Hedging Efficiency: A New Concept, A New Measure

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INTRODUCTION

In studies of futures markets much attention has been paid to the hedging effectiveness of futures contracts. The authors who have proposed measures of this effectiveness include Chang and Fang (1990), Ederington (1979), Gjerde (1987), Hsin, Kuo, and Lee (1994) and Lasser (1987). All these measures have in common that they try to indicate to what extent hedgers are able to reduce cash price risk by using futures contracts. In these studies hedging effectiveness refers to returns on portfolios. A particular futures contract can have different values with respect to hedging effectiveness, depending on which measure is used and on the hedger utility function. All measures are based on hedger characteristics and assume the futures contract to be perfect, meaning that there is no futures trading risk. However, futures contracts involve risks for hedgers. Therefore, the extent to which a futures contract offers a reduction in overall risk is an important criterion for the futures exchange management to evaluate hedging performance. Actually, the smaller the basis and market depth risks of a futures contract, the more the risk reduction. This criterion is relevant to hedgers, since futures contracts essentially render potential hedgers a service, i.e. risk reduction, at a price, i.e. brokerage fee and margin requirements. Therefore, this article introduces a concept of hedging efficiency and a measure of this efficiency, together indicating the quality of the hedging service provided by the futures contract.

The assessment has been made from the perspective of the management of the futures exchange. The futures market is assumed to be predisposed towards creating a superior value for customers (Narver and Slater (1990)) and thereby generating a high trading volume (Black (1986)). The article's goal is to provide the futures exchange management with a measure which is able to give insight into the performance of the exchange, thereby providing information about how the exchange management can use controllable instruments (for example contract specification, trading system etc.) in order to serve the hedgers. This measure is a useful tool for a futures exchange, as it enables the quality of the actual hedge to be evaluated.

After reviewing frequently used measures of hedging performance, i.e. hedging effectiveness, the risks in futures trading are examined. Then the conceptual aspects of hedging efficiency are discussed, and a new measure is presented. The final section summarizes the findings.

MEASURES OF HEDGING EFFECTIVENESS: A BRIEF REVIEW

In the theory on futures markets three hedging theories can be distinguished. First, traditional hedging, which emphasizes the potential of futures markets to avoid risk: cash positions are hedged by taking an equal but opposite position in the futures market. A second theory (Working (1962)) suggests that hedgers operate like speculators, being primarily interested in relative prices rather than absolute ones. According to Working, holders of a long position in the cash market will hedge if they expect the basis to fall, but not if a rise is expected. The latest and the most common theory nowadays is the portfolio approach. In this approach the risk of price changes is introduced into the hedging model in a variance function. Moreover, a frontier is traced, showing a relationship between variance and expected returns.

The recently proposed measures of hedging effectiveness are based on the last-mentioned hedging approach. Several studies (e.g. Ederington (1979), Franckle (1980), Hill and Schneeweis (1982), Wilson (1984), Howard and D'Antonio (1984), Chang and Shanker (1986), Overdahl and Starleaf (1986), Lindahl (1989), Chang and Fang (1990), Gjerde (1987), Pirrong, Kormendi and Meguire (1994), Hsin, Kuo and Lee (1994)) express the usefulness of trading a futures contract, based on comparing the results of a combined cash-futures portfolio and the cash position only. The objective of the studies using these measures was to assess the effective reduction in the fluctuation of revenue achieved by hedging the cash products in different futures markets. Many of these studies were concerned with successful cross hedging (Anderson and Danthine (1981)).

In table I the hedging performance measures are summarized and classified by their salient features.

TABLE I
Frequently Used Hedging Effectiveness Measures and their Characteristics[1].

Measure	Based on minimum variance hedge	Based on risk-return	Including cost involved in futures trading[2]	Including basis risk and liquidity risk
Ederington	yes	no	no	no
Overdahl and Starleaf	yes	no	no	no
Howard and D'Antonio	no	yes	no	no
Hsin, Kuo and Lee	no	yes	no	no
Gjerde I	no	no	yes	no
Gjerde II	yes	yes	yes	no
Chang and Fang	no	yes	no	no

The measures reviewed are concerned with optimizing the payoff of the portfolio, under the condition that the variance in returns is minimized or that some optimal balance is found between risk and return. All these measures implicitly assume that the futures contract is perfect, i.e. introduce no risks. However, futures contracts do introduce risks, which will have an impact on the variance of the hedger's returns. These risks have an impact on the success of a futures contract and are therefore of great interest to the management of the futures exchange (Black, 1986). In the next section the risks involved in futures trading are examined in detail before a concept and measure of hedging efficiency are elaborated on.

RISKS IN FUTURES TRADING

The motivation for hedging cash prices with offsetting futures contracts is to reduce, if not eliminate, cash price risk. It is generally recognized that futures markets can be used by traders to hedge the risks associated with the price fluctuations in the underlying spot market (Grossman (1986)). Any deviation in the cash-futures price relationship at the settlement date will be arbitrated away. However, if the arbitrage transaction costs are high, the necessary convergence of cash\futures price will not occur. This will introduce a risk for the hedger, which will negatively affect participation in futures markets. The existence of basis risk, which is specific to the futures market and does not exist in the cash forward market, introduces an element of speculation in the sense that hedgers are still exposed to this risk while hedging their physical commodity. Basis risk exists, because the futures and spot prices in the future period are not perfectly correlated. The basis risk is attributed to timing, location, and quality discrepancies between commodities traded in the cash market and those deliverable on futures (Paroush and Wolf (1989)). Also in the case of futures indexes, unanticipated variation in dividends may involve basis risk (Figlewski (1984)).

The degree of liquidity in a market is a key aspect of futures market performance (Cuny, 1993). Hedgers in liquid markets trade with little price effect on their transactions. However, in thin markets, the transactions of individual hedgers may have a significant effect on price and may therefore result in substantial 'transaction costs' (Thompson, Waller and Seibold, (1993)). A futures market is considered to be liquid if traders and participants can quickly buy or sell futures contracts at low transaction costs (Thompson and Waller (1987), Berkman (1992), Bessembinder and Seguin (1993), Affleck-Graves, Hedge and Miller (1994)). In this article liquidity refers to market depth. Kyle (1985) defines depth as the volume of unanticipated order flows required to shift prices by one unit. Market depth risk is the risk that the hedger faces when there is a sudden price fall or rise due to order imbalances; this risk seems important to systematic hedgers. Note that the hedger can eliminate this risk when (s)he gives his/her orders to the brokers in limit prices. However, using limit prices means that the hedger can face the risk that his trade cannot be executed. According to Lippman and McCall (1986) the thickness of the market for a commodity increases with the frequency of offers. Hasbrouck and Schwartz (1988) report the relation between market depth and the trading strategies that market participants apply. Passive participants may avoid depth costs or may even profit from the execution costs that others have to pay, whereas active participants generally incur depth costs.

Hedging replaces exposure to the risk of cash price changes with that to basis risk and market depth risk. An agent who wants to manage price risk, will weigh the futures trading risk against the need to eliminate the cash price risk. In the next section these two components will be integrated into a concept of hedging efficiency.

CONCEPTUAL ASPECTS OF MEASURING HEDGING EFFICIENCY

In this section a concept of hedging efficiency is described, from which a measure of hedging efficiency is derived. It has been written from the perspective of the futures exchange management, who is interested in the quality of the hedging service.

The existing measures of hedging effectiveness are related to the question of whether or not a potential hedger will use futures contracts to maximize utility on the basis of means and variances of prices. The measure which is described in this section informs

[1] List does not pretend to be exhaustive

[2] Brokerage costs and margin requirements.

the management of the futures exchange about the efficiency of a specific futures contract and therefore confronts the ideal hedge (where all risk, cash price risk and futures trading risk, is eliminated) with the actual capacity of the futures contract to reduce risk (see figure 1). This measure is more complementary rather than an alternative to the existing measures. A futures contract which is able to set a certain price without introducing other risks will best fulfill the hedger's need for hedging i.e. will have a positive impact on the trading volume. Note that this does not mean that in this case the hedger will always use that particular futures contract. This will also be influenced by the cost involved in futures trading i.e. commission costs and margin requirements. The hedger will weigh the cost involved in futures trading against the satisfaction established by the futures contract. Hedging efficiency is the capacity of the futures contract to reduce the overall risk: (basis risk, cash price risk and market depth risk) in relation to the cost involved in futures trading. For the futures exchange it is important to know how well the services provided by the futures contract meet the needs of the hedgers. The proposed measure of hedging efficiency assesses how well the futures exchange is able to achieve this goal. Figure 1 illustrates the concept of hedging efficiency.

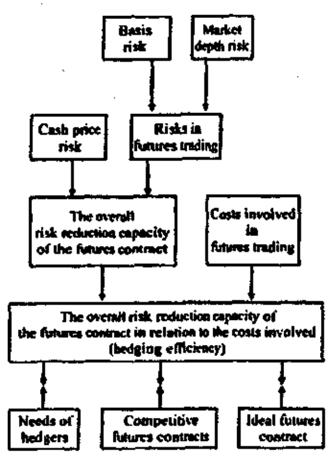

Figure 1. Concept of Hedging Efficiency.

This overall risk reduction capacity of the futures contract in relation to the trading costs involved is the hedging service which the futures exchange provides. Two factors are important for the futures exchange: whether it fulfills the need of the hedgers with respect to overall risk reduction, and whether it can compete with competitive futures contracts.

Table II shows the conceptual difference between the measure of hedging effectiveness reviewed and the proposed one.

TABLE II
Conceptual Differences Between the Measures of Hedging Effectiveness Reviewed and the Proposed Measure

	Measures of Hedging Effectiveness Reviewed	Proposed Measure of Hedging Efficiency
Related to:	hedgers	futures contract
Focus on:	cash market risk	cash market risk and futures trading risk
Concerned with:	performance of portfolio	hedging service of futures contract
Way of measurement:	measuring reduction in variance in portfolio	measuring distance between actual and perfect hedging services
Instrumental variables:	means and variances Sharpe index	variances divided into a systematic part and random part
Information for:	hedgers	management of futures exchange

Mark that because of the conceptual differences between the measures of hedging effectiveness reviewed and the proposed one, the latter is not a substitute, but rather a complement to the former.

MEASURE OF HEDGING EFFICIENCY

In this section a measure of hedging efficiency will be derived in accordance with the concept of the proposed hedging efficiency. Each step will be described, in order to understand the components which are combined in the measure (see figure 1).

Because the futures market offers a risk management service, this service preferably should not introduce additional risk itself. If the futures market introduces no additional risk, the futures contract is a perfect or ideal one, which will generate a price for the short hedger of[3] :

$$IPR_{t+1}=PF_{t}, \qquad (1)$$

which implies that $PF_{t+1}=P_{t+1}$,

where IPR_{t+1} is the price the hedger would realize for time $t+1$ when using an ideal futures contract, $P_{(t+1)}$ the commodity price in the cash market at maturity and $PF_{(t+1)}$ the futures price at maturity.

Basis Risk and Market Depth Risk

For an ideal futures contract, two conditions have to be satisfied. The first is that when the futures contract matures $P_{t+1}=PF_{t+1}$, i.e that there is no basis[4], and the second that there is no market depth risk. Such price changes may occur in the case of a long hedge as well as a short hedge. If a market selling (buying) order arrives, the transaction price will be the bid (ask) price. For a relatively large market selling (buying) order, several transaction prices are possible, at lower and lower (higher and higher) values, depending on the size of the order and the number of traders available. If the selling order is large, the price should keep falling to attract additional traders to take the other side of the order. Given a constant equilibrium price, a deeper market will be one, in which relatively large market orders produce a smaller divergence of transaction prices from the underlying equilibrium price. The price fall (rise) in the futures market is caused by the selling (buying) pressure in the futures market when large amounts of contracts enter at a specific point of time.

Several researchers (Roll (1984), Gloston and Milgrom (1985), Thompson and Waller (1987), (1988)) have proposed methods for estimating liquidity cost indirectly. These bid-ask-spread-based measures have some limitations. The price may change between the time at which the hedger buys or sells, and the hedger may earn much more or less than the spread quoted at the time of the first transaction. Therefore a measure for market depth which does not suffer from the limitations of the bid-ask spread is proposed:

$$DC_j=\sum_{k=1}^{K}\frac{V_k*(PF_1^j-PF_k^j)}{V}, \qquad (2)$$

[3] A long hedger could equally well have been used in this example. Because it is not essential for the derivation of the measure of hedging efficiency.

[4] The hedging efficiency measure is also applicable to the situation where the futures position is offset before maturity.

where DC_j is the market depth costs of futures contract j, PF_k the price of the k-th futures contract with k the number of changes in transaction prices with $k=1...K$, K the total number of transaction prices, V_k the volume of futures contracts sold at PF_k^j and V the total volume.

This measure assesses the average depth cost per futures contract. Table III demonstrates how this measure is calculated. Suppose that a hedger wants to sell 10 futures contracts. Table III describes the price path and the way in which the liquidity cost is measured in equation (2).

TABLE III

Example of Measuring the Market Depth Costs according to Equation (2) for Futures Contract j, where for Reason of Simplicity only One Order Flow is Examined

k	Transaction price	V_k	ΔPF_{k+1}	DC_j
1	10	2	0	
2	5	4	5	4.8
3	3	4	7	

The measure of market depth assesses the price fluctuation which is caused by the thinness of the market. However, price fluctuations are also caused by fundamental economic factors. This distinction can be made if order flow-specific transaction data are available, because it is assumed that during the sale or purchase of the futures contracts (which normally is a matter of minutes) the equilibrium price is constant and the price changes are caused by depth factors.

Note that the market depth costs are dependent on the basis at time of lifting. An example will make this clear. Suppose a cattle producer goes short the December 1995 contract at 62 US dollars. Now suppose that in December 1995 when (s)he enters the market to lift his/her hedge the current basis is 0.5 US dollar. (S)He will buy to cover his/her short position, thus the market depth effect will push the price upward, so that his or her actually realized basis is 0.1 US dollar. Thus, the market depth risk has actually improved the hedging efficiency.

The price actually realized will differ from equation (1) by means of the basis, liquidity cost and trading costs and can be described by[5]:

[5] Note that the basis and liquidity cost should not be a problem for the price the hedger wants to realize, if the hedger is able to internalize this basis and liquidity cost.

$$ARP_{t+1}=PF_t^1-B_{t+1}-DC_{t+1}-C, \quad (3)$$

where B_{t+1} is the basis of the futures contract and DC_{t+1} the market depth cost when initiating the futures position and ofsetting the futures position. The service of risk reduction by futures contracts is not free; the hedger has to pay for it, so C is the cost involved in futures trading per futures contract represented by the commission.

ARP_{t+1} is a stochastic variable, because of the stochastic nature of the basis and the market depth costs. The expected value and the variance of ARP_{t+1} can be expressed as: $\mu_A=E(ARP_{t+1})=PF_t^1-C-E(B_{t+1}+DC_{t+1})$ and $\sigma_A^2=E(ARP_{t+1}-\mu_A)^2$ respectively. Defining $FTR=B_{t+1}+DC_{t+1}$ and $\mu=E(B_{t+1}+DC_{t+1})$ the variance of ARP_{t+1} can now be written as:

$$\sigma_A^2=E(FTR-\mu)^2=E(FTR^2-\mu^2), \quad (4)$$

subsequently $E(FTR^2)=\sigma_A^2+\mu^2$.

Measure of Risks in Futures Trading

For the futures exchange it is very important and useful to know how great the distance is between the hedging service actually provided and the ideal service, i.e eliminating cash price risk without introducing any systematic risk by the futures exchange, i.e. $\mu=0$. The futures trading risk can now be written as: $E(FTR_{t+1}^2)$, which measures all futures trading risk compared to the situation without risk.

To interpret the measure of futures trading risk, remember that $E(FTR^2)=\sigma_A^2+\mu^2$. Since the requirement $E(B_{t+1}+DC_{t+1})=\mu=0$ is rarely met in reality, the futures trading risk $E(FTR_{t+1}^2)$ can be split into σ_A^2 and μ^2. In that case, μ^2 can be looked upon as the systematic deviation of a futures contract at time period $t+1$ from the ideal futures contract and σ_A^2 the random deviation. Knowledge of the systematic part is very important to the futures exchange because this part of the total deviation is caused by contract specification and futures exchange structure (trading system, kinds of traders allowed etc.) and therefore can be managed by the futures exchange. For example, a hedger in Jacksonville will know that (s)he has to discount the transportation cost when the futures contract specifies delivery in Chicago and that because of those cost the price set by a hedge will deviate from the price locked into with the help of a Chicago exchange i.e., the systematic deviation. The exchange in Chicago could reduce this systematic deviation by allowing delivery in Jacksonville (see Pirrong, Kormendi and Meguire (1994)). The random deviation is dependent on factors which are beyond the scope of the futures exchange.

Similar to the coefficient of variation[6] we assume for a futures trading risk measure ($FTRM$), the square root of the futures trading risk $E(FTR_{t+1}^2)$ relative to the net price of the hedger when using an ideal futures contract:

$$FTRM=\frac{\sqrt{E(FTR_{t+1})^2}}{PF_t^1-C}, \quad (5)$$

where the net price is the futures contract price minus the cost of commission, PF_t^1-C.

Hedging Efficiency

Risk in futures trading does not per se indicates how well a futures contract will fulfill the hedger's need. The hedger's need to reduce, if not to eliminate, cash market risk without introducing futures trading risk implies that both the risks of futures contracts and of the cash market have to be included in a measure of hedging efficiency.

Analogous to the measure of futures trading risk, that of cash price risk is defined as:

$$CPRM=\frac{\sigma_{CP}}{E_t(CP)}=\frac{\sqrt{E(CP_t-\overline{CP})^2}}{\overline{CP}}, \quad (6)$$

where $\overline{CP}$ is the mean of the cash price over the period from initiating the futures position to the time of liquidation of the futures position.

A hedger will be inclined to use a futures contract when the value of the futures trading risk measure (5) is low compared with that of the measure of cash price risk (6). In that case (s)he is exchanging high risk in the cash market for low risk in the futures market. For this reason the proposed measure of hedging efficiency is

$$E=\frac{FTRM}{CPRM}, \quad (7)$$

where $E\geq 0$.

This measure gives insight into the hedging performance of a futures contract.

[6] The standard deviation is expressed as a fraction of the mean. For data from different sources, the mean and standard deviation often tend to change together so that the coefficient of variation is relatively stable. Furthermore, being dimensionless the coefficient of variation iseasy to rember (Snedecor and Cochran 1994).

In practice, the proposed measure will range between zero and one. If the futures trading risk is greater than the cash price risk $FTRM > CPRM$ i.e. $E>1$, the hedger will not use that futures contract because this will increase the price risk.

Equation (7) can be rewritten as:

$$E=\frac{\sqrt{E(FTR_{t+1})^2}\,\overline{CP}}{(PF_t^1-C)\sqrt{E(CP_t-\overline{CP})^2}}=\frac{(\sqrt{\sigma_A^2+\mu^2})\,\overline{CP}}{(PF_t^1-C)\sqrt{E(CP_t-\overline{CP})^2}}, \tag{8}$$

where $\sqrt{\sigma_A^2+\mu^2}$ represents the distance between the actual hedging service and the perfect service, divided into a systematic and a random part.

The operational measure of hedging efficiency can now be expressed as:

$$E=\frac{\sigma_{FTR}\overline{CP}}{(PF_t^1-C)\sigma_{CP}}, \tag{9}$$

where $\sigma_{FTR}=\sqrt{(B_{t+1}+DC_{t+1})^2}$.

The application of this measure requires the futures exchange management to collect transaction specific data and cash market data. Because of the evolution of the information technology these data are in the future easy to obtain. Therefore it seems that our measure is very well applicable.

COMPARING THE EDERINGTON MEASURE WITH THE PROPOSED MEASURE OF HEDGING EFFICIENCY

The Ederington measure is still the most used measure in practise as well as in research. For that reason the Ederington measure is compared with the proposed measure of hedging efficiency, although they are in no way substitutes because they serve different goals. Both measures compare, to some extent, the variance generated by the cash market, or in terms of Ederington the unhedged position, with the variance in the hedged cash position. However, the contents of both variances differ. Especially the variance of the unhedged position in the Ederington measure is determined by the price change relation of spot and futures markets, whereas in the proposed measure of hedging efficiency the futures trading risk determines the variance of the unhedged position. The Ederington measure emphasizes the relationship between spot and futures prices, whereas the proposed one emphasizes the distance between the perfect and actual hedges. The Ederington measure is based on the minimum variance hedge and provides information for the hedger with respect to which part of the risk is reduced. The proposed measure is not based on hedger-specific characteristics but on basis risks and market depth risks. Furthermore, the proposed measure generates information for the futures exchange, with respect to which part of the difference between the actual hedging service provided and the perfect hedge is caused by random factors and which part can be managed by the controllable instruments of the exchange.

TABLE IV
Differences between the Ederington Measure (EM) and the Proposed Measure of Hedging Efficiency (E)

	Ederington Measure	Proposed Hedging Efficiency Measure
(1) Risk in unhedged position	$X_s^2 \sigma_{CP}^2$	$\frac{\sigma_{CP}}{\overline{CP}}$
(2) Minimum variance on a portfolio containing futures (Ederington); variance introduced by the futures itself (proposed hedging efficiency measure)	$X_s^2(\sigma_{CP}^2 - \frac{\sigma_{CP,PF}^2}{\sigma_{PF}^2})$	$\frac{\sqrt{\sigma_A^2+\mu^2}}{PF^1-C}$
(2) divided by (1)	$EM=\frac{\sigma_{CP,PF}^2}{\sigma_{CP}^2\sigma_{PF}^2}$	$E=\frac{(\sqrt{\sigma_A^2+\mu^2})\overline{CP}}{(PF_t^1-C)\sigma_{CP}}$

Where X_s^2 is the cash market position of the hedger.

The proposed measure is a relative one; it assesses not in an absolute sense as Ederington does, but recognizes that a deviation of 10 from 100 is different from a deviation of 10 from 1000. The Ederington measure does not incorporate the market depth costs, which are important in thin markets such as rice, nor does it generate information for the management of the exchange.

SUMMARY AND CONCLUSIONS

In this study a concept of overall risk reduction and a measure of hedging efficiency have been described. In contrast to the existing measures, this one does not focus on the performance of a portfolio but on the hedging service of the futures contract. Therefore, unlike other researchers measuring futures contract performance, this measure takes into account that futures contracts not only reduce cash price risk but also introduce additional futures trading risk, consisting of basis risk and market depth risk. The measure expresses the distance between the hedging service provided by the exchange and the perfect hedge. This distance is divided into a systematic part, which can be managed by the futures exchange, since that is caused by futures contract specification and futures exchange structure, and a random part, which is dependent on factors that are beyond the influence of the futures exchange. The hedging efficiency measure provides the hedger with a tool for comparing the competitive strength of alternative futures contracts. Not only the characteristics of the futures contract are incorporated in the measure of hedging efficiency but also the cash market risks, since both the quality of hedging service and the need for this service (i.e. the price risk in the cash market) are relevant to the success of the hedging service rendered by the futures exchange. The futures trading risk component of the measure indicates the hedging quality of the futures contract. The cash price risk component emphasizes the potential need for the futures contract. In order to make the measure of hedging efficiency operational, a measure of depth cost has been developed. Application of the measure of hedging efficiency measure might be worthwhile for the futures industry. Further research, in which the proposed measure is applied to different futures markets is clearly called for.

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