Hedging Foreign Currency, Freight and Commodity Futures Portfolios: A Note

by

Michael S. Haigh and Matthew T. Holt

WP 02-09

Department of Agricultural and Resource Economics
The University of Maryland, College Park

Hedging Foreign Currency, Freight and Commodity Futures Portfolios – a Note

Michael S. Haigh* and Matthew T. Holt**

Foreign exchange hedging ratios are simultaneously estimated alongside freight and commodity ratios in a time-varying portfolio framework. Foreign exchange futures are found to be by far the most important derivative instrument to be employed in order to reduce uncertainty for traders. Our results lend support to the decision by LIFFE to cease trading the BIFFEX freight futures contract because of its low levels of trading activity, which likely resulted from its apparent unattractiveness as a hedging instrument.

Manuscript Status: *The Journal of Futures Markets*, in press.

Acknowledgements: We would especially like to thank David Dickey, Barry Goodwin, Tom Grennes, and seminar participants at the University of Arizona and North Carolina State University. We would also like to thank an anonymous reviewer and the editor for comments on an earlier version of the paper.

Michael S. Haigh (corresponding author)*	Matthew T. Holt**
Assistant Professor	Professor
Department of Agricultural and Resource Economics	Department of Agricultural and Resource Economics and Economics
2120 Symons Hall	North Carolina State University
University of Maryland	Raleigh, NC 27695-8109
College Park, MD 20742-5535	(919) 513-4605 (Tel)
(301) 405-7205 (Tel)	(919) 515-7873 (Fax)
(301) 314- 9091 (Fax)	Matt_Holt@ncsu.edu
mhaigh@arec.umd.edu	

Hedging Foreign Currency, Freight and Commodity Futures Portfolios – a Note

Foreign exchange hedging ratios are simultaneously estimated alongside freight and commodity ratios in a time-varying portfolio framework. Foreign exchange futures are found to be by far the most important derivative instrument to be employed in order to reduce uncertainty for traders. Our results lend support to the decision by LIFFE to cease trading the BIFFEX freight futures contract because of its low levels of trading activity, which likely resulted from its apparent unattractiveness as a hedging instrument.

Key Words: Foreign Exchange, Freight, Commodity, Futures, M-GARCH

1. Introduction

In recent years there has been an explosion in the growth and trading of futures contracts. Despite this, very few futures contracts ultimately succeed (Silber, 1981, and Carlton, 1984). Reasons for failure have ranged from bad contract design to allegations of market manipulation (to name just two reasons). Undoubtedly a market must satisfy most, if not all, of the desirable characteristics needed for a futures contract to succeed, but quite possibly no one characteristic may be more important than volatility in the underlying market. Simply put, the less volatility the less important the futures contract is order to hedge the underlying uncertainty. It is perhaps for this reason more than any other that researchers focus on the hedging effectiveness of a futures contract in reducing price uncertainty.

Interestingly, unlike most derivative contracts, the BIFFEX (Baltic International Freight Futures Exchange) contract, which began trading at the London International Financial Futures Exchange (LIFFE) in May of 1985, was typically used along side other contracts in a hedging scenario. The reason is simply because freight is just one of several possible types of uncertainty (along with foreign exchange and commodity price) in international trade. It was natural therefore for Haigh and Holt (2000) to jointly evaluate the role of freight and commodity derivative instruments (but not foreign exchange) for international traders using modern time-series techniques (specifically MGARCH models). Their research highlighted the importance of taking into account spillovers between markets and concluded that ignoring the use of freight futures contracts in a trading environment increased risk (decreased utility) by approximately 15%. However, their work, like other previous research, has not considered the possibility of hedging commodity price, freight rate, *and* foreign exchange rate risks simultaneously, in a time-varying setting. There has been a lack of work in this area even though there is an intuitively appealing (and documented) linkage between these different, yet related markets (e.g., Goodwin et al. (1990)). Moreover, it is these *three* markets that may be the most concern to international traders. Accounting for all sources of risk is vital when assessing the hedging potential of a particular contract, because the hedging effectiveness of a new contract may be reduced if other risks are accounted for especially if there is a link between these markets. This point was well illustrated by Gagnon et al. (1998) who suggested that estimation procedures that measure hedge ratios in isolation tend to over-estimate the number of futures contracts required to hedge the cash position. Simply stated, if there is a natural linkage between the markets a natural hedge may already in place reducing the necessity of a particular contract.

In this empirical application, we extend previous research by providing a complete framework for a trader exposed to foreign exchange, commodity and freight price risk, while at the same time allowing for time-varying dependencies between the prices. We do this by using MGARCH modeling techniques introduced by Engle (1982) and Bollerslev (1986) and compare these (in a similar fashion as Haigh and Holt (2000)) to the Seemingly Unrelated Regressions (SUR) and Ordinary Least Squares (OLS) approaches. By accounting for foreign exchange uncertainty in the trader's objective function, an added layer of complexity is introduced, as all dollar denominated prices become products of jointly distributed random variables. The resulting hedge ratios are thus complicated yet tractable functions of means and central moments of all prices, an issue not yet addressed in the time-varying hedging literature.

By accounting for all types of uncertainty we are able to truly isolate the role of the BIFFEX contract after other types of uncertainty have been hedged. Therefore we test Gagnon et al.'s (1998) assertion and also ask whether the true hedging effectiveness of a derivative instrument is reduced once other critical forms of risk have been accounted for. Building on work by Kavussanos and Nomikos (1999,2000) and Haigh and Holt (2000) we conclude that the BIFFEX freight contract is not a particularly effective hedging instrument when evaluated alongside other related contracts.[1] However, we show that omitting the foreign exchange futures contract for traders results in substantial increase in portfolio risk, and that the relative importance of the freight contract is even smaller (only about 6% increases in utility) than that reported in other studies once *all* aspects of potential risks have been hedged. Our finding supports the decision by LIFFE to cease trading the BIFFEX contract in April 2002 because of its low trading volume, which likely resulted from its apparent unattractiveness as a hedging instrument.

2. Theoretical Framework

In this application we follow Haigh and Holt (2000) by considering a two-period problem for a hedger but here we focus on a European purchaser of U.S. grain who is exposed to foreign exchange rate uncertainty. In period one, the trader plans to purchase grain at the U.S. Gulf but is unsure of the future cash grain price, $G_{i,}$, where i = corn (c), wheat (w) or soybeans (s). The trader is also unsure of the future cash freight rate for transporting the grain on Route 1: U.S. Gulf to Rotterdam, ($R1$), and the future spot foreign exchange rate (S) necessary to convert the traders home currency into dollars to pay for the transactions. In the first period (t-1) all decisions regarding futures positions are made, while in the second period (t) all uncertainties are resolved and the futures positions are liquidated when the spot transactions take place. We assume throughout that the quantity shipped remains constant at 50,000 metric tons (e.g., 1,835,000 bushels in the case of soybeans).

The trader has at least three futures contracts at his disposal with which to hedge price uncertainty. First, the futures contract on the underlying commodity in question denoted C_i; second, the BIFFEX contract, B, with which to hedge the freight price uncertainty; and finally, the foreign exchange futures contracts, F, used to exchange the traders home currency into U.S. dollars with which to pay for the cash transactions. The return realized on the *hedged* portfolio at time t for the trader is:

$$(1)\qquad p_t = -G_{it}S_t - R1_t S_t + b_1(C_{it-1}S_{t-1} - C_{it}S_t) + b_2(B_{t-1}S_{t-1} - B_t S_t) + b_3(F_{t-1}G_{it-1} - F_t G_{it}),$$

where p_t is the total return (per ton) on the purchase of the commodity and b_1, b_2 and b_3 are the commodity, freight and foreign exchange futures positions (positive if short, negative if long). At time t, the trader pays $G_{it}S_t$ for grain purchased at the Gulf. Locking into futures contracts at time t-1 for price $C_{it\text{-}1}$ and depositing the required amount into a margin account could hedge part of that uncertainty. The proportion hedged is b_1. As futures contracts are denominated in U.S. dollars, the margin value of the futures contracts must be converted to U.S. dollars by multiplying the value by the current spot rate, $S_{t\text{-}1}$. At time t the grain trader would liquidate the futures contracts at price C_{it}, convert any proceeds from the margin account into the trader's home currency by multiplying by the spot exchange rate, S_t, and then purchase the entire unhedged position at the Gulf in U.S. dollars.[2] For ocean freight, the trader would go long BIFFEX contracts at time t-1 and resell the contracts at time t. As BIFFEX futures contracts are also denominated in U.S. dollars, the value of the futures contracts must be also converted to U.S. dollars by multiplying by the current spot rate, $S_{t\text{-}1}$. The last term in (1) determines the optimal number of foreign exchange futures contracts to be used for hedging foreign exchange risk. The foreign exchange futures prices are multiplied by the grain prices to provide an indication of the number of dollars needed for the expected grain purchases (because the hedge units must be determined *a priori* in practice).

The mean-variance framework enables one to easily incorporate transaction costs into the analysis (Kroner and Sultan, 1993; Gagnon et al., 1998). Assuming that our representative trader maximizes a mean-variance utility function, the problem is to select the optimal futures position, b_j, where j = grain (1), BIFFEX (2) or foreign exchange (3), for each contract, so as to maximize second-period utility adjusted for transaction costs:

$$\text{(2)} \qquad \underset{\beta_1,\beta_2,\beta_3}{\text{Max}}\, \boldsymbol{U}_{\text{t}} = \underset{\beta_1,\beta_2,\beta_3}{\text{Max}} \left[\text{E}(\pi_{\text{t}} \mid \Omega_{\text{t-1}}) - \boldsymbol{\psi}_t - \frac{\lambda}{2}\sigma^2(\pi_{\text{t}} \mid \Omega_{\text{t-1}}) \right],$$

where E denotes the (conditional) expectation operator, σ^2 denotes the variance operator, Ω_{t-1} is the information set available at time t-1, λ is the risk aversion coefficient, and π_{t} is as defined in (1) and ψ_t represents transaction costs incurred per unit (metric ton). In this analysis the coefficient of absolute risk aversion, represented by λ, was set equal to two, which is a level that is in line with most studies incorporating risk into the mean variance framework (see e.g., Kroner and Sultan, 1993). The variance of the return in equation (2) may be written as:

$$\text{(3)} \qquad \begin{aligned} \sigma^2(\pi_{\text{t}}) = {} & \sigma^2_{\text{G}_{\text{it}}\text{S}_{\text{t}}} + \sigma^2_{\text{R}_{\text{it}}\text{S}_{\text{t}}} + b_1^2\sigma^2_{\text{C}_{\text{it}}\text{S}_{\text{t}}} + b_2^2\sigma^2_{\text{B}_{\text{t}}\text{S}_{\text{t}}} + b_3^2\sigma_{\text{F}_{\text{t}}\text{G}_{\text{it}}} + 2\sigma_{\text{G}_{\text{it}}\text{S}_{\text{t}},\text{R}_{1\text{t}}\text{S}_{\text{t}}} + 2b_1\sigma_{\text{G}_{\text{it}}\text{S}_{\text{t}},\text{C}_{\text{it}}\text{S}_{\text{t}}} \\ & + 2b_2\sigma_{\text{G}_{\text{it}}\text{S}_{\text{t}},\text{B}_{\text{t}}\text{S}_{\text{t}}} + 2b_3\sigma_{\text{G}_{\text{it}}\text{S}_{\text{t}},\text{F}_{\text{t}}\text{G}_{\text{it}}} + 2b_1\sigma_{\text{R}_{1\text{t}}\text{S}_{\text{t}},\text{C}_{\text{it}}\text{S}_{\text{t}}} + 2b_2\sigma_{\text{R}_{1\text{t}}\text{S}_{\text{t}},\text{B}_{\text{t}}\text{S}_{\text{t}}} + 2b_3\sigma_{\text{R}_{1\text{t}}\text{S}_{\text{t}},\text{F}_{\text{t}}\text{G}_{\text{it}}} \\ & + 2b_1b_2\sigma_{\text{C}_{\text{it}}\text{S}_{\text{t}},\text{B}_{\text{t}}\text{S}_{\text{t}}} + 2b_1b_3\sigma_{\text{C}_{\text{it}}\text{S}_{\text{t}},\text{F}_{\text{t}}\text{G}_{\text{it}}} + 2b_2b_3\sigma_{\text{B}_{\text{t}}\text{S}_{\text{t}},\text{F}_{\text{t}}\text{G}_{\text{it}}}. \end{aligned}$$

The expression in (3) is a function of variances and covariances of *products* of stochastic variables that are, moreover, jointly distributed.[3] The first order conditions associated with maximizing (2) comprise a set of linear equations in the three unknowns: b_1, b_2, and b_3. Solving these equations for the three unknowns yields the optimal hedge ratios that would be employed by the trader (the complete derivations are excluded to conserve space). The components of each optimal hedge ratio are thus simply the variances and covariances of underlying prices, and the expected returns and λ. In the current application we retrieve variance-covariance estimates and forecasts of the returns from an MGARCH model.

Therefore the return on the portfolio is:

$$(4)\qquad \pi_t = -G_{it}S_t - R1_tS_t + b^*1(C_{it-1}S_{t-1} - C_{it}S_t) + b^*2(B_{t-1}S_{t-1} - B_tS_t) + b^*3(F_{t-1}G_{it-1} - F_tG_{it}) - y_t\,,$$

or for notational convenience: $p_t(b^*_i) - y_t$ if the trader updates, and

$$(5)\qquad \pi_t = -G_{it}S_t - R1_tS_t + b'_1(C_{it-1}S_{t-1} - C_{it}S_t) + b'_2(B_{t-1}S_{t-1} - B_tS_t) + b'_3(F_{t-1}G_{it-1} - F_tG_{it})\,,$$

or $\pi_t(b'_i)$ if the grain trader decides not to update, where b^*_i is the 'new' hedge ratio and b'_i is the hedge ratio from the most recent update. We assume that one round trip costs $25 for each contract for each market.[4] Importantly, care is taken in this analysis to only include the marginal cost associated with updating the portfolio. Similarly, for notational convenience, the conditional variance (i.e., equation (3)) of the trader's portfolio, if updating occurs, is simply denoted by $s^2(p_t(b^*_i))$. Likewise, if there is no updating the portfolio is denoted by $s^2(p_t(b'_i))$. Therefore in the expected utility framework the trader only updates at each time *t* if the following condition is satisfied:

$$(6)\qquad p_t(b^*_i) - y_t - \frac{l}{2}s^2(p_t(b^*_i) > p_t(b'_i) - \frac{l}{2}s^2(p_t(b'_i)\,.$$

3. Data and preliminary time-series analysis

Weekly Gulf prices covering the period May 17th 1985 – Jan 15th 1998 (where the last 73 observations were held back for out-of-sample forecasting) for corn (G_C), soybeans (G_S) and wheat (G_W) were obtained from the International Grains Council and United States Department of Agriculture. The

Baltic Exchange, LIFFE, and Clarkson Research Services provided data on freight cash (*R*1) and futures prices–BIFFEX (*B*). These data covered the same period of time as the Gulf data. The BIFFEX data starts with the nearest contract month, and runs until either the contract reaches its expiry date or until the first day of the actual contract month. The rationale behind constructing such a series is to avoid using data that may be affected by thin markets (see, e.g., Cecchetti et al., 1988). The daily data were converted to a weekly price by taking the settlement prices on the same day that the weekly grain prices were recorded (Thursday). *R1* is available in both index form and in U.S.$ per metric ton. The freight futures price is reported in index form, but, following Hauser and Neff (1993), is converted to a U.S. $ figure.

The Chicago Board of Trade (CBOT) futures prices were obtained from Datastream International for Corn (C_C), wheat (C_W), and soybean (C_S). These data were used to construct a series similar to that described for *B*. As trading in Euro futures is a relatively recent phenomenon, other currencies were tested for their correlation with the Euro spot rate. Accordingly, we find that the Deutschemark (DM) rate is highly correlated with the Euro spot rate (r = 0.968), and as such, this provides reliable proxy for the Euro foreign exchange rate against the dollar. DM futures data are therefore also constructed on a weekly basis along the same lines as the freight and grain futures contracts. Data for DM futures (*F*) and spot (*S*) prices were collected from Datastream International.

Each series described above was first tested for the existence of a unit root by using augmented Dickey and Fuller (1981) (ADF) tests. ADF test results indicate that all series are I(1). Johansen's (1988) cointegration procedure is also used to test for cointegration between pairs of cash and futures prices. Conditional variance dynamics of each individual series and results indicate substantial evidence of GARCH behavior in each case. Because no substantial deviations from normality are detected the multivariate systems are estimated under the assumption of normality.

4. Econometric methodology and model specification

In this application we employ positive definite MGARCH parameterization, which was introduced by Engle and Kroner (1995) (henceforth BEKK). In order to implement the BEKK model, it is necessary to jointly model the first two moments of the prices. All data are first differenced and if necessary the equations included an error correction term, to capture the cointegrating relationships. All mean equations were estimated as an AR(6) process—which was found to be suitable to render the residuals white noise—except for the foreign exchange rate equations, which were best described as martingale processes.[5] An MGARCH (1,1) model is used because of the substantial evidence that this model adequately characterizes the dynamics in second moments of prices (Kroner and Sultan 1993).

5. Estimation results

For all three traders' models (wheat, soybeans and corn), results were obtained from systems of equations estimated by using a nonlinear maximum likelihood estimation routine.[6] Mean equation results indicate that several lagged prices have significant impact on current prices. Of particular interest, however, are the variance-covariance parameter estimates. The spillover terms in the conditional covariance matrix for each model reveal many significant cross-equation influences, therefore lending support to the less restrictive BEKK structure.[7]

To highlight a few examples, there are significant linkages between $R1$ (cash freight) and the foreign exchange price innovations in the models. This result confirms the intuitively appealing link between freight prices and foreign exchange rates. That is, as most ship owners are not U.S. based and as freight rates tend to be denominated in dollars, any variability in the value of the dollar may have a significant effect on the conditional volatility of freight rates. There are also significant spillovers between the commodity prices and the foreign exchange rate. The Gulf price is clearly a function of many variables, but any appreciation/depreciation of the dollar will affect the 'real price' of grain for a trader whose home currency is not the U.S. dollar. Moreover, as the Gulf price fluctuates, the demand for shipping (and hence price of freight) may also be affected. The significance of the parameter associated with this effect highlights this linkage. Finally, and perhaps more intuitively, there is strong covariability between $R1$ and B, as illustrated by the significance of that parameter. This result is not surprising because $R1$ had a significant weight in the BPI, which formed the basis of trading in the freight futures market. Finally, with regards to the estimation procedure, results of several diagnostic tests for each model suggest that given the complexity of the models, the MGARCH specification works very well.[8]

6. Comparisons of hedging performance

For comparative purposes, basic OLS models and SUR models are also estimated. The SUR framework essentially entails modeling a system of OLS equations jointly but allowing for contemporaneous correlation between the disturbances in the equations. The SUR model facilitates a determination of how much advantage (if any) there is to estimating hedge ratios jointly while restricting the variances and covariances to be constant. Comparing the MGARCH model with the SUR model allows us to determine whether there is any advantage of estimating the variances and covariances jointly and allowing them to time-vary. Estimating the OLS model also permits another useful benchmark in the sense that it is identical to the SUR approach when we do not allow for contemporaneous correlation and restrict the speculative components to zero.

If there is not a statistical difference detected between these approaches then there is unlikely to be an economic difference and so the rewards to hedging using an MGARCH framework are likely to be low. Therefore Likelihood Ratio (LR) tests are first applied to compare the models. Results indicate that the MGARCH approach provides significantly more explanatory power. For instance, in comparing the MGARCH with the SUR model for all three models (wheat, soybeans and corn) LR test statistics were: 698.12, 638.82 and 1105.72 (with 91 degrees of freedom). Distributed as a Chi-square, these constrained models were rejected with a *p*-value of 0.000. Therefore, from a statistical standpoint it is imperative for trader to not only allow for interactions between the markets but to allow these interactions to time-vary.

A trader is more likely to be interested in economic differences between the competing approaches. For this reason hedge ratio simulations are undertaken for two time horizons: one in sample, the other out-of-sample. But as out-of-sample forecasts are designed to provide a more accurate assessment of hedging performance, we focus on these results.[9] Therefore, for each trader model and each econometric methodology, a forecast is made of the hedge for each week using the out-of-sample data. The subsequent week each model is re-estimated (with the new observation included) and the experiment repeated until 73 forecasts for each model are generated. Table 1 provides a summary of the hedge ratios. Likewise, evaluations of hedge ratio performance are reported in Table 2. While the variance-covariance matrix estimated from the six-equation SUR model is constant, the hedge ratios generated for the trader are in fact time-varying.[10] However, while the SUR hedge ratios are non-constant they do not vary as much as do those for the MGARCH model. Also, because new data are added each week the OLS hedge ratio, like the SUR and MGARCH methodologies, will experience some variability (albeit small) in the out-of-sample analysis.

Results presented in Table 1 illustrate the average hedge ratios generated for all three econometric specifications (OLS, SUR and MGARCH) for each of three trader models. It is clear that the average hedge ratios for the underlying commodity generated from the MGARCH and SUR methodologies differ from those generated by OLS. The only exception is the recommended grain hedge ratio of –0.536 for the MGARCH corn model, which is much closer to the recommended ratio of –0.675 suggested by the OLS model. The hedge ratios for each of the econometric models imply that the trader should take the intuitively correct position in each market to hedge portfolio risk, that is, go long in each of the futures market (negative sign). Surprising is the lack of importance of the CBOT (C_i) grain contracts for two of the portfolios. In particular, only 1.7% and 2.7% of the exposed cash positions should be hedged with CBOT contracts for the MGARCH framework in model I (wheat) and model III (soybeans) respectively, suggesting that for some markets the grain price uncertainty may be naturally hedged by freight and foreign exchange contracts. This is a result that is not picked up by Haigh and Holt (2000) as their model focused on a trader that is insulated from foreign exchange rate risk. Thus, by ignoring spillovers, a trader may 'overhedge' in a particular market. So in this instance we confirm Gagnon et al.'s (1998) suggestion that estimation procedures, generating hedge ratios in isolation (such as OLS), tend to over-estimate the number of futures contracts required to hedge the cash position. Interestingly however, for the case of the foreign exchange rate market, the recommended average MGARCH hedge ratio is –1.109 , –1.127 and –0.617 for the wheat, soybean and corn trader models, respectively. This compares to a lower recommended average hedge ratio of –0.923 in the OLS model.

Following Baillie and Myers (1991), and Gagnon et al. (1998), our evaluation proceeds under the assumption that the MGARCH specification is the correct probability model for the commodity, freight and foreign exchange prices. The 'full hedge' model, where the representative importer utilizes all available derivative instruments (freight, commodity and foreign exchange), is analyzed under the competing methodologies. Several 'partial hedge' models are also examined, where the trader utilizes just two of the available derivative instruments. Calculating the performance of the partial hedge in comparison to the full hedge then allows one to isolate the marginal contribution of the excluded contract.

To perform this analysis, utility derived from each commodity model is calculated over the entire period, and then averaged. The performance of the different hedge methods is then evaluated by computing the percentage improvement in utility compared to the unhedged case. Average utility for each portfolio (either full or partial) calculated from, respectively, the unhedged, OLS, SUR, or MGARCH models, is reported in Table 2. Also reported are the incremental utility increases (I.U.I.) vis-à-vis the unhedged portfolio, and the I.U.I. vis-a-vis the OLS model. The I.U.I. against the unhedged portfolio allows one to evaluate the 'marginal contribution' of a particular derivative instrument across and within models. The I.U.I. against the OLS model illustrates how much extra utility can be obtained by adopting the SUR or MGARCH methodologies.

As reported in Table 2, if by following this strategy over the 73 week forecast horizon the trader would still have been better off updating each period with the MGARCH model even after accounting for transaction costs. This result follows because the average utility obtained even after taking into account transaction costs still substantially outperforms the other econometric methods for all commodities. Alternatively, if the trader had followed the same strategy but had employed the SUR methodology to the full model, updating would have occurred 10 times for model I, 12 times for model II, and 10 times for model III. Even at that, the portfolio performance is superior to that obtained by using the OLS framework, confirming the importance of accounting for spillovers (albeit non time-varying).

When the BIFFEX freight futures market is not included in the portfolio (partial hedge A), performance does decline slightly vis-à-vis the unhedged portfolio. Specifically, the performance of the

MGARCH model in the full model implies an improvement over the unhedged portfolio by 74.60%. This percentage declines in partial hedge A to 68.26%, implying a marginal contribution of about 6.3% of the freight contract in the MGARCH framework. Similar magnitudes are found for models II and III, once again indicating some, albeit low importance of including freight futures contracts in the trader's portfolio. The BIFFEX contract seems to provide some limited help in managing price uncertainty when the OLS and SUR methodologies are employed. When the BIFFEX market is excluded the MGARCH model recommends less updating; however, lower utility levels are obtained relative to the full hedge model. Interestingly whereas Haigh and Holt (2000) reported a marginal contribution of the BIFFEX contract of about 15%, Kavusssanos and Nomikos (2000) report reductions in variance of about 18% (depending on the shipping route). However, because Kavussanos and Nomikos (2000) studied the BIFFEX in isolation, and Haigh and Holt (2000) incorporated just one other source of risk, we might infer that after hedging all relevant elements of risk, the BIFFEX contract becomes less and less essential.

The contribution of the commodity futures contracts varies across commodity and across econometric specification. For example, excluding the CBOT contract from the wheat, soybean and corn trader's MGARCH portfolio requires a decrease of utility of 0.45%, 8.74% and 9.83% respectively suggesting a slightly greater level of importance of hedging this element of uncertainty for these commodities compared to the BIFFEX. Moreover, unlike the BIFFEX market, these contracts are obviously useful in other risk management settings other than international trade (as suggested by their non-trivial trading volume at the CBOT). Ignoring the potential usefulness of the foreign exchange contract is the most detrimental omission. For the wheat, soybean, and corn traders, respectively, the foreign exchange contract contribution ranges from 29.3% to 76.2% in the MGARCH setup. The comparable contribution for the OLS model ranges from 49.94%, to –18.03% (again implying performance improves after its omission) and 7.78% for model I, II and III, respectively. Finally, for the SUR approach the foreign exchange futures contract contributes 58.39%, 55.91% and 44.76% respectively.

The incremental utility increase against the OLS model confirms previous results suggesting the importance of incorporating time-varying covariability in optimal hedge ratio estimation. In the full model, the MGARCH procedure provides a further 19.38%, 75.22% and 32.90% increase in utility for the wheat, soybean and corn traders respectively. Moreover, these results once again suggest that, although taking into account covariability and updating forecasts of cash and futures prices has a positive effect on reducing risk as shown in the SUR model results, it is the incorporation of time-varying *covariability* between cash and futures prices that leads to greater gains for international grain traders.[11]

7. Conclusion

In this note we examine linkages between freight, commodity, and foreign exchange prices and relax the assumption that cash and futures prices are independently distributed. Because we examine hedging for a prototypical trader purchasing grain at U.S. ports, our model includes exchange rate uncertainty in addition to freight rate and commodity price uncertainty. The implication is that the grain importer's expected utility function includes products of jointly distributed random variables which, moreover, posses time-varying covariability. Therefore, unlike previous studies that have sought to capture portfolio effects, the hedge ratios derived here are complicated albeit manageable functions of time-varying variances and covariances of *products* of random variables. These products are themselves functions of means and central moments of the underlying cash and futures prices.

The results we report here confirm that the assumption of independence is erroneous and incorporating more realistic assumptions regarding the co-dependency of prices directly into the hedging paradigm yields rewards in terms of risk reduction for traders. This research has also confirmed Haigh and Holt's (2000) finding that—despite the fact that frequent portfolio updating recommended by the MGARCH model may be more expensive than traditional modeling mechanisms such as OLS—the rewards in terms of reduced variability, and hence extra utility, considerably outweigh the extra transaction costs associated with doing so. This was found to be true for each commodity model evaluated. Also, the relative importance of each derivative contract in the overall portfolio for a trader was isolated.

Perhaps most crucially, this research has illustrated that the BIFFEX contract is not as important a hedging instrument when evaluated alongside other contracts for traders. While the commodity futures contracts are shown to be only slightly more important in this setting, these contracts are obviously vital in other risk management scenarios, and the volume of trade in these contracts at the CBOT supports this argument. However, unlike other contracts the BIFFEX freight futures contract is only used for hedging in international trade, and would likely be used alongside other derivative instruments. We find that once other types of risks have been accounted for, the importance of the BIFFEX contract declines (because natural hedges from other markets seems to occur) which may help explain its decline in popularity. Consequently these results may shed some light on why the contract now ceases to exist after seventeen years of trading. Importantly, our results suggest that of all three hedging instruments considered, omitting the foreign exchange contract from the trader’s portfolio is by far the most detrimental in terms of risk management.

Table 1
Out-of-Sample Average Hedge Ratios

	Freight hedge ratio	Grain hedge ratio	FOREX hedge ratio
Model I			
(Wheat)			
OLS	-0.340	-0.463	-0.923
	(0.000)	(0.000)	(0.000)
SUR	-0.371	-0.010	-0.866
	(0.000)	(0.000)	(0.000)
MGARCH	-0.361	-0.017	-1.109
	(0.013)	(0.015)	(0.015)
Model II			
(Soybeans)			
OLS	-0.340	-1.006	-0.923
	(0.000)	(0.001)	(0.000)
SUR	-0.360	-0.164	-0.748
	(0.000)	(0.002)	(0.002)
MGARCH	-0.444	-0.027	-1.127
	(0.051)	(0.546)	(0.632)
Model III			
(Corn)			
OLS	-0.340	-0.675	-0.923
	(0.000)	(0.000)	(0.000)
SUR	-0.378	-0.006	-0.809
	(0.000)	(0.000)	(0.000)
MGARCH	-0.339	-0.536	-0.617
	(0.006)	(0.310)	(0.379)

Figures in parenthesis are variances.

Table 2
Out-of-Sample Hedge Performance

	Model I (Wheat)			Model II (Soybean)			Model III (Corn)		
	Utility	I.U.I unhedged	I.U.I OLS	Utility	I.U.I unhedged	I.U.I OLS	Utility	I.U.I Unhedged	I.U.I OLS
Full Model: Using all three derivative contracts – freight, commodity and foreign exchange contracts									
Unhedged	-22210.8			-43732.8			-19231.9		
OLS	-6996.5 (3)	68.50%		-23300.8 (18)	46.72%		-9605.9 (3)	50.05%	
SUR	-6429.6 (10)	71.05%	8.10%	-8340.6 (12)	80.93%	64.20%	-8010.7 (10)	58.35%	16.61%
MGARCH	-5640.6 (73)	74.60%	19.38%	-5774.0 (73)	86.80%	75.22%	-6445.3 (73)	66.49%	32.90%
Partial Model (A): Using two derivative contracts – excluding the freight futures contract									
Unhedged	-22210.8			-43732.8			-19231.9		
OLS	-8446.5 (4)	61.97%		-25828.7 (20)	40.94%		-10226.2 (3)	46.83%	
SUR	-8184.0 (25)	63.15%	3.11%	-10489.7 (31)	76.01%	59.39%	-9110.9 (23)	52.63%	10.91%
MGARCH	-7049.6 (56)	68.26%	16.54%	-8675.0 (57)	80.16%	66.41%	-7712.02 (43)	59.90%	24.59%
Partial Model (B): Using two derivative contracts – excluding the commodity futures contract									
Unhedged	-22210.8			-43732.8			-19231.9		
OLS	-6306.3 (39)	71.61%		-8424.74 (38)	80.74%		-8218.1 (35)	57.27%	
SUR	-6492.6 (37)	70.76%	-2.95%	-10394.9 (31)	76.23%	-23.39%	-8169.3 (37)	57.52%	0.59%
MGARCH	-5742.4 (56)	74.15%	-8.94%	-9595.9 (38)	78.06%	-13.90%	-8355.3 (31)	56.55%	-1.67%
Partial Model (C): Using two derivative contracts – excluding the foreign exchange futures contract									
Unhedged	-22210.8			-43732.8			-19231.9		
OLS	-16733.2 (50)	24.66%		-13659.5 (38)	68.77%		-11101.8 (47)	42.27%	
SUR	-19398.5 (43)	12.66%	-15.93%	-32790.0 (40)	25.02%	-140.05%	-16618.3 (39)	13.59%	-49.69%
MGARCH	-19284.7 (40)	13.17%	-15.24%	-39101.6 (38)	10.59%	-186.26%	-12075.5 (39)	37.21%	-8.77%

This table displays the utility derived from the portfolio assuming that the grain trader rebalances the portfolio only when the potential increase in utility derived exceeds the transactions costs that would be incurred from adjusting the holdings of futures contracts. The utility (taking into transaction costs) is computed from equation (2). Transaction costs are assumed to be $25 per round-turn. The number of portfolio rebalancings is given in parenthesis.

References

Baba, Y., Engle, R.F., Kraft, D.F., and Kroner, K.F., 1989. Multivariate Simultaneous Generalized ARCH. unpublished manuscript, University of California, San Diego, Dept of Economics.

Bollerslev, T., (1986). Generalized Autoregressive Conditional Heteroskedacity. *Journal of Econometrics* 31, 301-327.

Borhrnstedt, G.W., and Goldberger, A.S., (1969). On the Exact Covariance of Products of Random Variables. *Journal of the American Statistical Association* 64, 1439-42.

Carlton, D.W., (1984). Futures Markets: Their Purpose, Their History, Their Growth, Their Successes and Failures. *The Journal of Futures Markets*. 4, 237 – 271.

Cecchetti, S.G., Cumby, R.E., and Figlewski, S., (1988). Estimation of the Optimal Futures Hedge. The *Review of Economics and Statistics* 70, 623-630.

Dickey, D.A., and Fuller, W., (1981). Likelihood Ratio Tests for Autoregressive Time Series with a Unit Root. *Econometrica* 49,1057-1072.

Engle, R.F., (1982). Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of U.K. Inflation. *Econometrica* 50, 987-1008.

Engle, R.F., and Kroner, K.F., (1995), Multivariate Simultaneous Generalized ARCH. *Econometric Theory* 11,122-150.

Gagnon, L., Lypny, G.J., and McCurdy, T.H., (1998). Hedging Foreign Currency Portfolios. *Journal of Empirical Finance* 5, 197-220.

Goodman, L.A., (1960). On the Exact Variance of Products. *Journal of the American Statistical Association* 55, 708-713.

Goodwin, B.K., T. Grennes., and M.K. Wohlgenant., (1990). Testing the Law of One Price when Trade Takes Time. *Journal of International Money and Finance* 9, 21 – 40.

Haigh, M.S., and M.T. Holt., (2000). Hedging Multiple Price Uncertainty in International Grain Trade. *American Journal of Agricultural Economics* 82, 881 – 896.

Hauser, R.J., and Neff., D., (1993). Export/Import Risks at Alternative Stages of U.S. Grain Export Trade. *The Journal of Futures Markets* 13, 579-595.

Johansen, S., (1988). Statistical Analysis of Cointegration Vectors. *Journal of Economic Dynamics and Control* 52, 169-210.

Kavussanos, M., and N.Nomikos., (1999). Futures Hedging when the Structure of the Underlying Asset Changes: the case of the BIFFEX contract. *The Journal of Futures Markets* 20, 775 – 801.

Kavussanos, M., and N.Nomikos., (2000). Constant vs. Time-Varying Hedge Ratios and Hedging Efficiency in the BIFFEX Market. *Transportation Research: Part E: Logistics and Transportation Review* 36, 229 – 248.

Kroner, K.F., and Sultan, J., (1993). Time Varying Distributions and Dynamic Hedging with Foreign Currency Futures. *Journal of Financial and Quantitative Analysis* 28, 535-551.

Lypny, G., and Powalla, M., (1998). The Hdging Effectiveness of DAX Futures. *The European Journal of Finance* 4, 345 – 355.

Silber, W.L., (1981). Innovation, Competition and New Contract Design in Futures Markets. *The Journal of Futures Markets* 1, 123 – 155.

Tong, W., (1996). An Examination of Dynamic Hedging. *Journal of International Money and Finance* 15, 19-35.

Endnotes

1. As the BIFFEX contract is based on a basket of dry-bulk shipping routes that comprise the Baltic Panamax Index (BPI) and because shipping route prices often move quite independently from one another, hedging a particular route that is part of the BPI may not be a perfect, making the hedge less appealing, and the volume of trading lower. For instance, over the period 1996 – 2000, the average trading volume was only 146 contracts. The monetary value of these contracts roughly corresponds to the cost of shipping 108,000 tons of grain from the U.S. to Japan. In 1995 trading began in over-the-counter (OTC) derivatives like Freight Forward Agreements (FFA's) and has since witnessed remarkable growth since. Indeed, many practitioners suggest that this was part of the reason that in June 2001, LIFFE, the authority regulating the BIFFEX contract, announced that trading in the BIFFEX contract would cease in April 2002.

2 . Here we ignore any opportunity gains or losses associated with interest rates on the margin account.

3. For the general case of jointly distributed random variables x and y, Goodman (1960) derives the exact variance of a product xy as: $V(xy) = E^2(x)V(y) + E^2(y)V(x) + 2E(x)E(y)C(x,y) + V(x)V(y) + C^2(x,y)$, where we denote $E(x)$ and $E(y)$ as the expectations of jointly distributed random variables x and y, $V(x)$ and $V(y)$ as the variances of x and y, and $C(x,y)$ as their covariance. Bohrnstedt and Goldberger (1969) extend Goodman's results to derive the exact covariance of two products xy and uv and applying asymptotic approximation procedure, yield the expression for the covariance of covariance of xy with uv: $C^*(xy,uv) = E(x)E(u)C(y,v) + E(x)E(v)C(y,u) + E(y)E(u)C(x,v) + E(y)E(v)C(x,u)$, where $C^*(.,.)$ denotes an approximate covariance. These are the exact expressions for the product of random variables that are used throughout this paper.

4. As the quantity being shipped is assumed to be 50,000 tons (or 1,965,000 (corn) bushels) a *full* CBOT hedge would imply a total of (1,965,000/5000) ≈ 393 contracts, at a cost of $9,825. The number of freight and foreign exchange contracts required for a full hedge is more complicated to calculate at each time t because both are functions of prices, unlike the CBOT commodity contracts which are fixed in quantity. Nonetheless, assume a level of the BPI of 925, and a cash price of freight of $7.30 per metric ton. In this case the recommended *full* hedge would be ($7.30(50,000))/925(10) ≈ 39 contracts or $975 as the value of a BIFFEX contract is calculated

by taking the level of the BPI and multiplying by \$10. The number of foreign exchange contracts needed by the trader is a function of the Gulf price. Therefore, assuming a cash price of \$2.67 per bushel for corn (or \$105 per ton), and that 1,965,000 bushels will be purchased, the expected dollar purchase will be ≈ \$5,246,550. At a U.S./DM exchange rate of 0.33, the number of contracts required for a *full* hedge would be 15,898,636DM/125,000DM ≈ 127 contracts totaling about \$3179. Therefore, assuming a full hedge in each market, the total cost would be approximately \$13,979 (or 42,362 DM). On a per ton basis this implies that the cost of full hedging is just \$0.27 or about 0.85 DM. If the expected price per ton is \$105 (318.18 DM), transaction costs are approximately 0.003 percent of the total value.

5. Following Tong (1996), the MGARCH structure used here has an AR representation in the mean equation to capture residual serial correlation. Seasonality was also tested for by applying harmonic variables set at quarterly and monthly cycles to each of the commodity and freight equations. Specifically, where the harmonic variables used are SIN1 = $\sin(2\pi t/13)$, COS1= $\cos(2\pi t/13)$ and SIN2 = $\sin(2\pi t/4)$, COS2 = $\cos(2\pi t/4)$, $t = 1,\ldots,T$ to represent quarterly and monthly seasonality respectively. Results indicated at all conventional significance levels that there was no evidence of remaining unexplained seasonality.

6. Given the large number of parameters and the fact that several versions of the models were constructed (one per commodity), tables reporting all parameter estimates are excluded to conserve space. These results are however available upon request.

7. An MGARCH linear diagonal specification was also estimated. Results from likelihood ratio tests confirm that for all three models (wheat, soybeans and corn) the BEKK is superior to the parsimonious alternative.

8. Skewness and kurtosis estimates indicate some departures from normality in the standardized residuals, as confirmed by Jarque-Bera normality tests but tests for remaining residual autocorrelation in the standardized residuals, squared standardized residuals, and their crossproducts, show, for the most part (after excluding a trivial set of outliers), that there are no serious misspecifications of the conditional mean and variance dynamics in the estimated models.

9. In-sample results are qualitatively similar to the out-of-sample results and are also available upon request.

10. The asymptotic expressions for the variance and covariance of products of random variables contains expressions for the variances and covariances of the prices, and expected values of the prices (see Footnote 3). As the expected values are forecasted values, the variance and covariance expressions for products of random variables will time-vary as a result of the updated forecasts.

11. As suggested by an anonymous reviewer, it may also be of interest to know whether utility values across models are statistically different. To this end, following Lypny and Powalla (1998) we conduct sign tests for the difference between expected and realized utility. Results suggest that the MGARCH approach significantly outperformed alternatives when foreign exchange risk was accounted for. However, after excluding the foreign exchange rate futures contracts performance declined and the MGARCH approach was outperformed by simpler alternatives. On several occasions the OLS and SUR performances were statistically similar.