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Abstract
Transferring the risk of price changes, or hedging, is most desirable when the costs of doing so are low relative to the benefits. This paper discusses the nature of these benefits and costs and reports on a related analysis of data from the NYMEX crude oil futures market. It is shown that likely risk reduction is directly related to the degree to which the crude oil futures, market can be characterized as efficient. Using data from the highly volatile period of 1983-90, we find evidence that supports the proposition that the crude oil futures market is efficient. There is no evidence for the existence of risk premiums, which constitute an additional cost to hedging. This is good news for hedgers, as it implies that risk transfer is free in the sense that hedgers need pay no premium to speculators.

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Costs and Benefits of Using NYMEX Crude Oil Futures

RICHARD DEAVES and
ITZHAK KRINSKY

Transferring the risk of price changes, or hedging, is most desirable when the costs of doing so are low relative to the benefits. This paper discusses the nature of these benefits and costs and reports on a related analysis of data from the NYMEX crude oil futures market. It is shown that likely risk reduction is directly related to the degree to which the crude oil futures market can be characterized as efficient. Using data from the highly volatile period of 1983-90, we find evidence that supports the proposition that the crude oil futures market is efficient. There is no evidence for the existence of risk premiums, which constitute an additional cost to hedging. This is good news for hedgers, as it implies that risk transfer is free in the sense that hedgers need pay no premium to speculators.

Le transfert du risque que représente la fluctuation des prix, c'est-à-dire les opérations de couverture, est surtout souhaitable lorsque les coûts des telles opérations sont faibles par rapport à leurs avantages. L'article examine la nature de ces avantages et de ces coûts et présente une analyse des données relatives au marché à terme du pétrole brut sur la NYMEX. Il y est démontré que la diminution probable du risque est directement liée au degré d'efficacité du marché à terme du pétrole brut. Se fondant sur les données du marché pendant la période très volatile de 1983-1990, les auteurs viennent étayer la thèse de l'efficacité du marché à terme du brut. Rien n'indique, par ailleurs, qu'il existe sur ce marché des primes de risque, lesquelles ajouteraient au coût des opérations de couverture. Les arbitragistes en couverture peuvent s'en réjouir, puisque cela signifie que le transfert du risque est « gratuit », en ce sens qu'il ne comporte aucune prime à verser aux spéculateurs.

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1. Introduction

The crisis in the Persian Gulf in 1990-91 has illustrated how important it is for end users of petroleum products to be able to reduce the risk of unexpected price changes. The collapse of mediation talks between Iraq and Kuwait in the summer of 1990, followed by the Iraqi invasion of Kuwait, pushed oil markets into turmoil. The price of crude oil contracts on the New York Mercantile Exchange (NYMEX) for the closest delivery date quickly passed US$20 per barrel, and by late September, the contract for November delivery had reached nearly $40 per barrel. Nor was the upward movement in prices smooth — day-to-day fluctuations in either direction were often several dollars. It is becoming clear to many observers that in such a market buyers and sellers of oil benefit greatly from the ability to reduce price risk through futures contracts.

Futures contracts are essentially specialized forward contracts. A *forward* contract is a sales transaction to be consummated in the future at a price agreed upon now. The buyer and seller agree on a future date for delivery, the price to be paid on that future date, and the quantity and quality of the commodity to be delivered. A *futures* contract differs in that it is standardized with respect to quality, quantity and delivery

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location, and thus can be traded on organized exchanges.[1] Organized futures markets have expanded dramatically in the second half of this century and have taken on an important role in energy trade.

As oil markets evolved during the past two decades, resulting in more flexible pricing in active spot markets, the stage was set for the development of an active energy futures market. More open pricing and increased volatility fostered the use of devices to manage pricing risk. This is why trading in energy futures grew rapidly during the 1980s. NYMEX's most successful energy futures contract, for crude oil, began trading in 1983, with West Texas Intermediate as the par grade. During January 1990, over two million (1000 barrel) contracts were traded.

The success of futures markets has been due to the two principal benefits that they provide: a risk transfer mechanism and price discovery. Market participants who face the risk of price fluctuations may wish to insure against such risk by entering into agreements, through standardized trading instruments, with people who are less averse to bearing risk. "Price discovery" refers to the idea that, by observing futures prices, market participants are able to gain insight into consensus beliefs about the expected future spot price of the commodity being traded.

To focus on the former benefit of futures markets, the transfer of pricing risk (referred to as "hedging") involves benefits and costs. The purpose of this paper is to discuss the nature of these benefits and costs and report on some related empirical analysis in the oil futures market.

The prime benefit involved is the ability to reduce risk. We show that the potential for risk reduction is directly related to the degree to which the crude oil futures market can be characterized as efficient. (For the moment "efficiency" can be sufficiently defined by observing that a financial market is said to be efficient if it utilizes all available information in setting prices.) From the statistical analysis reported on here, based on NYMEX data from the highly volatile period of 1983-90, we find evidence in support of the proposition that the crude oil futures market is efficient.

The cost of hedging, in addition to the obvious transactions costs, is directly related to the spread between the current futures price and the corresponding expected spot price. If the spread is positive, the end user of the product who is hedging by buying the commodity forward must bear an expected positive cost, while the producer who is selling the commodity forward receives an expected benefit. If the market is efficient, these spreads can only be viewed as premiums paid to avoid risk. Based on our statistical analysis, we are unable to conclude that such premiums are significantly different from zero. Thus, conditions for effective hedging appear to be met by the NYMEX crude oil futures market.

In Section 2 we describe the theoretical relationships among market efficiency, risk premium theory and the effectiveness of hedging. In Section 3 we report on a number of empirical tests on the existence of risk premiums and the efficiency of the NYMEX crude oil futures market. Section 4 concludes the paper.

2. Market Efficiency, Risk Premium Theory and Hedging Efficacy

Market Efficiency and the Potential Existence of Risk Premiums

As already noted, a market is said to be efficient if all relevant information for the determination of prices has been utilized. This implies that market participants are unable to determine any profitable trading strategies based on their analysis of the relevant information set.[2] An example of an inefficiency helps to clarify this definition.

1/ A future, unlike a forward contract, also requires a "goodwill" deposit or variation margin. The margin varies from day to day depending on price movements; such variation is referred to as "marking-to-market."

2/ See Fama (1970) for a full treatment of the efficient markets hypothesis. It should be stressed that in this definition "profitable" refers to profit in excess of what may be earned on investments with comparable risk. Positive returns occur in efficient markets; "abnormally" high returns do not.

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When a firm announces that earnings are better than anticipated, one expects its share price to rise; similarly an announcement of worse-than-anticipated earnings will bring about a fall in the share price. Rendleman, Jones and Latane (1982) have found, however, that the stock market tends to underreact to either very favourable or very unfavourable earnings announcements. This anomaly implies that the investors in their sample would have been able to earn abnormal profits by buying stocks of companies that had just made very favourable earnings announcements and selling stocks of companies subject to unfavourable announcements. Thus the markets they looked at can be said to be inefficient in relation to the type of information studied.

One objective here is to test data from the crude oil futures market for the presence of similar phenomena, or equivalently, to search for trading strategies which, using only publicly available information, will earn excess returns from trading in oil futures. If such evidence cannot readily be found, one can have more confidence in the hypothesis that oil futures markets are efficient.

To search for excess returns, it is necessary to postulate a theory which explains what constitutes "normal" prices and returns. Only within such a theoretical structure will it be possible to test hypotheses implied by the efficient markets theory. Within this framework it becomes important to consider the possible existence of a *risk premium*.

The standard pricing model applied to commodity futures is based on the idea that a risk premium determines the relation between the market price of a futures contract and the corresponding **anticipated** spot market price for the underlying commodity.[3] In particular, risk premium theory states that the futures price at time t for delivery at T ($F_{t,T}$), plus, potentially, a (positive or negative) risk premium (RP_T), is equal to the market consensus expectation at t of the spot price for T (E_tS_T). That is,

$$(1) \quad F_{t,T} + RP_T = E_t S_T \ .$$

In this specification, we have assumed that the risk premium is time-invariant.[4] Nevertheless, we have made no assumption about its magnitude and sign: it may be positive, negative or zero.[5] Why does it make sense to view this spread as a risk premium? Suppose it is positive. Then it is equivalent to the average reward for a market player who "goes long" in a futures contract at t and reverses his position just prior to delivery.[6] The reason is that futures prices converge to cash prices just prior to required delivery at T.[7] When such a player has no position (either actual or anticipated) in the cash (i.e., spot) market, he is termed a speculator. Since he willingly assumes risk, he must be rewarded by a risk premium.

Of course it should be realized that if all market participants share the same expectation of future cash prices (i.e., expectations are homogeneous), then all speculators will go long in futures. This can occur if most hedgers wish to sell

3/ An alternative theory is based on the costs of and returns from storing the commodity underlying the futures contract. According to the theory of storage, the return from purchasing a commodity at time t and selling it forward (using a futures contract) for delivery at time T, should be equal to the cost of storage (interest foregone, warehousing, and shrinkage) minus a convenience yield. For a discussion of storage theory see, for example, Telser (1958) and Fama and French (1987).

4/ There is a trend now in the finance literature to model premiums as time-variant. One problem introduced by this complication is that it is difficult to separate time-variation in premiums from inefficiency. For example, see Deaves and Krinsky (1991).

5/ Note, however, that the absolute value of RP_{T+1} is greater than the absolute value of RP_T, since the period of risk-bearing is longer.

6/ In the futures market, "going long" describes the position of a futures contract buyer whose purchase obligates him to accept delivery of the commodity unless he liquidates his contract with an offsetting sale. If a trader buys a future contract and subsequently sells an identical contract, the clearinghouse nets out his position to zero.

7/ Of course, perfect convergence only holds for a spot commodity of the same quality, and available at the same location, as specified in the futures contract. When there is a locational mismatch, additional risk is introduced. We abstract from this issue throughout the paper.

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futures to reduce price risk, as would be true if most hedging was done by producers. On the other hand, a negative risk premium, along with homogeneous expectations, would mean that all speculators would be selling futures contracts in expectation of declining futures prices, with the typical hedger being an end user; i.e., a **buyer** of the commodity.

One can draw an analogy with the purchase and sale of insurance. For instance, a commodity buyer who wants to hedge against a higher spot price will be willing to pay for that protection by buying a futures contract (a long position) at a price higher than his or her expected spot price. On the other hand, a commodity seller may wish to hedge against the actual future spot price being lower than expected and will be willing to take a short position at a forward price less than the expected spot price. **The market value of the risk premium will be determined by the distribution of expected spot prices among market participants, their preferences regarding risk and the proportion of long hedging demand relative to short hedging demand.**

The mechanism for providing such "insurance" is enhanced by the presence of speculators. They are important because their participation allows hedging to occur to a greater extent on one side of the commodity market (e.g., on the buying side) than on the other. Speculators are enticed to absorb a net demand or supply in a futures market by the risk premium.

For the market as a whole, the difference between the observed futures market price at time t and the average spot price expected to prevail at time T can be characterized as the average risk premium. In the theoretical model, an equilibrium average risk premium is determined through a supply-and-demand adjustment process. Suppose that at time t someone considers buying an oil futures contract to hedge against an unacceptably high price at time T, and that this person finds that F - E(S) is an acceptable premium. The contract for future delivery will be purchased. If there exist many people in similar positions, the increased demand for such contracts will cause F to increase until the risk premium is too high for any additional potential buyers. Similarly, if the risk premium is initially too high for any buyers, the process will work in reverse and F will fall. In this way an equilibrium risk premium will be established. That is, equation (1) will hold, with the equilibrium RP set by the marginal buyers and sellers.

Positive and Negative Risk Premiums

The risk premium is merely the expected return on a long futures position. To see this, consider the return on a futures contract in the case in which one buys a future and sells it (i.e., reverses his position) just prior to delivery. This return is the percentage change in the futures price; or, the difference between the log of the terminal futures price and the log of the initial futures price, as in equation (2):

$$(2)\quad FR_t = F_{T,T} - F_{t,T} \ .$$

Obvious arbitrage arguments enforce a terminal equilibrium between S_T and $F_{T,T}$. Thus we can write

$$(2a)\quad FR_t = S_T - F_{t,T} \ ,$$

which can be rewritten as

$$(2b)\quad FR_t = [E_tS_T - F_{t,T}] + [S_T - E_tS_T] \ .$$

Equation (2b) illustrates the two roles of a futures market mentioned at the beginning of this paper. The risk premium,

$$RP_T = E_tS_T - F_{t,T} \ ,$$

is the amount that sellers are willing to give up in order to lock in a known price. If this were negative, the absolute value of the premium would be the amount that buyers would be willing to give up. The second component,

$$M_T = S_T - E_tS_T \ ,$$

is the forecast error of the futures price as realized at T. It relates to the hypothesis that the market price of a futures contract provides the

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most comprehensive view of the spot price at time T, taking account of the expectations of all market participants. If expectations are perfectly rational, then M_T should be, on average, equal to zero (i.e., if M_T could be observed it would appear as "white noise"). This implies

(2c) $E_t FR_t = RP_T$.

Consider the likely sign of the risk premium. One would predict a positive average risk premium if those who wish to hedge the commodity being traded are "net short" in the futures market. In other words, there are more offers from the hedgers to sell the commodity than to buy it. This will be the case if the market is dominated by entities which possess (or anticipate possession of) the commodity, as in the case of a farmer about to harvest his crop, or an oil producer about to pump crude out of the ground. In order to insulate themselves from price fluctuations they sell (go short in) futures contracts. In this case, speculators willing to go long (i.e., those buying futures contracts) are needed to supply insurance, which implies that holders of such contracts should typically be rewarded by increases in the contract prices as a given delivery date approaches. This will occur if the futures price is less than the expected spot price, resulting in a positive risk premium.

That pattern of futures price changes is called "normal backwardation." Obviously, the reverse situation can also prevail. If most hedgers anticipate a future need for the commodity (such as in the case of end users of petroleum products), then, in order for the demand for price insurance to be satisfied, speculators would have to be willing to sell futures contracts to a greater extent than they buy them. As a reward for bearing risk, they would have to have the opportunity to reverse their positions at lower prices than those at which they originally sold. In such a market futures price declines would be the norm as delivery dates approach. This pattern of prices is referred to as "contango." It would not be surprising to find a contango pattern in the market for crude oil futures. In a market governed by either international governmental agreements or by international producers' cartels, a futures market may well appear as a counter-weight or a consumers' answer to producers' power (Anderson, 1984).

There are, however, other complications that could lead the absolute value of the risk premium to be small or close to zero. Even given a natural tendency towards contango pricing, the required reward for risk-bearing might be extremely small. This could happen if speculators are only slightly risk averse, or if the risk inherent in futures trading on the part of speculators can be dealt with to a great extent by portfolio diversification.[8]

In any case, there is certain to be some hedging interest on the selling side. In fact, long and short hedging activity might balance each other out, eliminating the need to entice speculators into favouring one side of the market in their trading. In the final analysis, the sign of the risk premium is an empirical question.

Efficiency and Hedging Performance

Next we demonstrate in a simple fashion that efficiency should be a central concern for those considering using futures markets for the purpose of risk transfer. Suppose an end user with a known future requirement for crude oil is considering whether he should buy at spot when the product is actually required, or immediately hedge by the purchase of an appropriate number of futures contracts. His need for the product is at $t^* \leq T$. Suppose he decides to buy in the spot market. It is possible to view the consequence of his choice in terms of an opportunity "return" (SR_t):[9]

(3) $SR_t = E_t S_{t^*} - S_{t^*}$.

8/ According to a central financial theory known as the capital asset pricing model, such diversifiable risk does not need to be rewarded: diversification is a substitute for compensation.

9/ In this section returns are defined from t to t^*. For example, $FR_t = F_{t^*,T} - F_{t,T}$.

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To the extent that the spot price turns out to be lower/higher than anticipated, there is an associated opportunity gain/loss.

If, however, one combines long futures positions with this implicit cash market position, then the hedged return is:

$$(4) \quad SR_t^h = SR_t + FR_t \ .$$

For simplicity assume the risk premium is zero.[10] To consider efficiency, suppose the market consensus expectation $E_t^m S_T$ is potentially different from the theoretically true expectation $E_t S_T$.[11] It is, of course, the market that determines prices, so

$$F_{t,T} = E_t^m S_T = E_t S_T + U_t \ ,$$

where $U_t = E_t^m S_T - E_t S_T$. If markets are efficient, U_t is tautologically zero. If markets are inefficient, U_t will sometimes be nonzero, and a market participant may be able to earn abnormal returns by improving on the market's forecast.

The problem is that hedging will be less efficient if market inefficiency exists. SR_t^h can be rewritten as

$$\begin{aligned}(4a) \quad SR_t^h &= E_t S_{t^*} - S_{t^*} + F_{t^*,T} - F_{t,T} \\ &= E_t S_{t^*} - S_{t^*} + [E_{t^*} S_T + U_{t^*}] - [E_t S_T + U_t] \\ &= [E_t S_{t^*} - S_{t^*}] + [E_{t^*} S_T - E_t S_T] + [U_{t^*} - U_t] \ .\end{aligned}$$

Consider the variance of SR_t^h in an efficient market relative to what it might be in an inefficient market. The third term in the above equation is only present in the case of inefficiency. A theoretical market participant with full knowledge could hypothetically know U_t (based on an accurate expectation of the spot price at T ($E_t S_T$) and a reading of the current future price in the market, which is equal to $E_t^m S_T$), and would be able to take its size and sign into account when undertaking a hedge. But the future difference, at t^*, between the market's expectation and the true expectation, U_{t^*}, cannot be even theoretically known at the time the decision is made.[12] This illustrates that the greater is the extent of inefficiency (i.e., the greater is VAR(U_t)) the less effective will hedging activity be.

3. Some Evidence from the Crude Oil Futures Market

Risk Premiums

Under the hypothesis of time-invariant risk premiums, it is straightforward to draw inferences on the magnitude and the sign of the premium.[13] Recall from equation (2c) that an expected futures return is identical to the risk premium, so mean *ex post* (observed) returns should be unbiased estimates of the premiums.

As mentioned earlier, returns were defined (using (2)) as log-differences of futures prices where the end of the return horizon is at the contract wind-up date. Mean returns for NYMEX crude oil futures contracts were calculated for one-, two-, and three-month horizons.[14] As shown in Table 1, in all cases a zero risk premium could not be rejected. For a forecast horizon of one month, for example, the mean return was 0.59%, which is not significantly different from zero. Equivalently, the insurance premium is zero.[15] This is good news for hedgers, since the only costs involved in participating in

10/ The analysis can be trivially extended to the case of nonzero premiums.

11/ To use the approach of Fama (1970), these expectations may differ because $E_t^m S_T$ is conditional on φ_t^m which is defined to be the information set actually utilized by the market in setting prices; and $E_t S_T$ is conditioned on φ_t, which is defined to be the true relevant information set. It is possible that the market may be missing something; i.e. φ_t^m, is a strict subset of φ_t. Note that earlier in this paper we have simply assumed that $E_t^m S_T = E_t S_T$.

12/ Note that if $t^* = T$ there is no difficulty, since due to the convergence of cash prices and futures prices. In reality of course most hedging does not have such a perfect timing match.

13/ Potential inefficiency will not bias the estimate if U_t is white noise.

14/ Historical crude oil settlement futures prices (daily closing) were obtained on diskette from Technical Tools, Inc., Los Altos, California.

15/ This may seem bizarre as compared to a standard insurance premium. Note, however, that standard insurance protects against downside outcomes, while hedging through the use of futures reduces upside potential as well as downside loss.

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Table 1: Mean Futures Returns

Forecast Horizon (Months)	Mean Return	T-statistic	Observations
1	0.00589	0.49499	79
2	0.01055	0.62215	79
3	0.01239	0.62972	79

the futures market are transaction costs.

Form of the Efficiency Tests

Given a constant risk premium, market efficiency implies that variability in returns is unpredictable. Thus the testing strategy is straightforward. If one regresses FR_t on information known *ex ante*, then no significant correlations should be detected. We should find all β_i to be equal to zero in the following regression model:

$$(5)\quad FR_t = \beta_0 + \sum_{i=1}^{N} \beta_i X_{it} + \epsilon_t \ .$$

Although many variables might be included in the information set (i.e., X_1, X_2, ... X_n) when testing the hypothesis, one would like to use elements which are likely, for economic reasons, to be important determinants of returns. Here we test three obvious candidates: past returns, the basis (i.e., the difference between the cash market price and the futures price at t), and a set of world macroeconomic variables.

Predictability of Returns Using Lagged Returns

Crude oil futures returns (using one- to three-month horizons) are regressed on past returns, lagged up to four time periods, as follows:[16]

$$(5a)\quad FR_t = \beta_0 + \sum_{i=1}^{N} \beta_i FR_{t-i} + \epsilon_t \ .$$

If any of the coefficients are statistically significant, this means that returns can be predicted (at least within the sample) on the basis of past returns. Under constant risk premiums, this implies unexploited profit opportunities for speculators, or inefficiency.

In Table 2 we present test-statistics for the null hypothesis that all slope coefficients are zero

Table 2: Predicting Returns Using Lagged Returns (F-Tests)

Number Of Lags	Forecast Horizon (Months) 1	2	3
1	1.8318	0.0559	0.2079
	(1,80)	(1,38)	(1,24)
2	0.8938	0.1879	0.2044
	(2,78)	(2,36)	(2,22)
3	0.6051	0.1321	0.1288
	(3,76)	(3,34)	(3,20)
4	0.5357	0.2458	0.1805
	(4,74)	(4,32)	(4,18)

Notes: The numbers in the parentheses are the degrees of freedom in the numerator and the degrees of freedom in the denominator respectively.

(F-tests). As is clear, for all maturities there is no strong evidence against the null hypothesis at conventional levels of significance. Fama (1970) characterized the lack of such predictability as "weak form efficiency." Thus, for all forecast horizons, the NYMEX crude oil futures market can be said to be weak form efficient.

Predictability of Returns Using the Basis

The next test of efficiency utilizes the basis. The basis is defined to be the difference between the current cash price and the current futures price. The reason for its consideration here is that it is a magnitude that all market participants tend to focus on. Futures returns are regressed on the basis in effect at the beginning of the return horizon, as follows:

$$(5b)\quad FR_t = \alpha + \beta\,[S_t - F_{t,T}] + \epsilon_t \ .$$

Estimates of the slope coefficients are presented in Table 3.[17] In no case is the slope coeffi-

16/ In this case it makes no sense to use overlapping observations, since returns will be autocorrelated by construction.

17/ Intercepts are omitted for brevity, but in no case does an intercept even approach statistical significance.

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Table 3: Regressions of Futures Returns on the Basis

Maturity	Observations	b	$\bar{R}^2$
1	79	0.4288687 (1.237241)	0.0067
2	79	0.3833742 (1.190426)	0.0008
3	79	0.0190552 (0.0321865)	-0.0129

Notes: $\bar{R}^2$ is the adjusted coefficient of determination for the regression of futures returns on the basis. T-statistics are shown in brackets below the coefficient estimates.

cient even close to being statistically significant. Once again, no inefficiency is apparent.[18]

Predictability of Returns Using Macroeconomic Information

In the next set of tests we introduce key macroeconomic variables. These are aggregated data for the OECD countries. They were chosen as explanatory variables because a number of existing studies suggest that they should have an impact on commodity prices and, therefore, presumably on returns on NYMEX crude oil futures.[19] The variables used in explaining one- to three-month futures returns are the inflation rate (i.e., growth rates in the OECD Consumer Price Index); growth in OECD industrial production; OECD narrow monetary expansion (i.e., M1); and changes in US short-term interest rates (as proxied by changes in US three-month Treasury bill rates).[20] Further, since the timing of the release of these data varies among countries and announcement types, we have experimented with different lag structures.

Table 4 contains test-statistics for which the null hypothesis is that lagged macroeconomic variables have no explanatory power in explaining crude oil futures returns. There is some evidence that it might be appropriate to reject the efficient markets hypothesis when lags beyond two are included, but not otherwise. For example, when four lags are included the null hypothesis can be rejected for all but the two-month horizon.

Table 4: Predicting Returns Using World Macroeconomic Variables

		Forecast Horizon (Months) 1	2	3
ALL VARIABLES (With 4 Lags)	Chi-Square value	30.42535	23.93554	26.95580
	(DF)	16	16	16
ALL VARIABLES (With 3 Lags)	Chi-Square value	18.71602	21.41168	17.66069
	(DF)	12	12	12
ALL VARIABLES (With 2 Lags)	Chi-Square value	14.09895	7.311712	9.458243
	(DF)	8	8	8
ALL VARIABLES (With 1 Lag)	Chi-Square value	6.050755	2.202695	5.660704
	(DF)	4	4	4

Notes: The dependent variable in these regressions is crude oil futures returns (using one- to three-month horizons). The right hand side variables are various lags of OECD inflation, growth in industrial production, and monetary expansion; and changes in US T-bill rates. DF denotes degrees of freedom for the Chi-Square test. The critical values for the Chi-Square test (5%) are 26.30 (16 DF), 21.00 (12 DF), 15.51 (8 DF), and 9.49 (4 DF).

It is notable that efficiency should be called into question only when longer lags are used. It could be that futures returns are not so much affected by these macroeconomic magnitudes as

18/ This is consistent with Ma (1989) for a sample ending in 1986.

19/ For example, see Kaminsky and Kumar (1989).

20/ Data for OECD countries were obtained from *Main Economic Indicators (Historical Statistics): 1969-1988*, Department of Economics and Statistics, OECD. The data for 1989 and 1990 were obtained from *Main Economic Indicators (Monthly)*. Interest rates were obtained from the *Federal Reserve Bulletin*, Board of Governors of the Federal Reserve System, Washington, D.C., (various issues).

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by their public dissemination. As stated earlier, releases tend to lag the periods to which they refer by varying amounts of time. Given this problem of lagged information release it is not necessarily the case that profitable opportunities for speculators were in fact available. To demonstrate inefficiency it would be necessary to prove that returns were predictable based on previously made announcements, but, given the uncertainty as to when the announcements were actually made, it is not possible for us to do this. In light of this issue, we remain unable to categorically reject market efficiency.

There is another reason for not summarily rejecting efficiency. Some significant correlation will always be found *ex post*, but a stronger result would require out-of-sample forecasting reliability. It has not been demonstrated that these variables will be helpful in predicting crude oil futures prices out-of-sample. In order to approach this issue, additional empirical work needs to be undertaken.

4. Conclusion

Market efficiency and the existence of a risk premium in the NYMEX crude oil futures market are of particular importance to end users of crude oil and refined products who may want to use this market to hedge against price risk. There is no evidence that risk premiums exist. In other words, crude oil futures prices are unbiased predictors of spot prices. This is good news to hedgers as it implies that risk transfer is free, in the sense that no premium need be paid to speculators by hedgers. Although the market appears to be efficient when past returns and the basis are used as explanatory variables, there is some evidence that futures returns may be predicted using macroeconomic variables. Nevertheless, even here a potential explanation exists which is quite consistent with market efficiency.

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