Minimum Variance Hedging and the Encompassing Principle: Assessing The Effectiveness of Futures Hedges

Mark R. Manfredo
Assistant Professor
Morrison School of Agribusiness and Resource Management
Arizona State University
Email: manfredo@asu.edu

Dwight R. Sanders
Assistant Professor
Department of Agribusiness Economics
Southern Illinois University
Email: dwights@siu.edu

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Abstract

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 also easily extended to cases involving multiple hedging instruments and general hedge ratio models. The methodology is demonstrated by evaluating the hedging effectiveness of Chicago Board of Trade's (CBOT) corn futures versus the Minneapolis Grain Exchange's National Corn Index (NCI) futures. The results indicate that the NCI futures encompass the CBOT futures for hedging country-level corn price risk in North Central Iowa; but, the NCI and CBOT futures are complementary in hedging terminal-level corn price risk at the U.S. Gulf.

Keywords: encompassing, hedging effectiveness, corn futures

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 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-squared 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; Martinez-Garmendia and Anderson), and it is routinely used by practitioners in many settings (Sparks Companies, Inc.). 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 both. 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). As well, futures exchanges often want to evaluate the hedging effectiveness of a new or proposed futures contract (or contract specification 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-squared 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 Federal Accounting Standard 133 (International Treasurer, 1998). Clearly, if a new or competing futures market does not provide a statistically significant reduction in residual basis risk (i.e., greater hedging effectiveness), then it is unlikely to be utilized by practitioners.[2] Thus the statistical improvement, or lack thereof, is an important consideration when evaluating the performance of proposed or new futures contracts, multiple cross-hedges, and other applications.

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. However, in this paper, the methodology is applied to the evaluation of new or proposed futures contracts.

The remainder of the paper is structured as follows. First, we develop the methodology through a careful presentation and illustration of linkages between minimum variance hedging and forecast evaluation. Namely, 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. Second, we provide an empirical application of our methodology in comparing the hedging effectiveness between Chicago Board of Trade corn futures and the new Minneapolis Grain Exchange's National Corn Index futures contract.

Finally, we provide conclusions as well as suggestions of how this proposed methodology could be used in other hedging applications.

Minimum Variance Hedging and Forecast Encompassing

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

$$\Delta CP_t = \alpha + \beta \Delta FP_t + e_t. \qquad (1)$$

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. While there has been some debate over whether this model should be estimated in price levels, price changes, or percent changes (Witt, Schroeder, and Hayenga, 1987), many researchers (Brorsen, Buck, and Koontz, 1998; Ferguson and Leistikow, 1998) use 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., Ditch 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 regards to risk reduction.[4]

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). The J-test is one method of testing non-nested hypotheses among competing models (Davidson and MacKinnon, 1981). Namely, Maddala (1992, p. 516) shows that the standard J-test is related to the optimum combination of forecasts. For example, assume that 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,

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

and the proposed or competing contract,

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

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.[5] Actual realizations of the dependent variable are represented by y. Given the fitted values from both the incumbent and competing models, and the actual realizations of the dependent variable, Maddala (1992, p. 516) shows that the following model can be estimated:

$$y-y_0 = \phi + \lambda(y_1-y_0) + v. \qquad (2)$$

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., λ=0) suggests that 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 Equation (3a) (Granger and Newbold, 1986 p. 268):

$$y-y_0 = \phi + \lambda[(y-y_0) - (y-y_1)] + v \qquad (3a)$$

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[6]:

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

This equation (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-λ is the weight that should be placed on the preferred model's forecast in constructing a composite forecast that minimizes mean squared forecast error. The null hypothesis that the preferred model "encompasses" the alternative (λ=0) is tested with a two-tailed t-test.[7] 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 that the competing futures contract provides no benefit in terms of reducing the residual basis risk associated with hedging in the preferred futures market. That is, the preferred futures market "encompasses" the competing futures market. If $0<\lambda<1$, then some amount hedging should be done in each market, 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.

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

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

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 that

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

and

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

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 trade-off between the ability of the competing futures market to reduce the residual basis risk associated with the preferred futures market through diversification, ρ<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 trade-off 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, λ>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 (λ>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 ($\rho_{e_0e_1} < 0$). In this instance, the competing model's diversification benefits always outweigh the level of its basis risk $\sigma_{e_0} > \sigma_{e_1}$, resulting in a $\lambda>0$.

Clearly, there is a well-defined trade-off 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, $\rho_{e_0e_1}$. This is consistent with standard portfolio theory and the results presented by Anderson and Danthine (1981). Thus, the evaluation of alternative hedges that just include a comparison between the levels of basis risk, σ_{e_0} and σ_{e_1}, may be misleading. The correlation among the basis, $\rho_{e_0e_1}$, 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 basis risk of 10% ($\sigma_{e_1} = 0.10$). By just examining these levels of basis risk, one might conclude that the new contract is not worth pursuing—it doubles the amount of basis risk to hedgers. However, this result is potentially misleading. If $\rho_{e_0e_1} < 0.50$, 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 (1993), 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 Criteria). 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 pointed out by Doran (1993), 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 pit falls. As shown by Harvey, Leybourne and Newbold (1998) and Harvey and Newbold (2000), the encompassing test can lack robustness if forecast errors (e_0 and e_1) are non-normal in small samples. One possible correction suggested by Harvey and Newbold (2000) is the use of White's heteroskedastic consistent estimator (see Hamilton, p. 219). Given this suggestion, we use White's estimator, when appropriate, in the following empirical application of the hedging evaluation methodology developed.

Empirical Application

The methodology developed above is applicable to both futures exchanges that are considering the introduction of new contracts, as well as for commercial hedgers who need an objective way to evaluate both new and existing hedging tools. With respect to Equation (3b), if $\lambda=0$, then a proposed (competing) futures market provides no improvement in basis risk over an existing (preferred) contract. Thus, there is likely to be little hedging demand for the new contract and it is more likely to fail. If $0<\lambda<1$, then the proposed contract may offer some benefits when used in conjunction with the existing contract. Finally, if $\lambda=1$, then the proposed contract is potentially a superior risk reduction tool relative to the incumbent futures contract. Thus, in an application of the presented methodology, we compare the hedging effectiveness of an incumbent futures market, the Chicago Board of Trade (CBOT) corn futures, to an alternative new contract, the National Corn Index (NCI) futures traded on the Minneapolis Grain Exchange (MGEX). While this application is clearly not meant to be an exhaustive study of the NCI futures, it does serve as a reasonable example and application of the encompassing principle to the evaluation of competing futures contracts.

The Minneapolis Grain Exchange (MGEX) recently introduced a cash settled corn contract based on the National Corn Index (NCI) compiled by Data Transmission Network.[8] The NCI is the simple average price for all bids collected in the United States for U.S. No. 2 Yellow Corn. On a daily basis, DTN collects bids from an average of 1630 elevators (nearly 90% of all U.S. elevators). Elevators in seven states—Iowa, Illinois, Nebraska, Kansas, Minnesota, Indiana, and Ohio—represent 75% to 80% of the bids collected. The single largest owner of the corn bids (i.e., elevator ownership) comprises only 3.3% of those collected. The MGEX's NCI futures contract cash settles to a simple average of the last three daily NCI prices published during the contract month. The settlement price is rounded to the nearest quarter cent using standard rounding techniques. Cash settlement occurs on the business day following the last trading day of the month, and a contract is listed for every calendar month. The NCI futures do not trade open outcry; rather they are listed on the MGEX's electronic platform, MGExpress.

To compare the potential hedging performance between the NCI and the CBOT contracts, cash prices are collected at two locations: North Central Iowa and the U.S. Gulf.

These two locations are chosen because they represent very different points in the marketing channel. The Iowa location reflects interior or farm-level prices in the Western Cornbelt, while U.S. Gulf prices are those quoted by export terminals. The cash data is provided by the U.S. Department of Agriculture.

The analysis focuses on a monthly hedging horizon. Monthly cash and futures data is collected from January 1993 through December 2001, resulting in 108 observations. Specifically, prices are drawn from the third to the last business day of each month for both cash and futures. This corresponds to the first day of the three-day averaging period for cash settlement of the NCI futures. This is 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). CBOT corn futures prices are also collected on this day. The price levels reflect the nearest to maturity futures contract (without entering the delivery month), and price changes are calculated to reflect changes in the price of the nearby contract. Care is taken such that price changes are not impacted by contract rollover.

Since the NCI futures are new, and little historical price data are available for analysis, 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, or biases that may exist in actual futures prices. 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), and it is one of the few alternatives available to contract innovators, such as exchanges, in evaluating new contracts. As well, 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 creates should be relatively small, and they do not detract from the example used to illustrate the presented hedging evaluation methodology.

In this analysis, the CBOT futures are considered the incumbent or preferred contract (Equation 1a), and the NCI is the alternative or competing contract (Equation 1b). As a first step in the analysis, Equations (1a) and (1b) are estimated, and the results are presented in Table I. A casual comparison of the R^2's suggest that the NCI provides some improvement in hedging effectiveness (81.5% versus 71.1%) at the U.S. Gulf, and a rather large improvement (96.8% versus 77.6%) in North Central Iowa. It follows that the NCI hedge also provides a lower standard deviation of residual basis risk at the Gulf (8.21 versus 10.26) and Central Iowa (3.60 versus 9.58). On the surface, this might lead one to conclude that the NCI futures are preferred to the existing CBOT futures in both markets. However, the estimated encompassing regressions show that this is not exactly the case.

The encompassing regression results are presented in Table II. The null hypothesis is that the CBOT futures encompass (λ=0) the proposed NCI futures. So, using the CBOT as the preferred market (e_0) and the NCI as the competing (e_1) market, Equation (3b) is estimated by OLS. If the residual series, v_t, displays heteroskedasticity (White's test) or serial correlation (LM test), then White's estimator or the Newey-West estimator, respectively, are employed (see Hamilton, p. 281).

The results for the U.S. Gulf market are presented in the first column of Table II, and the estimated λ suggests that the NCI futures should receive a weight of 0.799 and the CBOT futures a weight of 0.201 (1-λ). The estimated λ is statistically different from zero, indicating that the competing model receives some weight. But, it is also statistically less than one, indicating that the preferred futures also receives a non-zero weight. This result stems from the fact that $\rho_{e_0e_1} <$ 1 (see Table I). Although the residual basis risk for the NCI (8.21) is smaller than that of the CBOT (10.26), the diversification benefits provided by the relatively low correlation (0.649) allows the CBOT futures to receive a non-zero weight in the variance minimizing hedge. Therefore, at the Gulf export market, the risk-minimizing hedge would involve using both the CBOT and the NCI futures contracts. Clearly, this is not the conclusion that would have been obtained through an informal comparison of R-squared's in Table I. It is worth noting that the minimum variance hedge ratios are calculated by multiplying the estimated λ in Table II times the estimated β in Table I. So, at the Gulf, the minimum variance hedge ratios are 0.686 (0.859 x 0.799) in the NCI and 0.178 (0.888 x 0.201) in the CBOT futures. Therefore, short hedging a thousand bushels of corn would be accomplished by selling 686 bushels of NCI futures and 178 bushels of CBOT futures.

Next, examining the results for North Central Iowa, the estimated minimum variance hedge ratios are not statistically different from unity for either the CBOT or NCI (Table I, second panel). It is clear that the unconditional hedging effectiveness is higher for the NCI than the CBOT futures (96.8% versus 77.6%). Also, the residual basis risk is much less for the NCI (3.60 cents per bushel) than the CBOT futures (9.58 cents per bushel). This likely stems from the fact the NCI closely reflects interior pricing points—such as Iowa; whereas, the CBOT reflects terminal-level pricing. In Table II (second column), the encompassing regressions show that the CBOT futures are encompassed by the NCI with an estimated λ of 0.971, which is statistically greater than zero and not statistically different from one. Therefore, all the hedging weight is assigned to the NCI. This occurs despite a low correlation in basis risk between the two contracts ($\rho_{e_0e_1}$ = 0.305). In this instance, the lower residual basis variability ($\sigma_{e_0} > \sigma_{e_1}$) associated with the NCI swamps the diversification benefits provided by the low correlation.

In summary, the NCI encompasses the CBOT futures for hedging cash price risk at an interior or country-level point in the grain merchandising channel, North Central Iowa. However, at the terminal or export level the NCI futures may appear to provide greater hedging effectiveness and lower basis risk than the CBOT futures; but, they do not encompass the CBOT futures. Rather, the results suggest that at the U.S. Gulf, the NCI futures and CBOT futures are complementary hedging tools, each receiving some weight in the risk-minimizing hedge. This is an important result because it provides practitioners with the knowledge of how to evaluate and utilize the new contract. Also, it provides the MGEX with a more accurate assessment of the potential demand for the new contract.

While this particular application is only intended to serve as an illustration of the presented methodology, there are some practical caveats. First, it is maintained that the underlying NCI is a good proxy for futures prices. This was necessary given the lack of historical data for NCI futures, and is a common practice in this type of analysis. Second, liquidity and other trading costs are not considered. The presented methodology only considers the statistical significance in terms of reducing residual risk. Clearly, it is important that the economic significance be considered as well. This would include liquidity costs (Brorsen, Buck, and Koontz, 1998; Pennings and Muelenberg, 1997) as well as internal transaction costs (trading, accounting, and treasury functions). Any of these factors can impact the success of new contracts in the marketplace or the adoption of existing contracts within a firm. However, if an existing futures contract encompasses a competing contract, then the competitor is unlikely to be considered in the first place.

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 (Meyers 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.

Prior research has generally relied on an informal evaluation of R-squared values when comparing the hedging effectiveness of alternative contracts. This casual analysis can lead to the wrong conclusion if there is a diversification benefit to using both futures contracts. That is, the formal testing procedure presented allows for the acceptance (or rejection) of both models; whereas, the more casual approach, or an approach based on a selection criterion, usually results in the choice of a “best” model (Doran, 1993). Additionally, the encompassing principle—because it is a testing procedure as opposed to a selection method—easily allows for an accurate probabilistic statement of incorrectly rejecting the null. Moreover, the presented encompassing procedure is easily applied by practitioners, widely applicable, and the statistical properties are well developed in the forecasting literature (Harvey, Leybourne, and Newbold, 1998; Harvey, Leybourne, and Newbold, 1999; Harvey and Newbold, 2000; West, 2001).

The proposed methodology is illustrated through an examination of the hedging effectiveness of the incumbent CBOT corn futures and the competing NCI futures. In this application, we find that the proposed NCI futures encompass the CBOT corn futures at an interior region: North Central Iowa. But, the two markets are complementary at the U.S. Gulf terminal market. In other words, both futures contracts should receive some weight for Gulf hedges. Importantly, at the U.S. Gulf, an informal comparison of the R-squared's from minimum variance hedging regressions would have precluded the use of the CBOT futures and simply chosen the NCI as the "best" contract; whereas, the encompassing regression indicated the two contracts are complementary risk reduction tools for this cash market.

While the presented methodology and empirical application only consider two futures markets in a simple (unconditional) minimum variance hedging framework, the encompassing principle is easily applied to other situations. For instance, there is some evidence that *ex post* hedge ratios do not outperform naive one-for-one hedging strategies out-of-sample (Collins, 2000; Jong, DeRoon, and Veld, 1997). The presented methodology can easily be extended to this situation by simply imposing a hedge ratio of one for both the preferred and competing models (restrict β_0=1and β_1=1 in Equations 1a and 1b, respectively). Likewise, the presented research only considers two futures markets, the preferred and a single competitor. In practice, there may be numerous competitors. This is especially true in multiple cross-hedging situations (Miller, 1985; Dahlgran, 2000). Regression-based and other versions of the encompassing test can easily be extended to the multiple case as shown by Harvey and Newbold (2000). Meyers and Thompson (1989) suggest that minimum variance regressions should include additional explanatory variables such as lagged changes in cash and futures prices. These conditional minimum variance regressions can still be evaluated in the encompassing framework (Maddala, p. 515). 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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Table I. Unconditional Hedging Effectiveness Regressions, $\Delta CP_t=\alpha+\beta\Delta FP_t+e_t$, January 1993 – December 2001.

	U.S. Gulf		North Central Iowa	
	CBOT	NCI	CBOT	NCI
Estimated β	0.888	0.859*	0.984	0.993
St. Error	(0.092)[b]	(0.067)[b]	(0.119)[b]	(0.035)[a]
R-Squared	0.711	0.815	0.776	0.968
St. Dev. (e_t)	10.26	8.21	9.58	3.60
Corr., $\rho_{e_0 e_1}$	0.649		0.305	

*Statistically different from one at the 5% level using a two-tailed t-test.
[a]Estimated with White's heteroskedastic consistent estimator.
[b]Estimated with the Newey-West estimator.

Table II. Encompassing Regression, $e_{0,t} = \phi + \lambda[(e_{0,t} - e_{1,t})] + v_t$, January 1993 – December 2001.

	U.S. Gulf	N.C. Iowa
Preferred Market:	CBOT	CBOT
Estimated λ	0.799*+	0.971*
St. Error	(0.092)[b]	(0.080)[a]

+Statistically different from one at the 5% level using a two-tailed t-test.
*Statistically different from zero at the 5% level using a two-tailed t-test.
[a]Estimated with White's heteroskedastic consistent estimator.
[b]Estimated with the Newey-West estimator.

End Notes

[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 also consider the economic significance of the risk reduction as well as the costs associated with using a particular futures contract (Pennings and Meulenburg, 1997).
[3] Meyers 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, Meyers 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 that Equation (1) is estimated with price changes, but the methodology is applicable to alternative specifications including conditional hedging regressions.
[4] An exception to this is Chaherli and Hauser (1995) who utilize the J-test to make pair-wise comparisons among alternative cash settled corn and soybean futures contracts.
[5] 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.
[6] Note, the presented analysis implicitly assumes that 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).
[7] Harvey, Leybourne, and Newbold (1998) suggest a one-tail test in the context of a composite forecast. However, in a hedging context, where negative hedge ratios can exist (Anderson and Danthine), a two-tailed test is more appropriate.
[8]The information in this section was drawn from the Minneapolis Grain Exchange’s website (www.mgex.com) on March 21, 2002. The specific numbers reflect the MGE’s audit of the DTN data collection process on April 23-25, April 30-May 2, and July 2-5, 2001.