Hedging Strategies for Exports of Cereals and Cereal Products to the European Community

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The full integration of the European Community's (EC) national markets that should be completed by the end of 1992 may offer new profit opportunities in what should be the largest single market in the world. These opportunities are likely to attract, among others, a number of international agribusiness companies. Although the current agricultural surpluses in the EC may point to limited profit opportunities in the case of most raw commodities, better markets may exist for higher value added processed products such as specialty flours and baked goods, snacks, and candies. These products may be imported or produced in the EC, and the working of the Common Agricultural Policy (CAP) of the EC may greatly impact the relative profitability of the two alternatives. An example is the imposition of the variable import levy (VI) on imports of cereals and cereal products: as long as the EC threshold price, the minimum entry price into the EC market, is higher than the world price, imported grains are assessed a variable levy that increases the landed cost of the imported commodity—at least to the threshold level. Processed goods are assessed both a fixed levy and a variable levy based on a cereal-equivalent content. The imposition of the VI has at least two consequences: it increases production cost and it affects price risk, as changes in the VI may not match the changes in the cost of the commodity that is imported. Historically, the volatility of the VI value has been quite high. This problem has already been investigated in a number of studies (Debatisse, Dumas, and Yon (1980), Debatisse (1984), Braga and Martin (1987)).[1]

This article conducts an assessment of the VI risk for corn and soft wheat, thereby assisting the industry in the understanding of this important dimension of

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[1]The coefficient of variation of the VI, calculated from Thursday data in Deutsche marks from January 1980 to May 1990, is 38% for corn and 35% for wheat. The corresponding values calculated for the closing price of the nearby futures contract expressed in Deutsche marks at the spot exchange rate are 33% for corn, 22% for Soft Red Winter Wheat, 24% for Hard Red Winter Wheat, 25% for Northern Spring Wheat.

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the CAP. To achieve this objective, the description of the VI pattern between January 1980 and May 1990, is first used to broadly discuss the main determinants of VI changes. A model of the VI determination process is used to determine naive and risk minimizing futures hedging positions. The out-of-sample hedging effectiveness of several strategies is then investigated. Finally this article addresses the consequences on the VI cost and VI risk of recent changes in the CAP.

The next section describes the VI setting mechanism; readers already familiar with the working of the CAP may skip it. The development of the VI setting model and its application to the determination of naive and risk-minimizing hedge ratios are illustrated in the methodology section followed by an illustration and comment on the empirical results.

THE VARIABLE LEVY RISK

The import levy is set daily according to the EC regulations. It is equal to the difference between the lowest spot price of the commodity c.i.f. Rotterdam and the EC threshold price.[2] To determine the lowest commodity price, the prices c.i.f. different ports of entry into the EC are standardized by means of fixed quality and transportation cost coefficients to a c.i.f. Rotterdam base, expressed in European Currency Units (ECUs). Once the lowest price is selected, other calculations are necessary, mainly to account for the difference between the value of the financial and the "green" ECU/US dollar exchange rate and between the financial and "green" rates of each EC currency.[3] The Commission of the EC sets the VI, and may arbitrarily adjust the results of the calculation if deemed necessary. The levy to be paid is the one fixed for the day the commodity is imported, or the forward levy, if prefixed up to 45 days in advance. This prefixing privilege is of limited value to the trade, as it is often suspended to discourage speculative trading, in particular, during periods of commodity or currency market instability. Moreover, the CAP regulations spell out that the forward levy is calculated on the basis of spot and forward prices and futures market spreads, but cannot be lower than the spot levy. In a normal carrying charge market this penalizes the applicant.

In essence, four primary factors may determine a variable levy increase: a decrease of the lowest commodity price c.i.f. Rotterdam; a decrease in the ECU value of the US dollar; a change in any of the EC policy variables, such as an increase of the threshold price or a revaluation of the green ECU; on a discretionary decision of the EC Commission.

METHODOLOGY

Following Braga and Martin (1987), the empirical analysis of the hedging problem is conducted by building a model of the variable levy determination process that accommodates the relevant CAP regulations. The model is then used to derive naive hedge ratios and to estimate minimum-variance hedge ratios for both the commodity price and the exchange rate. These are then traded out of sample to simulate hedging strategies for a VI in Deutsche marks.

Following Anderson and Danthine (1981), the model is used to calculate the "pure hedge," not the "speculative" component of the desired hedge ratio. As

[2]The c.i.f. price is the price of the commodity inclusive of cost, insurance, and freight.

[3]The "green" rates are the *ad hoc* exchange rate that are used in all CAP calculations, and may differ from financial rates. Some of the adjustments are designed to avoid any arbitrage opportunity.

pointed out by Thompson (1987), the minimum variance approach may be inconsistent with the true decision-making process of the hedgers, as no hedger would ever want to sell futures in a rally or buy them in a declining market just to decrease the variance of the portfolio returns.[4] On the other hand, it is important to note that any profit from speculative futures trading could not be used to address the VI-specific problem that is investigated in this study.[5] In this sense, the minimum-variance results constitute an objective out-of-sample measure of the validity of the proposed VI model. This information is relevant for the professional risk managers of each company, who could use this model to determine the initial naive or risk minimizing futures positions. Any desired speculative position could then be added to these.

To illustrate the problem, it is assumed that a company is importing into the EC a given quantity of cereal, and that all costs are known, except for the VI. A number of futures positions are taken in an effort to cross-hedge a possible change in the VI. The net revenue from a change in the cost of the variable levy and in the value of the futures positions held in the company's portfolio is defined in eq. (1):

$$R = -dVI \cdot y + d\mathbf{p}'\mathbf{f}, \tag{1}$$

where dVI is the variable levy change during the relevant time interval, y is the quantity of the commodity for which the VI must be paid, $d\mathbf{p}$ is the vector of futures prices changes, and $\mathbf{f}$ is the vector of open futures positions.

The company wants to determine risk-minimizing hedge ratios, defined as the ratio between the futures position and the given cash position that would minimize the variance of the return R. Following Anderson and Danthine (1981), and restricting the analysis to a commodity and a currency futures position, the hedge ratios may be obtained by regressing the changes in the VI over the changes in the appropriate commodity and currency futures prices. A model of the CAP regulations, linking the changes in the commodity price and exchange rate to the changes in the VI, is necessary to properly specify this equation. The rather tedious exercise of incorporating the working of all the EC regulations into a simplified model of the linkage between the changes in the relevant commodity futures price, the Deutsche mark futures price, and the VI is illustrated in the Appendix. From this model, it is possible to derive the independent variables used in the estimation of eq. (2):

$$dVI_{\mathrm{DM}} = \alpha + \beta_{VI,c}dVI_c + \beta_{\mathrm{VI},er}dVI_{er} + \epsilon, \tag{2}$$

where dVI_c and dVI_{er} are the commodity and exchange rate components of dVI, the VI change, and $\beta_{VI,c}$ and $\beta_{VI,er}$ are the in-sample commodity and currency risk-minimizing hedge ratios.

Both dVI_c and dVI_{er} incorporate the effects of changes in the CAP parameters that may increase the volatility or the cost of the VI. The extent of this problem may be verified by repeating the analysis for the implied price (IPr), and comparing the two results. The IPr is defined as the commodity price c.i.f. Rotterdam that would have generated the observed variable levy, given the policy parameters of the

[4]Benninga, Eldor, and Zilcha (1983, 1984) show that, under reasonable assumptions, the minimum variance hedge ratios are optimal hedge ratios, irrespective of the hedger's utility function, except for the assumption of risk aversion.

[5]In a traditional portfolio model, as the one by Anderson and Danthine, a futures speculative position is set as a function of the expected futures price change and of trader's risk aversion, and it is unaffected by expected cash price (VI) changes.

CAP. The differences between a change in the VI, dVI_c, and a change in the IPr, $dIPr_c$, are determined by the changes in the threshold price, and in any of the CAP variables that are present in the former but absent in the latter. Included in both cases are the effects of traders' reactions to the changes in the policy variables, those of any "adjustment" decided by the EC Commission, and those resulting from the approximations made in the development of the model.

The IPr is not observable, but it may be derived from the proposed VI model, as shown in the Appendix. An equation similar to (2) is, therefore, estimated:

$$dIPr_{\mathrm{DM}} = \alpha + \beta_{IPr,c} d\mathrm{IPr}_c + \beta_{IPr,er} d\mathrm{IPr}_{er} + \epsilon, \tag{3}$$

where $dIPr_c$ and $dIPr_{er}$ are the commodity and exchange rate components of $dIPr_{\mathrm{DM}}$, the observed IPr change in Deutsche marks.

Minimum variance hedge ratios are estimated using eqs. (2) and (3) for weekly and monthly (4-week) hedges: Thursday levy and Tuesday futures prices are used to accommodate the timing of the variable levy determination mechanism. New estimates of optimal hedge ratios are obtained every 8 weeks using a 52-week sample, beginning in January 1980. The most recent estimates are used in the out-of-sample simulation.[6] During the out-of-sample 8-week simulation, the size of the currency futures position is adjusted weekly to account for changes in the price of the commodity or the value of the exchange rate. To investigate the possible presence of a delivery month effect, each simulation is repeated twice, rolling the commodity futures position at expiration of the contract, or four weeks before it. Dummy variables are used in the estimation to account for outliers that are, at times, found when CAP changes occur.[7] The wheat estimations are repeated for the three wheat futures, the Soft Red Winter contract traded at the Chicago Board of Trade, the Hard Red Winter contract traded at the Kansas City Grain Exchange, and the Northern Spring contract traded at the Minneapolis Grain Exchange. This is necessary since no *a priori* argument may be made regarding the selection of any of the three contracts. Two considerations underline the importance of this point: first, the EC quality premia may not reflect market differential, thereby possibly penalizing wheat of a specific quality; second, the lowest commodity price c.i.f. Rotterdam, not necessarily a transacted price, is used as a basis for the VI calculation.

The hedging effectiveness measure used in the article is an out-of-sample modification of the "rebuilt R2" concept presented by Overdahl and Starleaf (1986), that is defined as: $\mathrm{HE}_{out} = 1 - [\mathrm{Var}(d\mathrm{R}_{out})/\mathrm{Var}(d\mathrm{VI})]$, where $\mathrm{Var}(d\mathrm{R}_{out})$ and $\mathrm{Var}(dVI)$ are the variances of the returns of the hedged portfolio and of the unhedged variable levy position, so that HE_{out} measures the out-of-sample reduction in the variance of the variable levy returns obtained by trading the given commodity and currency hedge ratios, and adjusting the futures position on a weekly basis. A similar measure is calculated also for the implied price.

[6]The results of the mathematical model are only valid for a daily price or exchange rate change, but are extended to weekly intervals in the empirical model. This may distort the estimation of the minimum variance hedge ratios, particularly in the case of longer hedges. The weekly periodicity is selected for convenience, but it is clear that a shorter time interval should be considered in extremely volatile markets.

[7]The following observations are dropped from the sample: corn levy: 801218, 810108, 820805, 821028, 850207, 860703, 870709, 881006, 890705, 891005; corn price: same as corn levy and 880708, 890705; wheat levy: 800807, 811218, 820805, 821028, 830804, 840802, 850207, 850801, 860703, 870709, 880623, 880707, 890615, 890705; wheat price: 801218, 810108, 820805, 821028, 850207, 860703, 870709, 890615, 880707, 881006, 890705, 891005.

THE DATA

The VI data in ECU/ton for corn and wheat, and the appropriate CAP variables are from the *Official Journal of the European Community.* The commodity futures closing prices are from a CFTC data tape, the *Wall Street Journal,* and commercial data banks. The sample covers the period from January 1980 to May 1990.

THE GRAPHICAL EVIDENCE

Figures 1 and 2 illustrate the evolution between 1980 and 1990 of the variable levy, threshold price, and CBOT nearby futures closing price, measured in ECU per bushel on the last Thursday of each quarter and at the end of May 1990.

The first four years are characterized by relatively stable or decreasing levy values. For example, the corn levy increases from the initial 2.3 ECU/bu. to 2.9 ECU/bu. at the end of 1982, only to fall to 0.9 ECU/bu. during the second half of 1984. During the same period, the wheat levy oscillates between the initial 2.2 ECU/bu. to a maximum of 3.1 ECU/bu. at the end of 1982, and a minimum of 1.7 ECU/bu. in the second half of 1984. The picture changes substantially after the first quarter of 1985, with the corn levy increasing to a maximum of 4.6 ECU/bu. at the end of the third quarter of 1987, and the wheat levy increasing to 5.5 ECU/bu. at the end of June 1987. Following the drought of 1988, the corn levy decreases and stabilizes in the 3.2 to 3.4 ECU/bu. range; whereas the wheat levy decreases to a minimum of 3.3 ECU/bu. in September 1988, it falls below 3 ECU/bu. one year later, and increased to 3.9 ECU/bu. by May 1990.

Much of the post-1985 increase in the variable levy is the result of two monetary factors that concur in generating lower commodity prices expressed in ECU: first, the decrease in the value of the dollar from the March 1985 peak of more than 3.4 DM to the 1.6 DM level in December 1987; second, the EC decision to gradu-

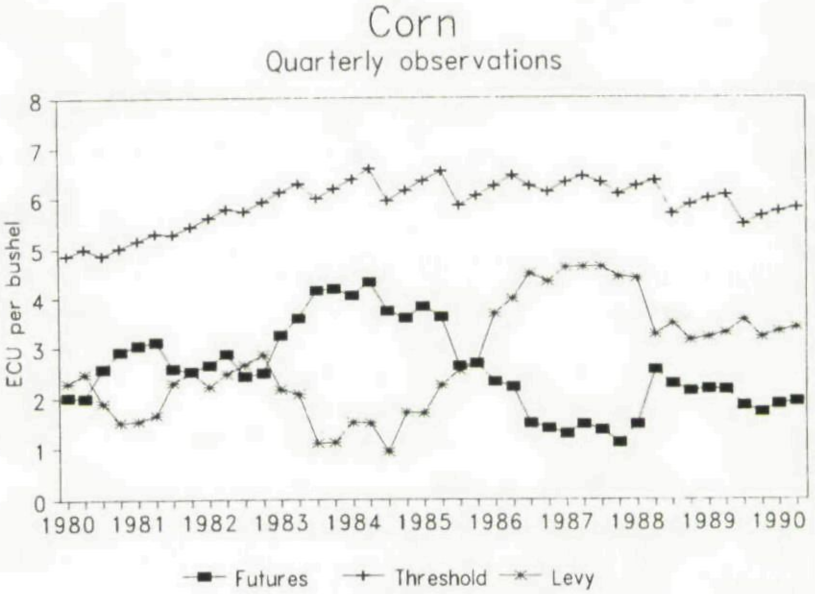

Figure 1

Corn threshold price, variable levy, and nearby futures price, ECU per bushel.

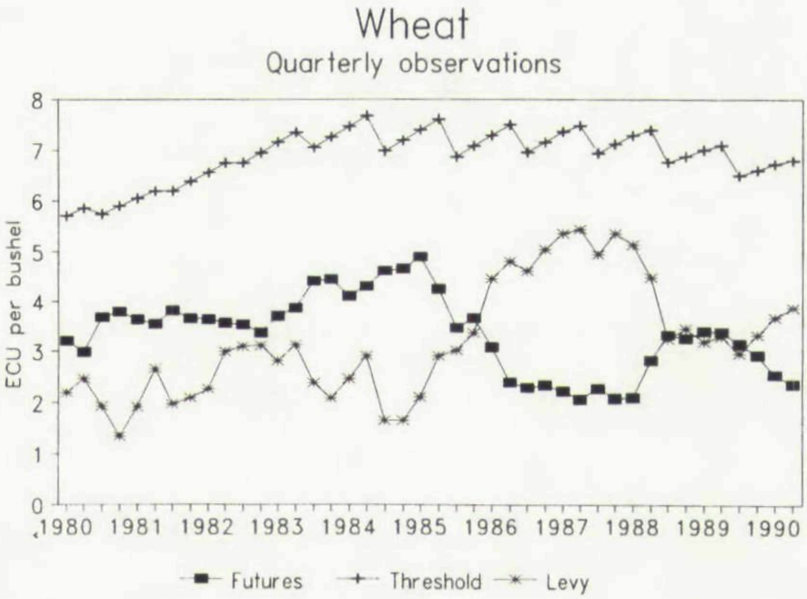

Figure 2
Wheat threshold price, variable levy, and nearby futures price, ECU/bu.

ally increase the reference value of the green ECU.[8] This pattern is best emphasized by the data in Figure 3, which reports nearby Chicago Board of Trade corn and wheat futures prices in US$/bu., and Figure 4, which illustrates the same data converted to ECU. During the first part of the sample, until the end of 1987, prices in US$ are substantially stable or decreasing, with the notable exception of the drought-PIK combination for corn in 1983 (Figure 3). A different pattern emerges when the same prices are measured in ECU, due to the pre-1985 rise of the US$ (Figure 4). Therefore, even if the threshold price in ECU increases substantially for both commodities, the corn and wheat variable levy does not increase proportionately. However, after 1985, the value of the levy increases substantially due to the collapse in the value of the dollar which is magnified by the increase in the reference value of the green ECU in terms of non-EC currencies. The 12% decrease in the US$ price of the nearby CBOT wheat contract between February 1985 and November 1987 translates into a 59% drop when measured in ECU; similarly, the 29% drop in corn prices in US$ translates to a decrease of 66% in ECU.[9] The decrease in the commodity prices in US$, following the 1988 drought, is also offset somewhat when measured in ECU, because of the temporary strength of the dollar after the end of 1987. The small-threshold price reductions, measured in ECU, during the more recent crop years are offset by the gradual increase in the reference value of the green ECU in terms of non-EC currencies.

Finally, as shown in Figure 5, the commodity-implied basis, defined as the difference between the EC-implied standard price and the relevant CBOT nearby futures

[8]The increase in the reference value of the green ECU is obtained by introducing the Central Rate Coefficient, a coefficient >1 that is used to artificially deflate the lowest commodity price c.i.f. Rotterdam. The CRC is equal to 1.145109 at the end of May 1990.

[9]The apparently confusing result is due to the extremely large drop in the value of the dollar during the same period. Between the end of February 1985 and the end of November 1987, the dollar lost approximately 50% of its value in term of the Deutsche mark.

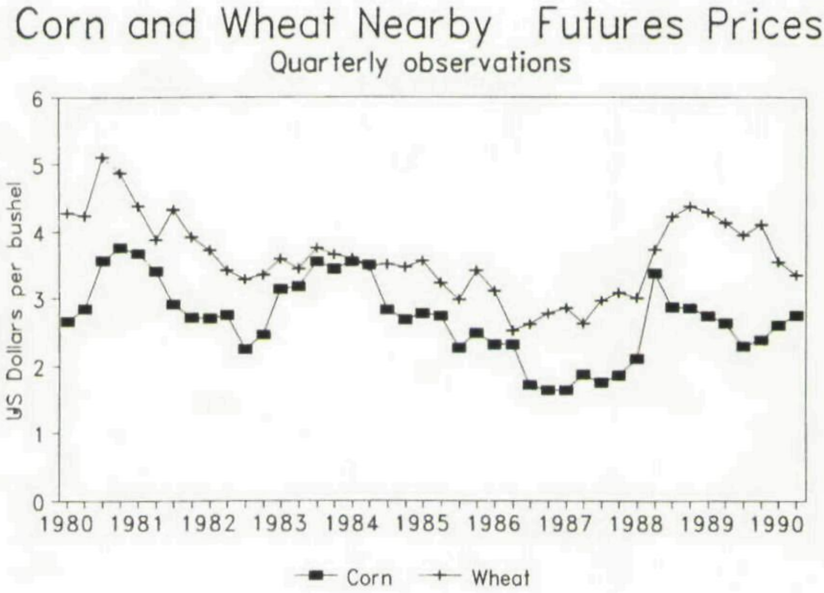

Figure 3
Corn and wheat nearby futures prices, US $/bu.

closing price, measured in ECU using a financial rate of exchange, is relatively more unstable for wheat than for corn. In all years, except 1984, 1988, and 1989, both the range and the variance of the wheat basis, measured on the last Thursday of each month, are larger than those measured for corn.[10]

THE IN-SAMPLE RISK-MINIMIZING HEDGE RATIOS

Table I reports the in-sample estimates of the commodity and currency risk-minimizing hedge ratios for the VI hedging strategies rolling the commodity position at expiration. The risk-minimizing hedge ratios are estimated using eq. (2). Similar results are obtained in the case of strategies rolling the commodity position 4 weeks before expiration, and in the case of the IPr hedging strategies. In the case of corn, the commodity and the currency hedge ratios are, in general, not statistically different from 1 in absolute value, irrespective of the hedge length and rolling strategy used.

The picture is somewhat different in the case of wheat where the commodity hedge ratio is always lower than 1 in absolute value for all weekly hedges, and some of the monthly hedges, irrespective of the wheat futures contract used. The currency hedge ratio is still not statistically different from unity. These results suggest that a corn trader may not experience a major difference in the out-of-sample hedging effectiveness of minimum risk or naive strategies, whereas the same may not hold in the case of wheat.

Only minor differences are, in general, found between the corresponding estimates from the full or the reduced sample. As the reduced sample excludes obser-

[10]It is important to note that a ECU/US$ financial exchange rate is used for the data presented in the figures. As such, it does not include the artificial increase in the value of the green ECU determined by the introduction of the central rate coefficient. If included, it would have decreased the commodity futures price in ECU in Figure 4 by this percentage. The basis in Figure 5 would be increased by the same amount.

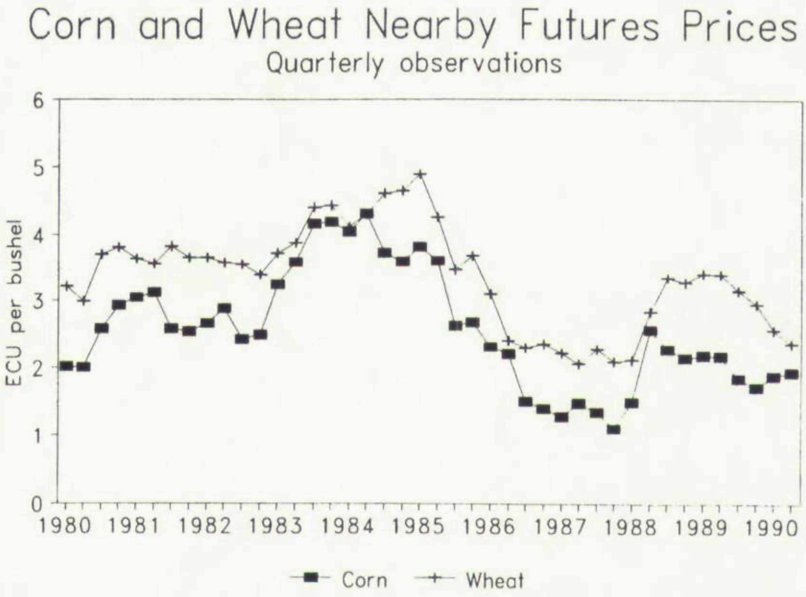

Figure 4
Corn and wheat nearby futures prices, ECU/bu.

vations most often associated with CAP policy changes, this evidence suggests that these changes are largely independent from short-term market conditions.

THE HEDGING EFFECTIVENESS

Tables II through V present the out-of-sample hedging effectiveness of the different hedging strategies, measured for the January 1981 to May 1990 and for the January 1988 to May 1990 sample periods. Weekly hedges are used in the cases of Tables II

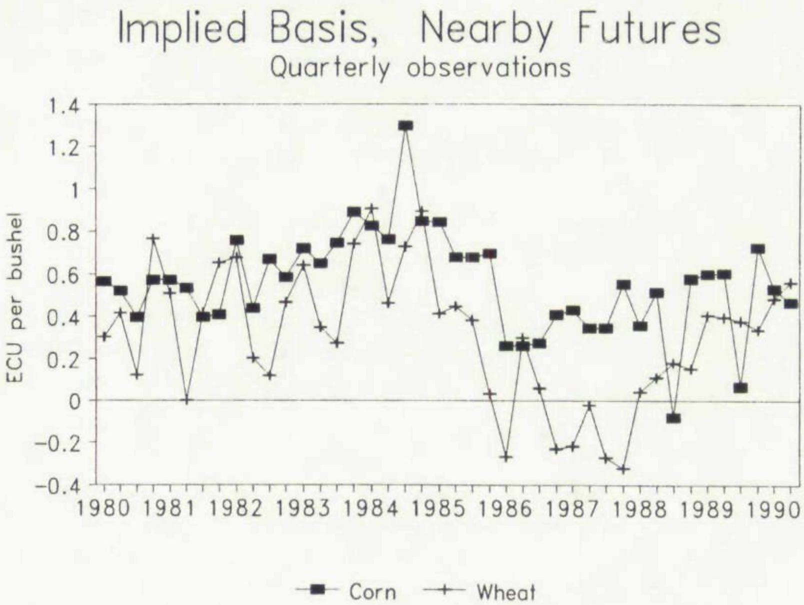

Figure 5
Corn and wheat implied nearby basis, ECU/bu.

and IV, and monthly hedges in Table III and V. The in-sample results are reported also. The full sample results include all data points. Some observations corresponding to the beginning of the CAP crop year are dropped for the reduced samples.[11] The regression strategies trade both commodity and currency risk-minimizing hedge ratios. The naive joint strategies trade naive commodity and currency futures positions. The results of a strategy trading only a naive commodity futures position or a naive currency futures position are presented also.

The difference between the corresponding hedge effectiveness measure for the full or reduced sample underlines the large impact of the changes in the threshold price and, therefore, in the VI observed at the beginning of the more recent crop years. These are generated by CAP changes, and obviously cannot be hedged. On the other hand, the hedger should not be too concerned by this evidence because, in the more recent crop years, the threshold and, therefore, the levy actually decrease at the beginning of the EC crop year.

In the case of corn, when the first observation of each crop year is removed from the sample, approximately three-fourths of the risk may be diversified using a joint commodity and currency hedge. Little difference exists between the regression and the joint naive hedging strategies. This result is not surprising because both the commodity and currency hedge ratios are often not different from unity. A commodity-only naive strategy is preferred over a currency-only naive one. It is better to roll the commodity position from the nearby to the next deferred contract at expiration rather than 1 month earlier, which may suggest that the variable levy is determined on the basis of the prices of the nearby futures. Regardless of whether this is due to the prices quoted by the trade (Slabotzky, 1984), or to the EC sticking to the nearby price requirement, this finding underlines the fact that the levy position is exposed to potential delivery problems in Chicago, plus, of course, to potential problems specific for the European market.[12] Overall, the changes in the CAP variables that impact the VI, but not the IPr, decrease the effectiveness of the hedging strategies; although the difference between the corresponding VI and IPr results is rather limited in the case of the reduced sample, because much of the impact of the CAP changes is lost when the sample is reduced. Although the results of the 1981–1990 sample cannot be directly compared with the corresponding ones for the 1988–1990 period, it is possible to suggest that the model may capture only a small fraction of a minor VI or IPr change, particularly in the case of the weekly hedges; but it appears to be sufficiently effective for larger changes and longer hedges.

The impact of the large changes in the threshold price at the beginning of the crop year is felt also in the case of wheat, irrespective of the commodity futures used. The results of a joint commodity and currency hedging strategy remain rather poor even when the reduced sample is used: only approximately one-third of the risk may be diversified when weekly data are used, although this increases to two-thirds for monthly observations, which suggests that the wheat VI may be slower than the corn one to reflect a commodity price change. The joint naive strategies

[11]This is necessary as the CAP induced change in the threshold price at the beginning of the crop year would arbitrarily distort the hedge effectiveness measure, making it useless. The reduced sample does not include the observations indicated in footnote 7.

[12]Although it is true that a lower variance of portfolio returns may be achieved by rolling the commodity position at expiration, it is important to remember that there is an inverse relation between commodity futures prices and VI. An increase in the price of the commodity because of delivery problem would, therefore, decrease the levy. Caution should be used by the practitioner interpreting the empirical results.

Table I
SELECTED IN-SAMPLE RISK MINIMIZING HEDGE RATIOS

	1981–1990 Weekly Data		1981–1990 Monthly Data		1988–1990 Weekly Data		1988–1990 Monthly Data	
	Commodity	Currency	Commodity	Currency	Commodity	Currency	Commodity	Currency
Corn:								
Full sample	0.921	−1.007	0.813	−1.013	0.869	−1.232	0.800	−1.210
	(0.0778)	(0.0614)	(0.116)	(0.100)	(0.186)	(0.0961)	(0.329)	(0.179)
Reduced sample	0.926	−1.012	0.841	−1.035	0.951	−1.126	0.864	−1.177
	(0.0672)	(0.0538)	(0.105)	(0.0986)	(0.125)	(0.0651)	(0.323)	(0.169)
Soft Red Winter Wheat:								
Full sample	0.913	−0.688	1.018	−0.837	0.938	−0.420	1.308	−1.374
	(0.0829)	(0.0626)	(0.152)	(0.125)	(0.205)	(0.148)	(0.407)	(0.473)
Reduced sample	0.912	−0.670	1.074	−0.900	1.037	−0.427	1.234	−0.903
	(0.0727)	(0.0512)	(0.110)	(0.0903)	(0.134)	(0.0982)	(0.213)	(0.234)
Hard Red Winter Wheat:								
Full sample	0.857	−0.572	0.925	−1.017	0.960	−0.486	1.281	−1.333
	(0.0956)	(0.0891)	(0.159)	(0.198)	(0.205)	(0.170)	(0.411)	(0.480)
Reduced sample	0.854	−0.565	0.979	−1.150	1.054	−0.529	1.103	−1.008
	(0.0727)	(0.0512)	(0.110)	(0.0903)	(0.134)	(0.0982)	(0.213)	(0.234)
Northern Spring Wheat:								
Full sample	0.836	−0.512	0.838	−0.507	0.966	−0.305	1.306	−0.825
	(0.0966)	(0.0960)	(0.169)	(0.190)	(0.209)	(0.162)	(0.412)	(0.292)
Reduced sample	0.834	−0.581	0.885	−0.855	1.058	−0.518	1.111	−0.566
	(0.0800)	(0.0795)	(0.130)	(0.153)	(0.131)	(0.102)	(0.222)	(0.157)

Note: Standard errors in parentheses.

Table II
HEDGING EFFECTIVENESS, CORN, WEEKLY OBSERVATIONS

	Variable Levy				Implicit Price			
	1981–90[a] (%)	1988–90[a] (%)	1981–90[b] (%)	1988–90[b] (%)	1981–90[a] (%)	1988–90[a] (%)	1981–90[b] (%)	1988–90[b] (%)
Full sample:								
Regression, in-sample	45	60	44	60	46	38	44	35
Regression, out-of-sample	41	58	40	58	44	38	42	34
Reduced sample:								
Regression, in-sample	52	75	46	74	58	79	50	78
Regression, out-of-sample	47	73	45	73	54	76	53	74
Naive joint	52	74	50	58	58	78	56	78
Naive commodity	33	62	30	61	36	65	34	64
Naive currency	15	12			18	13		

[a]The commodity futures position is rolled at expiration.
[b]The commodity futures position is rolled 4 weeks before expiration.

Table III
HEDGING EFFECTIVENESS, CORN, MONTHLY OBSERVATIONS

	Variable Levy				Implicit Price			
	1981–90[a] (%)	1988–90[a] (%)	1981–90[b] (%)	1988–90[b] (%)	1981–90[a] (%)	1988–90[a] (%)	1981–90[b] (%)	1988–90[b] (%)
Full sample:								
Regression, in-sample	55	64	53	63	58	57	57	55
Regression, out-of-sample	49	57	47	54	56	55	53	54
Reduced sample:								
Regression, in-sample	62	67	60	68	59	59	58	60
Regression, out-of-sample	55	58	54	56	56	57	54	58
Naive joint	62	68	61	69	40	32	38	32
Naive commodity	42	59	37	37	27	28	25	28
Naive currency	19	15			13	5		

[a]The commodity futures position is rolled at expiration.
[b]The commodity futures position is rolled 4 weeks before expiration.

Table IV
HEDGING EFFECTIVENESS, WHEAT, WEEKLY OBSERVATIONS

	Variable Levy				Implicit Price			
	1981–90[a] (%)	1988–90[a] (%)	1981–90[b] (%)	1988–90[b] (%)	1981–90[a] (%)	1988–90[a] (%)	1981–90[b] (%)	1988–90[b] (%)
Soft Red Winter:								
Full sample—								
Regression, in-sample	30	22	29	25	40	43	39	44
Regression, out-of-sample	30	13	30	15	40	38	39	39
Reduced sample—								
Regression, in-sample	38	39	36	40	43	42	42	43
Regression, out-of-sample	40	33	39	34	44	37	43	38
Naive joint	33	23	31	27	34	24	33	29
Naive commodity	9	−6	7	−2	6	−6	5	0
Naive currency	15	31			18	31		
Hard Red Winter:								
Full Sample—								
Regression, in-sample	19	25	20	26	29	45	30	46
Regression, out-of-sample	19	14	21	14	28	39	29	40
Reduced sample—								
Regression, in-sample	25	41	29	42	30	44	32	45
Regression, out-of-sample	26	33	28	34	31	38	32	39
Naive joint	19	33	24	35	22	35	28	37
Naive commodity	−1	2	5	6	−2	2	5	7
Northern Spring:								
Full sample—								
Regression, in-sample	17	28	24	28	27	45	29	47
Regression, out-of-sample	16	14	17	13	25	40	26	39
Reduced sample—								
Regression, in-sample	17	42	26	43	28	44	31	46
Regression, out-of-sample	23	36	25	36	27	40	28	38
Naive joint	19	32	22	36	22	32	26	37
Naive commodity	1	0	4	7	0	−1	3	7

[a]The commodity futures position is rolled at expiration.
[b]The commodity futures position is rolled 4 weeks before expiration.

outperform the corresponding joint minimum risk ones in the case of monthly hedges. A commodity only naive strategy is essentially worthless in the case of weekly hedges and, at times, it actually increases the volatility of the portfolio returns, as indicated by the negative HE values. This strategy remains quite ineffective even for monthly hedges, whereas a currency only naive hedge performs only marginally better. The impact of the 1988 drought is similar to what was described for corn, as an increased hedging effectiveness is observed.

Overall, the model performs better for corn than for wheat, and this may be due to the difficulties experienced in the estimation of the commodity hedge ratio for wheat after the first half of 1985, whereas the estimation of the currency hedge ratio

Table V
HEDGING EFFECTIVENESS, WHEAT, MONTHLY OBSERVATIONS

	Variable Levy				Implicit Price			
	1981–90[a] (%)	1988–90[a] (%)	1981–90[b] (%)	1988–90[b] (%)	1981–90[a] (%)	1988–90[a] (%)	1981–90[b] (%)	1988–90[b] (%)
Soft Red Winter:								
Full sample—								
Regression, in-sample	37	22	36	22	59	62	56	61
Regression, out-of-sample	33	26	32	26	52	59	50	59
Reduced sample—								
Regression, in-sample	58	62	55	60	58	63	56	61
Regression, out-of-sample	48	47	46	45	51	57	49	56
Naive joint	58	63	55	62	58	61	56	62
Naive commodity	18	21	15	23	18	14	15	23
Naive currency	20	43			21	44		
Hard Red Winter:								
Full Sample—								
Regression, in-sample	29	22	32	21	50	63	52	62
Regression, out-of-sample	25	27	28	25	44	63	46	63
Reduced sample—								
Regression, in-sample	47	65	50	67	49	66	52	66
Regression, out-of-sample	36	49	39	49	42	65	45	69
Naive joint	47	68	50	69	49	68	52	44
Naive commodity	17	33	18	34	20	21	21	34
Northern Spring:								
Full sample—								
Regression, in-sample	18	21	20	21	37	57	40	59
Regression, out-of-sample	16	30	32	26	34	55	35	59
Reduced sample—								
Regression, in-sample	38	60	40	64	39	60	41	63
Regression, out-of-sample	28	36	46	45	35	60	35	62
Naive joint	38	53	55	62	38	50	42	56
Naive commodity	12	24	15	23	12	22	15	34

[a]The commodity futures position is rolled at expiration.
[b]The commodity futures position is rolled 4 weeks before expiration.

did not present particular problems. Since the VI is set on the basis of the lowest standard commodity price which may be neither representative of real market conditions, nor representative of the price of the commodity actually imported in the EC. Two considerations are appropriate: first, this extreme price measure may likely reduce the hedging effectiveness for the wheat VI risk more than for the corn one because the latter is a more homogeneous commodity, possibly with fewer trade distorting export subsidies; second, the hedging of the variable levy risk should be considered separately from that of the commodity price risk because the two are likely different, particularly in the case of wheat.

Some final comments regarding the relative performance of the three wheat futures. No practical difference is evident among the three wheat futures in the case of weekly hedges; but for monthly ones, the Hard Red Winter futures seem to be marginally more effective than the Northern Spring or the Soft Red Winter contracts. It would be very difficult to select one of the three contracts: although no major difference seems to emerge after 1984, the CBOT is a better instrument during the first part of the sample. In the more recent years the Kansas City futures seems to perform marginally better that the Minneapolis and Chicago ones, particularly for monthly hedges. Despite this difference, when the contract specification of the three wheat futures are considered in relation to what was said for the EC wheat trade position and the EC levy-setting mechanism, particularly, the wheat quality consideration, it seems unlikely that either the KCBT or the MGE futures could substantially outperform the CBOT as a levy-hedging instrument.

THE COST OF THE *CAP* CHANGES

Tables VI and VII illustrate the annual change in the value of the VI or IPr, and selected hedge portfolios, all measured in DM per bushel, and obtained by marking to market the position on a weekly basis and converting the results to DM at the spot financial rate of exchange. In the case of corn, for example, during the period between January 1981 and December 1981, the VI increases by 3.02 DM/bu. This increase is reduced to 0.93 DM/bu. after accounting for the futures profits of a joint regression strategy using the nearby commodity contract until expiration.

Table VI
ANNUAL CHANGES IN THE VALUE OF THE VARIABLE LEVY AND OF SELECTED PORTFOLIOS, DM/BU., WEEKLY STRATEGIES

Commodity and Year	Levy	Joint Regression		Joint Naive		Commodity Naive		Currency Naive
		a	b	a	b	a	b	
Corn:								
1981	3.02	0.93	1.40	0.79	1.16	−0.97	−0.60	4.78
1982	0.82	0.72	0.50	0.56	0.12	−0.12	−0.56	1.50
1983	−4.02	−0.11	−0.50	0.35	0.21	−1.49	−1.62	−2.18
1984	1.36	2.68	1.59	2.91	1.91	0.79	−0.21	3.48
1985	2.40	0.53	−0.04	1.06	0.56	2.86	2.37	0.60
1986	3.94	2.59	2.52	2.00	1.69	3.17	2.86	2.77
1987	0.00	−0.70	−1.13	−0.59	−0.80	0.09	−0.13	−0.67
1988	−3.00	−1.25	−1.25	−1.55	−1.53	−2.24	−2.21	−2.32
1989	0.11	−0.26	−0.59	−0.48	−0.78	−0.45	−0.75	0.08
1990[c]	0.47	0.94	0.89	0.83	0.79	0.91	0.88	0.38
Soft Red Winter Wheat:								
1981	1.19	−0.30	−0.30	−1.20	−1.35	−3.11	−3.25	3.10
1982	2.50	1.21	1.03	0.32	0.11	−0.45	−0.66	3.27
1983	−1.97	−1.03	−1.45	−0.75	−1.10	−2.69	−3.05	−0.02
1984	−1.06	0.81	0.58	0.88	0.49	−1.36	−1.75	1.19
1985	4.27	2.14	2.45	2.20	2.48	4.21	4.49	2.26
1986	4.32	3.53	3.04	4.91	3.41	6.16	4.66	3.08
1987	0.06	−0.63	−0.62	−0.37	−0.33	0.40	0.44	−0.71
1988	−4.48	−3.72	−3.71	−2.50	−2.40	−3.19	−3.10	−3.79
1989	−0.29	−0.34	−0.38	−1.08	−1.10	−1.01	−1.03	−0.36
1990[c]	1.28	1.20	0.95	1.23	0.69	1.35	0.81	1.16

Table VI—Continued

Commodity and Year	Implied Price	Joint Regression [a]	Joint Regression [b]	Joint Naive [a]	Joint Naive [b]	Commodity Naive [a]	Commodity Naive [b]	Currency Naive
Hard Red Winter Wheat:								
1981	1.19	0.67	0.15	0.34	−0.21	−1.57	−2.11	3.10
1982	2.50	3.30	2.21	3.73	2.13	2.95	1.36	3.27
1983	−1.97	0.25	−0.05	0.29	−0.10	−1.66	−2.05	−0.02
1984	−1.06	1.41	0.39	1.40	0.72	−0.84	−1.52	1.19
1985	4.27	2.22	1.75	2.39	1.91	4.40	3.92	2.26
1986	4.32	3.16	3.05	3.22	2.52	4.47	3.76	3.08
1987	0.06	−0.66	−0.73	0.12	0.04	0.89	0.81	−0.71
1988	−4.48	−3.72	−3.64	−2.55	−2.44	−3.24	−3.13	−3.79
1989	−0.29	0.09	−0.16	−0.19	−0.61	−0.12	−0.54	−0.36
1990[c]	1.28	0.92	0.89	0.67	0.68	0.79	0.80	1.16
Northern Spring Wheat:								
1981	1.19	1.64	0.79	1.23	0.47	−0.67	−1.43	3.10
1982	2.50	3.00	2.42	3.27	2.48	2.50	1.71	3.27
1983	−1.97	1.44	1.10	1.77	1.09	−0.17	−0.85	−0.02
1984	−1.06	−0.11	−0.17	0.49	0.31	−1.75	−1.93	1.19
1985	4.27	2.55	2.48	2.39	2.15	4.40	4.17	2.26
1986	4.32	3.18	2.97	2.59	1.70	3.84	2.95	3.08
1987	0.06	−0.61	−0.67	−0.77	−0.71	−0.00	0.06	−0.71
1988	−4.48	−3.70	−3.77	−2.59	−2.49	−3.29	−3.18	−3.79
1989	−0.29	−0.29	−0.51	−0.76	−1.01	−0.69	−0.94	−0.36
1990[c]	1.28	0.97	0.92	0.88	0.80	1.01	0.92	1.16

[a]The commodity futures position is rolled at expiration.
[b]The commodity futures position is rolled 4 weeks before expiration.
[c]To the end of May 1990.

Table VII
ANNUAL CHANGES IN THE VALUE OF THE IMPLIED PRICE AND OF SELECTED PORTFOLIOS, DM/BU., WEEKLY STRATEGIES

Commodity and Year	Implied Price	Joint Regression [a]	Joint Regression [b]	Joint Naive [a]	Joint Naive [b]	Commodity Naive [a]	Commodity Naive [b]	Currency Naive
Corn:								
1981	−2.25	−0.45	−0.94	−0.03	−0.39	1.73	1.37	−4.01
1982	0.09	0.20	0.47	0.35	0.79	1.03	1.47	−0.59
1983	4.27	0.29	0.69	−0.10	0.04	1.74	1.87	2.43
1984	−0.77	−1.70	−0.85	−2.34	−1.34	−0.18	0.82	−2.93
1985	−2.54	−1.07	−0.53	−1.15	−0.64	−3.02	−2.51	−0.68
1986	−3.65	−1.72	−1.28	−1.56	−1.22	−2.82	−2.48	−2.39
1987	−0.06	0.59	0.98	0.61	0.85	−0.16	0.08	0.70
1988	2.85	1.51	1.58	1.20	1.17	1.98	1.95	2.07
1989	−0.75	−0.28	0.08	−0.09	0.25	−0.12	0.22	−0.72
1990[c]	−0.04	−0.55	−0.51	−0.45	−0.41	−0.55	−0.51	0.06

Table VII—Continued

Commodity and Year	Implied Price	Joint Regression [a]	Joint Regression [b]	Joint Naive [a]	Joint Naive [b]	Commodity Naive [a]	Commodity Naive [b]	Currency Naive
Soft Red Winter Wheat:								
1981	−0.39	0.88	0.90	2.13	2.28	3.91	4.06	−2.17
1982	−1.31	−0.04	0.14	0.92	1.13	1.64	1.85	−2.04
1983	2.50	1.51	1.90	1.40	1.75	3.22	3.57	0.68
1984	1.56	−0.09	0.20	−0.26	0.14	1.87	2.27	−0.57
1985	−4.21	−2.20	−2.43	−2.20	−2.49	−4.15	−4.44	−2.27
1986	−3.75	−3.08	−2.43	−4.47	−2.85	−5.73	−4.10	−2.50
1987	−0.12	0.52	0.50	0.31	0.26	−0.50	−0.55	0.70
1988	4.19	3.32	3.30	1.99	1.88	2.73	2.62	3.46
1989	−0.37	−0.18	−0.12	0.52	0.55	0.45	0.47	−0.29
1990[c]	−0.86	−0.76	−0.47	−0.81	−0.19	−0.94	−0.32	−0.73
Hard Red Winter Wheat:								
1981	−0.39	−0.08	0.44	0.59	1.13	2.37	2.91	−2.17
1982	−1.31	−2.12	−1.04	−2.49	−0.90	−1.77	−0.17	−2.04
1983	2.50	0.32	0.63	0.37	0.76	2.19	2.58	0.68
1984	1.56	−0.48	0.42	−0.80	−0.10	1.34	2.04	−0.57
1985	−4.21	−2.20	−1.75	−2.40	−1.90	−4.35	−3.85	−2.27
1986	−3.75	−2.56	−2.37	−2.67	−1.90	−3.92	−3.16	−2.50
1987	−0.12	0.50	0.54	−0.25	−0.16	−1.06	−0.97	0.70
1988	4.19	3.35	3.23	2.05	1.92	2.78	2.66	3.46
1989	−0.37	−0.76	−0.45	−0.49	−0.01	−0.57	−0.09	−0.29
1990[c]	−0.86	−0.41	−0.39	−0.17	−0.18	−0.30	−0.30	−0.73
Northern Spring Wheat:								
1981	−0.39	−0.90	−0.14	−0.30	0.46	1.47	2.24	−2.17
1982	−1.31	−1.80	−1.21	−2.04	−1.25	−1.31	−0.52	−2.04
1983	2.50	−0.73	−0.44	−1.12	−0.44	0.70	1.38	0.68
1984	1.56	0.72	0.78	0.17	0.35	2.30	2.49	−0.57
1985	−4.21	−2.57	−2.50	−2.40	−2.16	−4.34	−4.10	−2.27
1986	−3.75	−2.48	−2.27	−1.97	−1.02	−3.23	−2.28	−2.50
1987	−0.12	0.53	0.56	0.77	0.70	−0.05	−0.11	0.70
1988	4.19	3.46	3.58	2.10	1.98	2.83	2.71	3.46
1989	−0.37	−0.23	0.01	0.16	0.45	0.08	0.37	−0.29
1990[c]	−0.86	−0.50	−0.43	−0.42	−0.32	−0.54	−0.45	−0.73

[a]The commodity futures position is rolled at expiration.
[b]The commodity futures position is rolled 4 weeks before expiration.
[c]To the end of May 1990.

The differences between the levy and the implied price changes are substantial for both commodities. Between 1980 and 1990, the corn VI increases by 5.1 DM/bu., whereas the corn implied price decreases by about 2.9 DM/bu., thereby leaving a difference of about 2.2 DM/bu. Since the CAP changes are exogenous and cannot be hedged, it is not surprising that the changes in the value of the hedged portfolios are generally higher, in absolute value, in the case of the VI than for the IPr. This may represent a substantial "structural" cost to the traders because the VI setting mechanism is completely outside their control. Although these results generally hold also in the case of wheat, much of the loss for the wheat VI strategies takes place during the 1985 and 1986 years. More importantly, and contrary to what happened to corn, this large gap cannot be explained on the basis of the difference between levy and implied price changes. During the same years, the price strategies perform better although they still fall short of matching the implied price changes by approximately 4.3 DM/bu.

The poor results for both the levy and the price strategies after 1984 are common to the three wheat futures and support the hypothesis of a progressive decoupling of the US wheat futures and the implied wheat price in Rotterdam. The results seem to improve after 1987, particularly when the KCBT and the MGE futures are used, although wide swings are still present in the different contract months.

SUMMARY AND CONCLUSION

The empirical results presented in this article show that the CBOT corn futures can be used together with the International Monetary Market Deutsche mark futures to hedge the EC-variable levy risk with acceptable results both in terms of risk reduction and hedge cost. Since the CAP changes have a significant impact on the levy cost and on its volatility, it is not surprising to find that it is easier to hedge the changes in the implicit world market price c.i.f. Rotterdam, resulting from the EC calculations, than the changes in the variable levy.

In the case of wheat, the CBOT contract is a good hedging instrument up to the 1984–85 crop year, whereas the Kansas City and the Minneapolis futures contracts perform rather poorly during this period. The situation worsens after 1984, when all contracts offer poor results. This coincides with the wheat export subsidy war between EC and US that generated lower prices in the world market and may have determined the decoupling of the world market prices and US futures. As in the case of corn, the hedging effectiveness for the wheat VI increases during the 1988–1990 period.

A clear implication of the large difference in hedging effectiveness between full and reduced sample is that CAP changes are a major determinant of VI changes. Obviously, these changes cannot be hedged.

One may conclude that the hedging effectiveness is rather low, which is not surprising, given the complexities of the cross-hedge. Two important points should, however, be made. First, given the increase in hedging effectiveness in the more recent years, it is possible to suggest that the undiversifiable VI basis risk is less important, relative to the diversifiable commodity and currency risks, when the markets are more volatile. Therefore, the hedging effectiveness is higher when needed most, that is, when risk is higher. Second, it is more difficult to hedge the wheat VI than the corn one and the wheat VI seems to be slower than the corn one to reflect a commodity price change, so that a short-term hedge of the wheat VI is still quite risky.

In general, there is little difference between minimum-risk hedging strategies and joint naive ones, at least in the case of corn. This may suggest that the additional effort necessary for the estimation of minimum risk hedge ratios may not be warranted, and that traders should only account for the CAP regulations, as detailed in the Appendix, when determining the size of both the commodity and currency hedge position.

Despite the lower hedging effectiveness, traders should roll the hedge before the delivery month, particularly when a widening of the spread between the nearby and the next commodity contract is expected, as this may increase the return of the hedged portfolio.

The out-of-sample effectiveness of the joint commodity and currency hedges is higher than the one obtained when only the commodity or the currency risk is hedged. This emphasizes the need to consider both the commodity and the currency components of the VI. In large companies, the foreign exchange risk-management function may be separated from that for the commodity price risk. The results stress the importance of the transfer of the information regarding the correct currency risk exposure arising from the VI position, away from the commodity traders, who normally manage the purchase of the physical commodity and the relative commodity hedging strategies, to the corporate finance department.

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Appendix

DERIVATION OF THE VARIABLE LEVY-SETTING MODEL

The VI setting mechanism is illustrated in eq. (A1) and (A2). The former gives the general value, in ECU, of the VI for commodity c on day t. The latter gives the value in Deutsche marks (DM) for a commodity imported in the Federal Republic of Germany (FRG). The different time subscripts used in the two equations, and elsewhere in the Appendix, reflect the proper timing of the calculations, as specified by the EC regulations.

$$\mathrm{VI}_{c,\mathrm{ECU},t} = T_{c,\mathrm{ECU},t} - P_{c,i,t-1} \cdot \mathrm{ER}_{\mathrm{ECU}/i,t-2}/\mathrm{CRC}_{t-1}, \tag{A1}$$

$$\mathrm{VI}_{c,\mathrm{DM},t} = [\mathrm{VI}_{c,\mathrm{ECU},t} \cdot \mathrm{MC}_{\mathrm{FRG},t} + \mathrm{MCA}_{\mathrm{FRG},c,t}] \cdot \mathrm{GER}_{\mathrm{DM},t}. \tag{A2}$$

T is the threshold price for the commodity c. P is the lowest price of the "standard quality" commodity, c.i.f. Rotterdam, expressed in the ith currency. ER is the ECU value of the ith currency, normally US$, obtained as the unweighted average of the financial exchange rates between the US$ and the "narrow band" Belgian, Danish, Dutch, French, German, and Irish currencies, each multiplied by the respective central parity with the ECU. CRC is the central rate coefficient, first introduced for the 1984–85 crop year; CRC is a fictitious exchange rate that increases the reference value of the "green ECU," thereby allowing a devaluation of the strong "green" currencies, the necessary step for the desired abolition of positive MCA, without the politically undesirable consequence of a drop in the domestic agricultural prices. The CRC was initially set at 1.033651 on August 1, 1984; it is equal to 1.145109 at the end of May 1990. MC is the monetary coefficient for Germany; MC is intended as an exchange rate adjustment in international trade to compensate for the difference between the financial and the green value of an EC currency. MCA is the monetary compensatory amount for the commodity imported into the FRG; MCA are designed to avoid arbitrage between the different domestic EC markets. GER is the green rate of exchange for the Deutsche mark; green rates are ad hoc exchange rates used by the CAP.

Using eq. (A1), and assuming that the price of the commodity being considered is in US$, eq. (A2) may be rewritten as (A2′):

$$\begin{aligned} \mathrm{VI}_{c,\mathrm{DM},t} = \{[&T_{c,\mathrm{ECU},t} - P_{c,\$,t-1} \cdot \mathrm{ER}_{\mathrm{ECU/\$},t-2}/\mathrm{CRC}_{t-1}] \\ &\cdot \mathrm{MC}_{\mathrm{FRG},t} + \mathrm{MCA}_{\mathrm{FRG},c,t}\} \cdot \mathrm{GER}_{\mathrm{DM},t}. \end{aligned} \tag{A2′}$$

The expected VI change due to a given change in the commodity price or the $/DM exchange rate can be obtained by calculating the differential of eq. (A2′) with respect to $P_{c,\$,t-1}$ and $\mathrm{ER}_{\$/\mathrm{DM},t-2}$, the spot exchange rate between US$ and DM:

$$\frac{dVI_{c,\mathrm{DM},t}}{dP_{c,\$,t-1}} = -\mathrm{ER}_{\mathrm{ECU/\$},t-2} \cdot \mathrm{MC}_{\mathrm{FRG},t} \cdot \mathrm{ER}_{\mathrm{DM},t}/\mathrm{CRC}_{t-1}. \tag{A3}$$

$$\begin{aligned} \frac{dVI_{c,\mathrm{DM},t}}{d\mathrm{ER}_{\$/\mathrm{DM},t-2}} = &-P_{c,\$,t-1}/\mathrm{CRC}_{t-1} \cdot \delta\mathrm{ER}_{\mathrm{ECU/\$},t-2}/\delta\mathrm{ER}_{\$/\mathrm{DM},t-2} \\ &\cdot \mathrm{MC}_{\mathrm{FRG},t} \cdot \mathrm{GER}_{\mathrm{DM},t}. \end{aligned} \tag{A4}$$

It is assumed that the derivatives of $T_{c,\mathrm{ECU},t}$, CRC_t, $\mathrm{MC}_{\mathrm{FRG},t}$, $\mathrm{MCA}_{\mathrm{FRG},t}$, and $\mathrm{GER}_{\mathrm{DM},t}$ with respect to $P_{c,\$,t-1}$ and the derivatives of $T_{c,\mathrm{ECU},t}$, $P_{c,1,t-1}$, CRC_t, $\mathrm{MC}_{\mathrm{FRG},t}$, $\mathrm{MCA}_{\mathrm{FRG},t}$, and $\mathrm{GER}_{\mathrm{DM},t}$ with respect to $\mathrm{ER}_{\$/\mathrm{DM},t-2}$ are equal to zero in the short run.

Equations (A3) and (A4) reflect the relevant EC regulations and link the change in $P_{c,\$,t-1}$ and $\mathrm{ER}_{\$/\mathrm{DM},t-2}$ to the change in the VI. They may, therefore, be used as independent variables to estimate the commodity and currency risk minimizing hedge ratios for the VI risk, eq. (2) in text. Before doing so, both equations should be rewritten in terms of changes in the relevant commodity or Deutsche mark futures contracts. It is, therefore, necessary to calculate $\mathrm{ER}_{\mathrm{ECU/\$},t}$, the exchange rate between the ECU, and the US$ used by the EC, $\delta\mathrm{ER}_{\mathrm{ECU/\$},t}/\delta\mathrm{ER}_{\mathrm{DM},t}$, its derivative with respect to the financial exchange rate between the US$, and the DM, and $dP_{c,\$,t}$.

As $\mathrm{ER}_{\mathrm{ECU/\$},t}$ is calculated by the EC using only the "narrow band" currencies in the European Monetary System (EMS), the financial rate of exchange between ECU and US$ may not be used in the calculation. The result of the complex EC process is approximated by assuming that $ER_{ECU/\$,t}$ is equal to the inverse of the product of the financial exchange rate between DM and US$ by the green exchange rate between ECU and DM, adjusted by the appropriate monetary coefficient. The bias introduced is limited by the relative fixity of the cross-parity within the EMS strong currencies.

In the short run, it is assumed also that the change in the price c.i.f. Rotterdam is equal to the change in the closing price of the nearby commodity futures for the previous day.

The derivative of $ER_{ECU/\$,t-2}$ with respect to $ER_{\$/DM,t-2}$ can now be calculated:

$$\frac{dER_{ECU/\$,t-2}}{dER_{\$/DM,\,t-2}} = -1/[ER_{\$/DM,t-2} \cdot MC_{FRG,t} \cdot GER_{DM,t}]^2. \tag{A5}$$

Equation (A3) can be rewritten as (A6), and eq. (A4) can be rewritten as (A7), using (A5), deriving $P_{c,\$,t-1}$ from (A2′), and substituting the change in the International Monetary Market (IMM) DM futures for the change in the spot exchange rate.

Equations (A6) and (A7) are used in the text as independent variables in eq. (2):

$$dVI_{c,DM,t} = -dFP_{c,t-2}/(ER_{\$/DM,t-2} \cdot CRC_{t-1}) \tag{A6}$$

$$dVI_{c,DM,t} = [dER_{IMM\$/DM,t-2}/ER_{\$/DM,t-2}] \cdot [T_{c,ECU,t-2} - VI_{c,ECU,t-2}] \cdot MC_{FRG,t} \cdot GER_{DM,t} \tag{A7}$$

The inefficient timing of the current legislation allows the trader to forecast the expected change of the VI with a one-day advantage. To be able to exploit this advantage, a further simplification is necessary, as $P_{c,\$,t-1}$, the EC standard commodity price in US$ c.i.f. Rotterdam is not normally known to the traders: the last observed VI value may be used to derive the price that is used instead of $P_{c,\$,t-1}$ in the calculations. In eq. (A7), $P_{c,ECU,t-2} = [T_{c,ECU,t-2} - VI_{c,ECU,t-2}]$ is used.

The practical calculation of all variables used in eq. (2) in text is as follows: the dependent variable is the observed VI change in ECU from the *Official Journal of the EC,* expressed in DM/bu. at the DM green rate of exchange, adjusted for the MC; dVI_c is calculated using eq. (A6), and it is equal to the observed change in the closing price of the appropriate commodity futures contract, measured in DM using the spot exchange rate between DM and US$, adjusted by the central rate coefficient, and lagged two days; dVI_{er} is calculated using (A7), and it is equal to the observed change in the closing price of the nearby DM futures, measured in DM at the spot financial rate, multiplied by the latest available implied price, expressed in DM at the green rate adjusted for the MC.

An intuitive explanation is used to illustrate the working of the model. A change in the relevant futures price should determine a value of dVI_c that is inversely proportional to the values of the relevant spot exchange rate between US$ and the DM and of the central rate coefficient (CRC) of the CAP. This change could be hedged by selling the appropriate quantity of commodity futures that, in the case of a naive hedge, would be equal in size to the spot position for which the levy is to be paid, divided by the value of the CRC. In the text of this article, the term "naive" is defined to indicate a futures position that is equal to 100% of the given cash position, after accounting for the CAP regulations, as it is done in the derivation of eqs. (A6) and (A7). The reduction in the commodity futures position is, therefore, necessary since the CRC is used by the EC to deflate the commodity price in US$ before calculating the VI, so that a futures position equal to 100% of the cash position would generate a cash flow equal to $(1 \cdot \text{CRT}) \times 100 = 114\%$ of the expected VI change, using the CRT value at the end of the sample period. The correct naive futures position, multiplied by the most recent estimate of the risk-minimizing commodity hedge ratio, would determine the futures position in a minimum variance hedging strategy. This may be easily seen from the definition of hedge ratio for risk-minimizing strategy, $\text{HR}_{rm}: \text{HR}_{rm} = f_{rm}/y = \hat{\beta}$, where f_{rm} is the futures position, y is the given cash position for which the VI is to be paid, and $\hat{\beta}$ is the coefficient of the regression of the observed changes in the dependent variable, the VI, over the changes in the appropriate futures price. From this definition, $f_{rm} = \hat{\beta} \cdot y$. By definition, a naive strategy sets the hedge ratio $\text{HR}_n = 1$, so that $f_n = y$. It follows then that $f_{rm} = \hat{\beta} \cdot f_n$.

A change in the relevant currency futures price will determine a value of $d\text{VI}_{er}$ that could be hedged by taking a long position in IMM DM futures that, in the case of naive currency hedge, would be equal in size to the DM value of the cash commodity position, at the implied commodity price, divided by the CRC. The effect of an exchange-rate fluctuation is in fact proportional to the commodity price used by the EC for the VI setting, again deflated by the CRC. The implied commodity price (IPr) is defined as the price c.i.f. Rotterdam that would have generated the observed levy, given the values of the CAP variables, and it is defined in eq. (A8):

$$\text{IPr}_{c,\text{DM},t-1} = [T_{c,\text{ECU},t} - \text{VI}_{c,\text{ECU},t}] \cdot \text{MC}_{\text{FRG},t} \cdot \text{GER}_{\text{DM},t} \cdot \text{CRC}_{t-1}. \qquad \text{(A8)}$$

As for the commodity hedge, the desired currency futures position in a risk-minimizing strategy is obtained by multiplying the naive position by the most recent estimate of the risk-minimizing currency hedge ratio.

A numerical example is now presented. It is based on the actual data for the last two observations used in the study, May 17 and May 24, 1990. The initial values of the relevant variables are: $\text{VI}_t = 132.60$ ECU/ton, $\text{FP}_{c,t} = 2.8475$ US$/bu., $\text{ER}_{\text{IMM},t} = 0.6085$, $\text{ER}_t = 0.6095$. One week later, the variables remained unchanged, the data are: $T = 228.22$ ECU/ton, $\text{MC} = 1$, $\text{GER} = 2.3736$ DM, $\text{CRC} = 1.145109$. All data are consistent with the lag structure implied by the timing of the CAP. A hedger adopting a naive strategy would, therefore, sell $(1/1.1451) = 0.87$ bushel of corn and buy $(228.22\text{–}132.60) \cdot 2.3736/39.368 = 5.77$ Deutsche marks for each bushel of corn to be imported.

The result of this strategy results in a profit of $-(2.7475 - 2.8475)/(0.5987 \cdot 1.145109) = 0.1459$ DM/bu. from the commodity futures position (eq. (A6)), and a loss of $[(0.5977\text{-}0.6085)/0.5987] \cdot (228.22 - 132.60) \cdot 2.3736/39.368 = -0.1040$ DM/bu. from the currency futures position (eq. (A7)) for a total profit of 0.0419 DM/bu. The observed VI increase of 1.02 ECU/ton is equal to 0.0612 DM/bu. In this example, then, a niave hedge reduces the VI increase by $(0.0419/0.0612) \times 100 = 68.5\%$. In the case of a risk-minimizing strategy, using the hedge ratios reported in Table I as an example, the commodity position is equal to 92.1% of the naive one, whereas the currency position is equal to 100.7% of it. The total profit from the risk-minimizing strategy is, therefore, equal to 0.0292 DM/bu., or 47.7% of the VI increase.

Finally, the variables used in eq. (3) in text may be found by partially differentiating IPr, as is done for the VI in eqs. (A2′) to (A7). The two independent variables may be obtained by multiplying (A6) and (A7) by CRC_{t-1}. The dependent variable in eq. (3) is obtained from the first differences of (A8). All variables used in eq. (3)

are calculated net of changes in the threshold price and central rate coefficient. The observed changes in the implied price are then regressed over $d\mathrm{IPr}_c$ and $d\mathrm{IPr}_{er}$ to obtain an estimate of $\beta_{\mathrm{IPr},c}$ and $\beta_{IPr,er}$, the risk-minimizing hedge ratio for the implied price risk. In the case of a long commodity position, a naive hedge would, therefore, be short the quantity of cereal to be imported and long the Deutsche mark value of the commodity at the implied price in marks. Risk-minimizing positions may be calculated, as is done for the VI, by multiplying the naive positions by the latest available hedge ratio.