developed in which the decision problem was to select the optimal hedge ratio under two behavioral assumptions - risk minimization or utility maximization under risk aversion. We found that "cross-hedges" for the prices of the cotton varieties examined have significant risk reduction potential.[19] We simulated ex-ante cross-hedges and found that in each case, hedging was effective in reducing price risk. In most of the cases, the risk reduction benefits from ex-ante hedges were around 50%, meaning that the use of N.Y. cotton futures contracts could remove 50% of the intra-year cotton price volatility. Naive hedges, overall, also reduced risk but at times led to significant risk increases rather than risk reduction.[20] Hedges come at a cost. In every simulation we found that risk reduction resulted in a lower return to the portfolio. Attitudes towards risk, i.e., degree of risk aversion, determine how much of the risk-return tradeoff (i.e., the hedging costs) is acceptable. For a risk-averse hedger, the benefits of hedging lie not so much in any potential for increased returns as in the reduction in variance.

[19]A typical cross-hedge in cotton is to hedge the price of one quality by using a futures contract based on a different quality.

[20]Naive hedge is the hedge that has one as a hedge ratio. Hedge ratio is the amount of futures contracts needed to hedge a certain quantity of a commodity (cotton in our case).

REFERENCES

Arrow, K., 1971, Essays in The Theory of Risk Bearing, North Holland Press, (Amsterdam).

Claessens, S. and P. Varangis, 1993, "Risk Management Strategies in the Costa Rican Coffee Sector", in *Commodity Risk Management and Finance*, Vol. II, S. Claessens and R.C. Duncan, eds., Johns Hopkins University Press (Baltimore and London).

__________, and P. Varangis, 1994, "Commodity Risk Management in Developing Countries" in *Derivative Instruments and Hedging Strategies for Emerging Capital Markets*, G. Tsetsekos and M. Papaioannou, eds., Dow Jones Irwin, (Illinois) (forthcoming).

Ederington, L., 1979, "The Hedging Performance of the New Futures Markets", *Journal of Finance*, 34, pp.157-70.

Gemmill, G., 1985, "Optimal Hedging on Futures Markets for Commodity-Exporting Nations', *European Economic Review*, 27, pp.243-61.

Larson, D., 1993, "Policies for Coping with Price Uncertainty for Mexican Maize", PRE Working Paper No. 1120, The World Bank.

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

Milonas, N., and A. Vora, 1987, "Sources of Non-Stationarity in Cash and Futures Prices", *Review of Research in Futures Markets*, 4, pp.315-37.

Ouattara, K., T. Schroeder and L.O. Sorenson, 1992, "Potential Use of Futures Markets for International Marketing of Cote d'Ivoire Coffee", *Journal of Futures Markets*, 10, pp.113-21.

Rolfo, J., 1980, "Optimal Hedging under Price and Quantity Uncertainty: The Case of a Cocoa Producer", *Journal of Political Economy*, 88, pp.100-16.

Satyanarayan, S., E. Thigpen and P. Varangis, 1993, "Hedging Cotton Price Risk in Francophone African Countries", PRE Working Paper, The World Bank Policy Research Paper No. 1233, December.

Varangis, P., E. Thigpen, and T. Akiyama, 1993, "Risk Management Prospects for Egyptian Cotton", PRE Working Paper No. 1077, The World Bank.

Working, H., 1953, "Futures Trading and Hedging", *American Economic Review*, pp.314-43.

Policy Research Working Paper Series

	Title	Author	Date	Contact for paper
WPS1306	Capital Flows and Long-Term Equilibrium Real Exchange Rates in Chile	Ibrahim A. Elbadawi Raimundo Soto	June 1994	R. Martin 39065
WPS1307	How Taxation Affects Foreign Direct Investment (Country Specific Evidence)	Joosung Jun	June 1994	S. King-Watson 31047
WPS1308	Ownership and Corporate Control in Poland: Why State Firms Defied the Odds	Brian Pinto Sweder van Wijnbergen	June 1994	M. Kam-Cheong 39618
WPS1309	Is Demand for Polluting Goods Manageable? An Econometric Study of Car Ownership and Use in Mexico	Gunnar S. Eskeland Tarhan N. Feyzioglu	June 1994	C. Jones 37699
WPS1310	China's Economic Reforms: Pointers for Other Economies in Transition	Justin Yifu Lin Fang Cai Zhou Li	June 1994	C. Spooner 30464
WPS1311	The Supply Response to Exchange Rate Reform in Sub-Saharan Africa (Empirical Evidence)	Mustapha Rouis Weshah Razzak Carlos Mollinedo	June 1994	J. Schwartz 32250
WPS1312	The New Wave of Private Capital Inflows: Push or Pull?	Eduardo Fernandez-Arias	June 1994	R. Tutt 31047
WPS1313	New Estimates of Total Factor Productivity Growth for Developing and Industrial Countries	Vikram Nehru Ashok Dhareshwar	June 1994	M. Coleridge-Taylor 33704
WPS1314	The Significance of the "Europe Agreements" for Central European Industrial Exports	Bartlomiej Kaminski	June 1994	M. Pateña 37947
WPS1315	Global Tradable Carbon Permits, Participation Incentives, and Transfers	Bjorn Larsen Anwar Shah	June 1994	C. Jones 37754
WPS1316	Preserving the CFA Zone: Macroeconomic Coordination After the Devaluation	Shantayanan Devarajan Michael Walton	June 1994	C. Jones 37699
WPS1317	Estimating the Efficiency Gains of Debt Restructuring	Jeremy Bulow Kenneth Rogoff Ning S. Zhu	July 1994	R. Vo 33722
WPS1318	Exchange-Rate-Based Stabilization in Argentina and Chile: A Fresh Look	Miguel A. Kiguel Nissan Liviatan	July 1994	M. Divino 33739

Policy Research Working Paper Series

	Title	Author	Date	Contact for paper
WPS1319	The Financial System and Public Enterprise Reform: Concepts and Cases	Asli Demirgüç-Kunt Ross Levine	July 1994	B. Moore 35261
WPS1320	Capital Structures in Developing Countries: Evidence from Ten Countries	Asli Demirgüç-Kunt Vojislav Maksimovic	July 1994	B. Moore 35261
WPS1321	Institutions and the East Asian Miracle: Asymmetric Information, Rent-Seeking, and the Deliberation Council	Jose Edgardo Campos Donald Lien	July 1994	B. Moore 35261
WPS1322	Reducing Regulatory Barriers to Private-Sector Participation in Latin America's Water and Sanitation Services	Barbara Richard Thelma Triche	July 1994	M. Dhokai 33970
WPS1323	Energy Pricing and Air Pollution: Econometric Evidence from Manufacturing in Chile and Indonesia	Gunnar S. Eskeland Emmanuel Jimenez Lili Liu	July 1994	C. Jones 37699
WPS1324	Voucher Funds in Transitional Economies: The Czech and Slovak Experience	Robert E. Anderson	July 1994	F. Hatab 35835
WPS1325	The Economics of Research and Development: How Research and Development Capital Affects Production and Markets and Is Affected by Tax Incentives	Anwar Shah	July 1994	C. Jones 37699
WPS1326	Banks, Capital Markets, and Corporate Governance: Lessons from Russia for Eastern Europe	Gerhard Pohl Stijn Claessens	July 1994	L. Hovsepian 37297
WPS1327	Is the Debt Crisis History? Recent Private Capital Inflows to Developing Countries	Michael Dooley Eduardo Fernandez-Arias Kenneth Kletzer	July 1994	S. King-Watson 31047
WPS1328	The Use of New York Cotton Futures Contracts to Hedge Cotton Price Risk in Developing Countries	Panos Varangis Elton Thigpen Sudhakar Satyanarayan	July 1994	D. Gustafson 33714