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Comparing Hedging Effectiveness: An Application of the Encompassing Principle

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An empirical methodology is developed for statistically testing the hedging effectiveness among competing futures contracts. The presented methodology is based on the encompassing principle, widely used in the forecasting literature, and applied here to minimum variance hedging regressions. Intuitively, the test is based on an alternative futures contract's ability to reduce residual basis risk by offering either diversification or a smaller absolute level of basis risk than a preferred futures contract. The methodology is easily extended to cases involving multiple hedging instruments and general hedge ratio models. Empirical applications suggest that the encompassing methodology can provide information beyond traditional approaches of comparing hedging effectiveness.

Key words: cross-hedging, encompassing, hedging effectiveness

Introduction

Minimum variance measures of hedging effectiveness have not changed dramatically since Ederington's (1979) initial use of the correlation coefficient to measure the relationship between changes in cash and futures prices. In fact, minimum variance hedging effectiveness is most commonly evaluated through an ordinary least squares (OLS) regression of the change in cash price as a linear function of the change in the futures price (Leuthold, Junkus, and Cordier, 1989, p. 92), where the resulting R^2 is the measure of hedging effectiveness (Hull, 2002, p. 85).

The use of this measure is commonplace in the futures literature (see Ferguson and Leistikow, 1998; Martinez-Garmendia and Anderson, 1999), and it is routinely used by practitioners in many settings (e.g., Sparks Companies, Inc., 2001). For instance, a producer of sunflower seeds may want to know if cross-hedges should be placed in the Winnipeg canola futures market, the Chicago soybean futures market, or a composite hedge using both markets. Similarly, hedgers may be faced with the choice of determining which futures contract to use when similar futures contracts are listed on different exchanges, such as the case with wheat (e.g., Kansas City versus Chicago), stock indices (e.g., S&P 500 futures versus DJIA futures), and interest rate instruments (e.g., T-bill futures versus Eurodollar futures). Moreover, futures exchanges often want to evaluate the hedging effectiveness of a new or proposed futures contract (or contract specification

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changes) relative to existing contracts. In each of the above cases, the decision maker must decide if one futures contract provides an advantage over another in terms of reducing market price exposure or increasing hedging effectiveness.[1]

While the casual comparison of R^2 values from the common hedging regression can be useful in evaluating hedging effectiveness, usually no attempt is made in this type of analysis to determine if the results are statistically significant. In other words, is the hedging performance of one contract statistically superior to another in terms of risk reduction? Clearly, this is a crucial question for developers and potential users of futures markets. This is especially true given that traditional futures exchanges face increasing competition from electronic markets and hedgers need to identify the most "effective hedge" to gain favorable accounting treatment under Financial Accounting Standard 133 (International Treasurer, 1998). If a new or competing futures market does not provide a statistically and economically significant reduction in residual basis risk (i.e., greater hedging effectiveness), then it is unlikely to be utilized by practitioners.[2] Thus the economic improvement, or lack thereof, is an important consideration when evaluating the performance of proposed or new futures contracts, multiple cross-hedges, and competing futures contracts.

The objective of this research is to present an empirical methodology for evaluating alternative futures contracts in a hedging effectiveness framework. In doing this, we combine two somewhat disparate strands of literature: forecast evaluation and minimum variance hedging. The results are important because they provide a framework for statistical analysis, where academics and practitioners have often relied on casual or ad hoc comparisons. The presented methodology is easily implemented, and can be extended to a variety of applications. In this study, the methodology is illustrated through the comparison of two competing futures markets, the choice of multiple cross-hedges, and the evaluation of a proposed futures contract.

The remainder of the paper is structured as follows. First, the methodology is developed through a careful presentation and illustration of linkages between minimum variance hedging and forecast evaluation. Specifically, we show how the residual basis risk of competing futures contracts—resulting from an OLS regression of change in cash price on change in futures price—can be used in a forecast encompassing framework to determine if one of the competing futures contracts encompasses the other. Alternatively, a combination of futures contracts may minimize basis risk, suggesting the use of a composite hedge. Second, empirical applications of the methodology are provided in various situations where alternative hedges must be compared. Finally, conclusions as well as suggestions of how this proposed methodology could be used in other hedging applications are presented.

Minimum Variance Hedging and Forecast Encompassing

Ex post minimum variance hedge ratios are typically estimated with the following ordinary least squares regression (Leuthold, Junkus, and Cordier, 1989, p. 92):

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[1] The discussion and results in this paper extend to all hedging instruments (over-the-counter or exchange traded). However, for the sake of exposition, we will limit our discussion and examples to futures contracts.

[2] Of course, hedgers must consider the economic significance of the risk reduction as well as the costs associated with using a particular futures contract (Pennings and Meulenberg, 1997).

$$\Delta CP_t = \alpha + \beta \Delta FP_t + e_t, \tag{1}$$

where ΔCP_t and ΔFP_t are the change in the cash price (*CP*) and futures price (*FP*), respectively, over interval t. The parameter β is the ex post minimum variance hedge ratio, α is the systematic trend in cash prices, and e_t is the residual basis risk. Although there has been some debate over whether this model should be estimated in price levels, price changes, or percentage changes (Witt, Schroeder, and Hayenga, 1987), many researchers (e.g., Brorsen, Buck, and Koontz, 1998; Ferguson and Leistikow, 1998) have used price changes as shown in equation (1).[3] The R^2 from estimating equation (1) is a measure of hedging effectiveness, and it is often used to compare alternative hedging instruments (e.g., Ditsch and Leuthold, 1996). While this type of analysis is commonly used, it does not attempt to determine if the results are statistically significant. For instance, when comparing the hedging effectiveness of one futures contract to another using R^2, it is typically not reported whether one hedging instrument is statistically superior to the other with regard to risk reduction.

The *J*-test is one method of testing nonnested hypotheses among competing models (Davidson and MacKinnon, 1981). In the following analysis, statistical significance in comparing hedging performance between alternative contracts is addressed with a slight interpretive modification to the *J*-test discussed in Maddala (1992, p. 515). Namely, Maddala (p. 516) shows that the standard *J*-test is related to the optimum combination of forecasts. For example, assume there are two competing contracts available for hedging a cash transaction. A standard minimum variance regression is used to evaluate the hedging effectiveness of the incumbent or preferred contract,

$$\Delta CP_t = \alpha_0 + \beta_0 \Delta FP_t^0 + e_{0,t}, \tag{1a}$$

and the proposed or competing contract,

$$\Delta CP_t = \alpha_1 + \beta_1 \Delta FP_t^1 + e_{1,t}. \tag{1b}$$

The fitted values from the preferred contract, equation (1a), are represented by y_0, while the fitted values for the competing model in equation (1b) are denoted by y_1.[4] Actual realizations of the dependent variable are now represented by y. Given the fitted values from both the incumbent and competing models, and the actual realizations of the dependent variable, the following model can be estimated (Maddala, p. 516):

$$y - y_0 = \phi + \lambda(y_1 - y_0) + v. \tag{2}$$

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[3] Myers and Thompson (1989) suggest a generalized approach to estimating hedge ratios, where equation (1) would include other explanatory variables (e.g., lagged values of cash and futures prices). The estimated hedge ratio is then conditional as opposed to the unconditional version shown in equation (1). However, Myers and Thompson also argue that unconditional hedge ratios estimated with price changes provide a close approximation to conditional hedge ratios. Thus, for this research, it is assumed equation (1) is estimated with price changes, but the methodology is applicable to alternative specifications including conditional hedging regressions.

[4] The terms "preferred" and "competing" are commonly used in the forecast evaluation literature. This is purely a naming convention with respect to the encompassing methodology used, and does not reflect any a priori beliefs regarding the hedging performance of the alternative contracts examined.

In the context of hedging, $y - y_0$ is the residual basis risk of the preferred model, and $y_1 - y_0$ is the difference in fitted values between the competing and preferred models. If λ is not significantly different from zero, then the competing model does not add any explanatory power relative to the preferred model. Thus, in the context of a futures hedge, the statistical insignificance of λ (i.e., $\lambda = 0$) suggests the competing contract does not reduce residual basis risk beyond that provided by the preferred contract.

Adding λy to both sides of equation (2) and simplifying yields (Granger and Newbold, 1986, p. 268):

$$y - y_0 = \phi + \lambda[(y - y_0) - (y - y_1)] + v, \tag{3a}$$

where $y - y_0$ is again the residual basis risk of the preferred futures contract, and $y - y_1$ is the residual basis risk of the competing contract. Given that $y - y_0$ is the residual basis risk of the preferred futures contract [e_0 from equation (1a)], and $y - y_1$ is the basis risk for the competing contract [e_1 from equation (1b)], equation (3a) can be expressed in terms of forecast errors or, in the case of hedging, basis risk:[5]

$$e_{0,t} = \phi + \lambda[(e_{0,t} - e_{1,t})] + v_t. \tag{3b}$$

Equation (3b) is analogous to Harvey, Leybourne, and Newbold's (1998) regression-based test for forecast encompassing, where λ is the weight that should be placed on the competing model and $1 - \lambda$ is the weight that should be placed on the preferred model's forecast in constructing a composite forecast which minimizes mean squared forecast error. The null hypothesis that the preferred model "encompasses" the alternative ($\lambda = 0$) is tested with a two-tailed t-test.[6] Accepting the null hypothesis implies a composite forecast cannot be constructed from the two series that would result in a smaller expected squared error than using the preferred forecasts by themselves.

Placing this forecast encompassing framework into a hedging context is straightforward and intuitive. In particular, a failure to reject the null hypothesis that $\lambda = 0$ implies the competing futures contract provides no benefit in terms of reducing the residual basis risk associated with hedging in the preferred futures market—i.e., the preferred futures market "encompasses" the competing futures market. If $0 < \lambda < 1$, then some amount of hedging should be done in each market (a composite hedge), where λ is the weight assigned to the competing futures contract. Finally, if $\lambda = 1$, then the alternative or competing contract "encompasses" the preferred, and all the hedging should be done in the competing futures market.

As demonstrated by Maddala (1992, p. 516), the λ in equation (3b) that produces the minimum forecast error, or in this framework the minimum basis risk, can be written as:

$$\lambda = \frac{\sigma_{e_0}^2 - \rho_{e_0 e_1}}{\sigma_{e_0}^2 + \sigma_{e_1}^2 - 2\rho_{e_0 e_1}\sigma_{e_0}\sigma_{e_1}}, \tag{4a}$$

[5] Note, the presented analysis implicitly assumes the hedging is done using the minimum variance hedge ratios in equations (1a) and (1b). However, the results and methodology hold if the hedge ratios are restricted to one (unit-for-unit hedging).

[6] Harvey, Leybourne, and Newbold (1998) suggest a one-tailed test in the context of a composite forecast. However, in a hedging context, where negative hedge ratios can exist (Anderson and Danthine, 1981), a two-tailed test is more appropriate.

where σ^2, σ, and ρ are the variance, standard deviation, and correlation, respectively, among residual basis risk from the preferred (e_0) and competing (e_1) models. Furthermore, Maddala shows

$$\lambda \geq 0 \text{ iff } \frac{\sigma_{e_0}}{\sigma_{e_1}} \geq \rho_{e_0 e_1}, \tag{4b}$$

and

$$\lambda < 0 \text{ iff } \frac{\sigma_{e_0}}{\sigma_{e_1}} < \rho_{e_0 e_1}. \tag{4c}$$

The relationships expressed in (4b) and (4c) provide a concise and intuitive explanation of λ—the weight assigned to the competing futures market. The magnitude and sign of λ can be thought of as a tradeoff between the ability of the competing futures market to reduce the residual basis risk associated with the preferred futures market through diversification ($\rho < 1$), or by offering less absolute basis risk than the preferred futures contract ($\sigma_{e_0}/\sigma_{e_1} > 1$). Intuitively, a hedger has exchanged a portfolio of flat price risk for a portfolio of basis risk. From standard portfolio theory, the risk associated with the residual basis variation can be reduced by adding hedges that either offer less basis risk ($\sigma_{e_0} > \sigma_{e_1}$) and/or diversification benefits ($\rho_{e_0 e_1} < 1$).

This tradeoff is best illustrated through simple examples of equation (4). Consider the cases where $\rho_{e_0 e_1} > 0$. When $\rho_{e_0 e_1} = 1$, there is a perfect correlation in basis risk between the two futures contracts, and thus there are no diversification benefits from using the alternative futures market. In this instance, $\lambda > 0$ only if $\sigma_{e_0} > \sigma_{e_1}$. That is, in the absence of diversification benefits, the competing market only receives hedging weight if its basis risk is smaller than that of the preferred market. When $\rho_{e_0 e_1} = 0.5$, there are some benefits due to diversification of basis risk, so the competing market receives positive hedging weight ($\lambda > 0$) if its basis risk is less than twice the size of the preferred market's ($2\sigma_{e_0} > \sigma_{e_1}$), zero weight if its basis risk is precisely one-half that of the preferred market ($2\sigma_{e_0} = \sigma_{e_1}$), and negative weight if its basis risk is more than twice the preferred's ($2\sigma_{e_0} < \sigma_{e_1}$).

Now, consider the case where $\rho_{e_0 e_1} = 0$, or there is no correlation in basis risk between the two futures contracts and consequently considerable diversification benefits. In this situation, $\lambda > 0$ as long as $\sigma_{e_0}/\sigma_{e_1} \neq 0$, or as long as the preferred contract does not already provide a perfect hedge ($\sigma_{e_0} = 0$). Finally, consider the case where the basis risk between the preferred and competing contracts is negatively correlated ($\rho_{e_0 e_1} < 0$). In this instance, the competing model's diversification benefits always outweigh the level of its basis risk, resulting in $\lambda > 0$.

Clearly, there is a well-defined tradeoff between the relative magnitude of basis risk associated with each futures market (σ_{e_0} and σ_{e_1}) and the correlation in residual basis risk, $\rho_{e_0 e_1}$. This is consistent with standard portfolio theory and the results presented by Anderson and Danthine (1981). Thus, the evaluation of alternative hedges including just a comparison between the levels of basis risk, σ_{e_0} and σ_{e_1}, may be misleading. The correlation among the basis, $\rho_{e_0 e_1}$, must be taken into account.

For example, assume a new futures contract (competing) is being considered. The existing futures contract (preferred) has a basis risk of 5% ($\sigma_{e_0} = 0.05$), and the new contract has a basis risk of 10% ($\sigma_{e_1} = 0.10$). By only examining these levels of basis risk,

one might conclude the new contract is not worth pursuing—it doubles the amount of basis risk to hedgers. However, this result is potentially misleading. If $\rho_{e_0 e_1} < 0.50$, then the diversification benefit outweighs the higher basis risk, and $\lambda > 0$. Thus the new contract is, in fact, useful to hedgers. Hedgers can further reduce their basis risk by hedging a portion of their price exposure in the new futures market. That is, the existing futures market does not encompass the proposed contract.

This proposed methodology improves upon informal or ad hoc comparisons between models that are often found in applied research (Doran, 1993; Diebold and Mariano, 1995). As pointed out by Doran, the presented testing approach is preferred to discrimination methods (model choice based on an information criterion) because testing may lead to the acceptance of both models. Furthermore, testing assigns a probability to the incorrect rejection of the null (such probabilities are difficult to obtain and rarely used for discrimination criteria such as the Akaike Information Criterion). One could further argue that equations (1a) and (1b) could be artificially nested into a composite model, $\Delta CP_t = \alpha_3 + \beta_3 \Delta FP_t^0 + \beta_4 \Delta FP_t^1 + e_{3t}$, with the t-statistics on β_3 and β_4 serving as a test for significant hedging relationships in each futures contract (Anderson and Danthine, 1981). However, as noted by Doran, if ΔFP_t^0 and ΔFP_t^1 are highly collinear, which would often be the case for competing futures contracts, then the power of this test is reduced. This is not an inherent problem in the encompassing test presented in equation (3b).

The proposed encompassing test in equation (3b) is not without its statistical pitfalls. As shown by Harvey, Leybourne, and Newbold (1998), and by Harvey and Newbold (2000), the encompassing test can lack robustness if forecast errors (e_0 and e_1) are nonnormal in small samples. One possible correction suggested by Harvey and Newbold is the use of White's heteroskedastic consistent estimator (White, 1980). Given this suggestion, in the case of heteroskedasticity, White's estimator is used, and the estimator of Newey and West (1987) is employed in the event of autocorrelation.

Empirical Applications

The encompassing methodology is applicable both to futures exchanges considering the introduction of new contracts, as well as to commercial hedgers who need an objective way to evaluate existing hedging tools. With respect to equation (3b), if $\lambda = 0$, then a competing futures market provides no improvement in basis risk over a preferred contract. If $0 < \lambda < 1$, then the alternative contract provides benefits when used in a composite hedge with the preferred contract. Finally, if $\lambda = 1$, then the competing contract is potentially a superior risk reduction tool relative to the incumbent futures contract.

To illustrate the use and strengths of the encompassing methodology relative to more traditional approaches of assessing hedging effectiveness, encompassing is applied to three examples: choosing between existing futures contracts, choosing multiple cross-hedges, and the evaluation of a proposed futures contract. The first two examples are chosen to facilitate comparisons with past studies that use different empirical methods, and the third example illustrates a practical problem faced by contract innovators. The encompassing method can be applied to a wide range of situations. However, it is important to choose examples where the results can be discussed in the context of prior research (Tomek, 1993).

The first example considers the decision of how hedges should be allocated across two existing futures contracts—the Kansas City Board of Trade (KCBT) and Chicago Board

of Trade (CBOT) wheat contracts. In this example, a merchant decides which market, or combination of markets, provides the greatest hedging effectiveness. The results are compared to a similar study by Brorsen, Buck, and Koontz (1998). The second example examines the cross-hedging choices for a commodity without an existing futures market—cottonseed meal. Dahlgran's (2000) stepwise regression approach to this problem provides the impetus for the example. The final example simulates a situation routinely faced by contract developers, namely how the hedging effectiveness of a proposed new futures contract compares to an existing contract. For this example, the hedging effectiveness of an incumbent futures market, the CBOT corn futures, is compared to an alternative new contract, the National Corn Index (NCI) futures traded on the Minneapolis Grain Exchange (MGEX).

Existing Futures Contracts

Brorsen, Buck, and Koontz (1998) demonstrate that hedgers of hard red winter wheat at the U.S. Gulf maximize expected utility by placing hedges in the KCBT wheat futures, as opposed to CBOT wheat futures, despite higher transaction costs often associated with the KCBT. In this spirit, the encompassing principle is applied in evaluating the hedging effectiveness of KCBT wheat futures to effectiveness of the CBOT wheat futures for a hedger of hard red winter wheat at a U.S. Gulf terminal (Houston). In doing this, month-end data are collected from the U.S. Department of Agriculture (USDA) and the Bridge/CRB databases from March 1999 through December 2002 (46 observations). Following Brorsen, Buck, and Koontz, the minimum variance hedge equations (1a) and (1b) are estimated in first differences, and it is assumed hedges are held in the nearby contract month.[7] Care is taken to ensure futures price changes reflect the nearby contract and are not impacted by contract rollovers.

In this analysis, the KCBT futures, which call for par delivery of hard red winter wheat, is considered the preferred contract [equation (1a)]. The CBOT futures, which allow for par delivery of soft red winter wheat, serve as the alternative contract [equation (1b)]. Equations (1a) and (1b) are estimated, and the results are presented in table 1 (panel A). A casual comparison of R^2s suggests the KCBT futures provide the greatest level of hedging effectiveness (87.6% versus 71.2%). It follows that the KCBT hedge also provides a lower standard deviation of residual basis risk (8.04¢ versus 12.03¢ per bushel). However, because of the relatively low correlation of basis risk (0.518), it is possible a composite hedge, using both markets, may provide the greatest risk reduction.

The encompassing regression results are presented in panel B of table 1. The null hypothesis is that the KCBT futures encompass the CBOT futures ($\lambda = 0$). So, using the KCBT as the preferred market (e_0) and the CBOT as the competing market (e_1), equation (3b) is estimated by ordinary least squares. The estimated hedging weight (λ) on the CBT futures is 0.122, which is not statistically different from zero. This implies the hedging weight ($1 - \lambda$) for the KCBT is not statistically different from one. Based on this result, it follows that a hedger of U.S. Gulf hard red winter wheat will not reduce

[7] Unlike Brorsen, Buck, and Koontz (1998), the hedging regressions are not estimated using overlapping time-series observations; thus, autocorrelation is not a pervasive problem. However, the residual series, v_t, is tested for heteroskedasticity (White's test) and serial correlation (Lagrange multiplier test). Then, where appropriate, White's estimator or the Newey-West estimator, respectively, is employed (see Hamilton, 1994, p. 281).

Table 1. Kansas City versus Chicago Wheat Results (March 1999–December 2002)

PANEL A. HEDGING REGRESSIONS		
Description	KCBT	CBOT
Estimated Hedge Ratio (β)	0.932	1.055
(Standard Error)	(0.054)	(0.102)
R^2	0.876	0.712
Standard Deviation (e_t)	8.04¢	12.03¢
Correlation ($\rho_{e_0 e_1}$)	0.518	
PANEL B. ENCOMPASSING REGRESSION (preferred market = KCBT)		
Description	KCBT	CBOT
Estimated Hedging Weight (λ)[a]		0.122
(Standard Error)		(0.114)

[a]The estimated λ is the hedging weight received by the competing market (CBOT) from estimating equation (3b) in the text.

residual basis risk by placing part of the hedge in CBOT wheat futures. Instead, all of the hedging should be done in the KCBT contract. Although the methodology presented here is different from the procedure used by Brorsen, Buck, and Koontz (1998), the results are generally consistent with their conclusions.

Multiple Cross-Hedges

Dahlgran (2000) uses a stepwise regression procedure to determine the best futures markets for cross-hedging cottonseed meal in California. Over four-week hedge horizons, Dahlgran found cottonseed meal price risk can be hedged in a combination of oats, Minneapolis wheat, Japanese yen, and soybean meal futures. Here, in illustrating the use of the encompassing principle for evaluating multiple cross-hedges, the procedure is applied to a similar data set to determine the composite cross-hedge that minimizes basis risk. Specifically, four-week hedges of the USDA cash cottonseed meal price in Clarksdale, Mississippi, are examined.

Following Dahlgran, hedges are placed in the nearby oats (O), Minneapolis wheat (MW), Japanese yen (JY), and soybean meal (SM) futures contracts. Monthly price changes of the cash price and nearby futures are collected from February 1994 through May 2003 (112 observations). As with the previous example, care is taken to ensure the nearby futures series reflect only changes in the nearby contract, avoiding any complications caused by contract rollover. Further, to account for the use of multiple contracts in hedging cottonseed meal, equation (3b) is expanded to a multiple encompassing scenario by adding a $\lambda_i(e_{0,t} - e_{i,t})$ term for each of the i alternative hedges considered (Harvey and Newbold, 2000). The null hypothesis that the competing markets do not reduce residual basis risk from results achieved under the preferred market ($\lambda_i = 0$, for $i = 1, 2, 3, ..., n$) is tested with an F-test.

The individual hedging regression results are presented in panel A of table 2. Clearly, the hedging relationships are weak, with only SM having a hedge ratio statistically greater than zero. Using SM as the preferred contract, it is not surprising that none of

Table 2. Cross-Hedging Cottonseed Meal Results (February 1994–May 2003)

PANEL A. HEDGING REGRESSIONS

Description	Soybean Meal (SM)	Minneapolis Wheat (MW)	Japanese Yen (JY)	Oats (O)
Estimated Hedge Ratio (β)	0.248	0.150	-0.256	0.160
(Standard Error)	(0.087)	(0.138)	(0.379)	(0.138)
R^2	0.069	0.011	0.004	0.012
Standard Deviation (e_t)	12.97¢	13.38¢	16.01¢	$13.74
Correlation ($\rho_{e_0 e_1}$)		0.965	0.961	0.964

PANEL B. ENCOMPASSING REGRESSION (preferred market = SM)

Description	SM	MW	JY	O
Estimated Hedging Weight (λ_i)[a]		-0.067	0.015	0.136
(Standard Error)		(0.904)	(0.848)	(0.876)

[a] The estimated λ_i is the hedging weight received by the competing market i.

the estimated λ_i's in the encompassing regression (table 2, panel B) are statistically different from zero given the weak relationships found in the individual regressions (table 2, panel A). That is, the SM hedge provides the lowest level of residual basis risk. Moreover, the residual correlations between SM and the other futures hedges are nearly unity, suggesting no diversification is provided by using the alternative futures contracts. Given these findings, the encompassing regression allocates all the hedging weight to soybean meal futures (SM).

These results are certainly different from those presented by Dahlgran (2000). But, a possible explanation is the difference in cash market locations examined (California versus Mississippi), as well as the time intervals examined. Another explanation is the alternative procedures used for identifying the hedging markets, a stepwise regression approach versus an encompassing framework. Regardless, this example illustrates a particularly useful application of the encompassing principle which may produce results different from alternative approaches to choosing and evaluating multiple cross-hedges.

Proposed Futures Contracts

In their quest to increase volume of trade and remain competitive, exchanges are often faced with the daunting task of introducing new futures contracts. However, the success rate of new futures contracts is notoriously poor (Carlton, 1984). Obviously, contract innovators do not have the luxury of actual historical futures data to evaluate a proposed contract. Rather, they must rely on a proxy for the futures price to determine potential hedging effectiveness. Mindful of this decision process, the applicability of the encompassing procedure in evaluating the hedging effectiveness of a proposed contract relative to an existing contract is illustrated.

The MGEX recently introduced a cash settled corn contract based on the National Corn Index (NCI) compiled by Data Transmission Network. The NCI is the simple average price for all elevator bids collected in the United States for U.S. No. 2 yellow

corn.[8] The MGEX's NCI futures contract cash settles to a simple average of the last three daily NCI prices published during the contract month. Cash settlement occurs on the business day following the last trading day of the month, and a contract is listed for every calendar month.

To compare the potential hedging performance between the new NCI and the existing CBOT corn contracts, monthly cash and monthly nearby futures data are collected from January 1993 through December 2001. Cash prices are USDA reported quotes for the U.S. Gulf (New Orleans). Both cash and futures prices are drawn from the third to the last business day of each month. This corresponds to the first day of the three-day averaging period for cash settlement of the NCI futures—the day when the NCI futures should most closely converge with the underlying index before being influenced by the averaging settlement process (Kimle and Hayenga, 1994). To be consistent with the NCI futures, CBOT corn futures prices are also collected on this day. Price changes are calculated to reflect changes in the price of the nearby contract, resulting in 107 monthly observations.

In the investigative stage of contract development, contract developers do not have access to historical futures prices of the new contract in question. Hence, in this case, the underlying NCI must be used as a proxy for the cash settled futures contract. Clearly, the underlying NCI is not a futures price and does not reflect possible carrying charges, premia, and biases that may exist in actual futures prices. Likewise, supply and demand issues which impact a local basis are not modeled.[9] This can result in an overestimate of R^2 in hedging effectiveness regressions, because changes in the underlying cash index reflect both expected and unexpected changes, whereas changes in a futures contract would reflect only unexpected changes (Lindahl, 1989). Nonetheless, using the underlying index as a proxy for the futures is common in this type of analysis (Schroeder and Mintert, 1988; Elam, 1988; Chaherli and Hauser, 1995). Moreover, the monthly delivery cycle and cash settlement feature of the futures should result in a predictable convergence of the NCI futures and the underlying index (Kahl, Hudson, and Ward, 1989). Therefore, any bias this procedure creates should be relatively small.

A strength of the encompassing methodology is the flexibility to specify the hedging regressions in (1a) and (1b) in the most appropriate manner. For instance, conditional hedging regressions can be specified (Myers and Thompson, 1989). Here, we use equation (1a) to control for the fact that the CBOT corn contract has five delivery months per year, and hedge ratios may be different in months proceeding delivery. Therefore, the CBOT minimum variance hedge, equation (1a), is conditioned on a slope shift variable and intercept shift variable for the months prior to delivery (February, April, June, August, and November). This specification captures differences in the CBOT hedging performance in months prior to delivery and allows for the calculation of delivery and nondelivery month hedge ratios. This procedure ensures the results from the encompassing regression are not biased in favor of the NCI futures due to their monthly expiration cycle.

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[8] Detailed information on the National Corn Index is available online at the Minneapolis Grain Exchange's website (www.mgex.com).

[9] See Leuthold, Junkus, and Cordier (1989, chapter 3) for a discussion of the factors affecting the basis for storable commodities.

Table 3. Minneapolis NCI versus Chicago Corn Results, U.S. Gulf–New Orleans (January 1993–December 2001)

PANEL A. HEDGING REGRESSIONS		
Description	CBOT	NCI
Nondelivery Months Estimated Hedge Ratio (β)	1.072	0.859
(Standard Error)	(0.077)	(0.067)[a]
Delivery Months Estimated Hedge Ratio (β)	0.736	
(Standard Error)	(0.071)	
R^2	0.746	0.815
Standard Deviation (e_t)	9.61¢	8.21¢
Correlation ($\rho_{e_0 e_1}$)	0.614	
PANEL B. ENCOMPASSING REGRESSION (preferred market = CBOT)		
Description	CBOT	NCI
Estimated Hedging Weight (λ)[b]		0.699
(Standard Error)		(0.097)

[a] Estimated with Newey and West's heteroskedasticity and autocorrelation consistent estimator.

[b] The estimated λ is the hedging weight received by the competing market (NCI) from estimating equation (3b) in the text.

CBOT futures are considered the incumbent or preferred contract, equation (1a), and the NCI is the alternative or competing contract, equation (1b). The hedge coefficient for the CBOT is estimated at 1.072 for nondelivery months, and a statistically smaller 0.736 is calculated for delivery months (table 3, panel A). Clearly, separating the delivery and nondelivery months is important in specifying the hedge equation in (1a). Like the CBOT delivery month ratio, the NCI hedge coefficient is statistically smaller than one. Further, a casual comparison of R^2 values would suggest the NCI is the better hedge for U.S. Gulf corn. However, this conclusion is misleading because it ignores the basis diversification achieved from a composite hedge, which is captured with the encompassing regression.

The encompassing results are presented in panel B of table 3, and the estimated λ suggests the NCI futures should receive a weight of 0.699 and the CBOT futures a weight of 0.301 (1 - λ). The estimated λ is statistically different from zero, indicating the competing model (NCI) receives some weight. But, it is also statistically less than one, indicating the preferred futures also receives a nonzero weight. This result stems from the fact that $\rho_{e_0 e_1} < 1$. Although the residual basis risk for the NCI (8.21) is smaller than that of the CBOT (9.61), the diversification benefits provided by the relatively low correlation (0.614) allow the CBOT futures to receive a nonzero weight in the variance minimizing hedge. Therefore, at the U.S. Gulf export market, the risk-minimizing hedge would involve using both the CBOT and the NCI futures contracts.[10] Clearly, this is not the conclusion which would have been obtained through an informal comparison of R^2s.

[10] It is worth noting that the minimum variance hedge ratios are calculated by multiplying the estimated λ in panel B of table 3 times the estimated β in panel A. For example, the minimum variance hedge ratios are 0.600 (0.859 × 0.699) in the NCI, and 0.222 (0.736 × 0.301) in the CBOT futures in months prior to delivery. Therefore, short hedging 5,000 bushels of U.S. Gulf corn is accomplished by selling 3,000 bushels of NCI futures and 1,110 bushels of CBOT corn futures.

Empirical Application Discussion

Although none of these examples constitute comprehensive hedging studies in and of themselves, they do illustrate several potential uses of the encompassing principle in comparing hedging effectiveness. While the encompassing principle only considers the reduction in residual basis risk in determining hedging effectiveness, clearly there are other, often less quantitative factors, which influence the hedging decision. For instance, the liquidity of the futures market used, management effort in implementing the hedges, and trading costs must be considered. This is particularly true when using multiple futures contracts to hedge a particular cash position (e.g., the cottonseed meal example) or transacting in thin markets (e.g., the NCI futures contract). Any of these factors can influence the adoption of hedging strategies by a firm (Pennings and Meulenberg, 1997).

Summary, Conclusions, and Extensions

A methodology for comparing alternative futures markets in a minimum variance framework is presented. The methodology ties together the "encompassing principle" from the forecast evaluation literature (Harvey, Leybourne, and Newbold, 1998) with the minimum variance hedging literature (Myers and Thompson, 1989). The result is a simple regression test of whether or not a preferred futures market encompasses a competing futures market in a minimum variance hedging framework. If the preferred futures contract encompasses the competitor, then the competitor does not receive any hedging weight. If the competitor encompasses the preferred, then the competitor receives all the hedging weight. Finally, the two futures markets may be complementary, where the minimum variance hedge utilizes both markets.

In each case, the methodology specifically considers the tradeoff between the magnitude of basis risk associated with each futures market, and the correlation in residual basis risk between alternative contracts. While the traditional approach to evaluating hedging effectiveness is through the ad hoc examination of R^2 values resulting from a minimum variance hedge regression, the encompassing methodology allows one to determine if improved hedging performance of one (or more) contracts relative to another is indeed statistically significant. The statistical properties of the encompassing methodology are well developed in the forecasting literature, and the approach is easily applied to a number of practical hedging situations.

To demonstrate the usefulness and applicability of the encompassing principle in evaluating hedging performance, the proposed methodology is illustrated through three examples: choosing between existing futures contracts, determining multiple cross-hedges, and the analysis of a proposed futures contract. In the first example, the encompassing method demonstrates that hedging in the KCBT futures minimizes U.S. Gulf hard red winter wheat basis. This finding is consistent with results reported by Brorsen, Buck, and Koontz (1998). In the second example, multiple cross-hedges are examined for cottonseed meal. Unlike Dahlgran (2000), who uses a stepwise regression approach, the encompassing approach shows that all cross-hedging should occur in the soybean meal futures contract. In the final example, the results of the encompassing regression suggest the proposed NCI futures and the CBOT corn futures may be complementary hedges at the U.S. Gulf terminal market, with both futures contracts receiving some weight in a composite hedge. Importantly, an informal comparison of the R^2s from

minimum variance hedging regressions would have precluded the use of the CBOT futures and simply chosen the NCI as the "best" contract. Indeed, the encompassing regression provided information beyond that of the R^2, indicating the two contracts are complementary risk reduction tools.

The encompassing methodology presented here can be readily extended to other situations. For instance, there is some evidence that ex post hedge ratios do not outperform naive one-for-one hedging strategies on an out-of-sample basis (Collins, 2000; Jong, DeRoon, and Veld, 1997). The presented methodology can easily be adapted to evaluate this situation by simply imposing a hedge ratio of one for both the preferred and competing models by restricting $\beta_0 = 1$ and $\beta_1 = 1$ in equations (1a) and (1b), respectively. As suggested by Myers and Thompson (1989), minimum variance regressions should include additional explanatory variables such as lagged changes in cash and futures prices. Indeed, conditional minimum variance regressions can be evaluated in the encompassing framework (Maddala, 1992, p. 515), as was the case in adding intercept and slope shifters in the evaluation of the NCI and CBOT futures.

The examples presented in this study, however, are limited in the sense that the hedge ratios are time invariant. Future research may expand the methodology to examine the performance of time-varying hedge ratios (Garcia, Roh, and Leuthold, 1995). Generally speaking, the encompassing principle is widely applicable to evaluating futures contracts and provides an intuitive and rigorous approach to determining the statistical difference in hedging effectiveness between competing futures markets.

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