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Benjamin Miranda Tabak

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Edited by:

Research Department (Depep)

(E-mail: workingpaper@bcb.gov.br)

Authorized by Ilan Goldfajn (Deputy Governor for Economic Policy).

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On the Information Content of Oil Future Prices*

Benjamin Miranda Tabak**

Abstract

This paper deals with the efficiency of the Brent Crude oil future contracts and tests whether futures can be used to predict realized oil spot prices. Evidence suggests that future prices up to three-months contracts on Brent Crude are unbiased predictors of future spot prices but the explanation power is not high (around 20%). Furthermore, using cointegration techniques the unbiasedness hypothesis for future prices as predictors of realized spot prices could not be rejected. When the sample is divided into sub-periods, the absence of bias in futures prices is rejected.

Keywords: information content, Brent Crude, oil prices, futures, cointegration.
JEL: C53, G14, and G15.

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** Research Department, Central Bank of Brazil. Author's e-mail address: Benjamin.tabak@bcb.gov.br

1. Introduction

There has been little agreement in the financial literature on whether future prices have power to forecast realized spot prices. For many markets as interest rates, exchange rates and commodities, there has been a huge research effort to assess whether forward and future markets have forecasting power. However, empirical evidence is mixed.

If future and forward prices serve as efficient predictors of futures spot prices is a question that many researchers have been tackling with during the last decades. In the foreign exchange market, results shown by Scott (1982) suggest that prices in futures and forward markets do not reveal any additional information on market expectations that is not already revealed in spot prices. According to Scott (1982), "In foreign exchange markets forward rates are very poor predictors of future changes in the exchange rates." Obstfeld and Rogoff (1996), based on empirical evidence for many series, recommend betting on the opposite direction of that indicated by the forward rates, suggesting that forward exchange rates are far from efficient predictors.

On interest rates, Fama (1984) tests whether the current forward-spot differential has power of forecasting either the future premium or the future change in the one-month spot interest rate and concludes that forward rates have information about future spot rates. Cole and Reichenstein (1994) found evidence that Eurodollar futures rates fully reflect information contained in their data and furthermore that futures rates on the contract expiring in one quarter provides an efficient forecast of LIBOR at expiration but more distant futures rates contain risk premium which increases with the contract expiration date.

For commodities, Fama and French (1987) found evidence that futures prices have time varying expected premiums and power to forecast future spot prices. Crowder and Hamed (1993) test the efficiency of the oil futures market from March 1983 to September 1990, using data from the New York Mercantile Exchange. In a cointegration analysis framework they found evidence supporting the efficiency hypothesis but not the arbitrage equilibrium hypothesis. For metal markets, Chowdhury (1991) finds evidence that futures prices are biased predictors of the subsequent spot prices.

This paper assesses whether futures contracts on oil have information content concerning realized spot oil prices. The Brent Crude futures contracts traded at the International Petroleum Exchange (IPE) are used spanning the period from January 1990 to December 2000. Another important question addressed here is whether futures prices are unbiased predictors of futures spot prices. Crowder and Hammed (1993) analyze these contracts (one month futures contracts) using cointegration analysis. In this paper besides a cointegration approach we also use Fama (1984) regressions to test the unbiasedness hypothesis for the oil futures market and study the behavior of contracts up to three months.

Oil futures prices frequently exhibit backwardation in which futures prices are below spot prices. Backwardation represents a puzzle for economists, as it appears to violate intertemporal no arbitrage conditions. An explanation for backwardation could be that as most hedgers are producers, they would hedge using short future positions. Hedgers will be called to pay a premium in order to induce speculators to take opposite long positions. Thus futures prices below spot prices give speculators an expected profit. This would mean that premium risk would play an important role in futures contracts pricing.

Backwardation can also be explained by means of an economic concept: the convenience yield. The convenience yield would be a flow of non-pecuniary benefits that commodity stockholding perceive that do not accrue to holders of futures and forward contracts. This could explain why futures prices would be below spot prices for long periods of time.

A last explanation of backwardation would be the one given by Litzenberger and Rabinowitz (1995) that argue that ownership of oil reserves may be viewed as owning a call option whose exercise price corresponds to the extraction costs. In this context, backwardation arises from the equilibrium tradeoff between exercising the option and keeping it alive.

Summarizing, it does not seem clear whether oil futures prices would be good predictors of realized spot prices. There may be some biases that could be most pronounced in times of greater uncertainty as speculators would ask for higher risk premiums. Testing whether risk premium implicit in oil futures contracts are time-varying is also done.

To the best of our knowledge, the only research paper assessing efficiency on Brent Crude futures is that of Kellard et al. (1999). In this paper the authors test the one-month contract for Brent oil and other commodities[1].

The contribution of this paper is that it tests the efficiency hypothesis up to the Brent Crude 3-months futures contracts, so it look to the futures contract short end curve. The main motivation for the study is that the Brazilian Ministry of Finance has decided that it will use the average price on Brent Crude Oil every quarter to adjust domestic prices for oil, with obvious implications on domestic inflation. The question that arises is that if futures prices can be used to forecast future realized oil prices and thus can help forecast future domestic inflation. The interest on oil contracts has its origin from the oil shock that happened in 1999 and 2000. Prices for Brent Crude averaged US$ 12,53 in the second half of 98. In 99 and 2000 the average rose to US$ 17,96 and US$ 28,64, respectively. In 2000, prices reached a peak of US$ 34,55. The Brent Crude futures contract is one of the world's most important pricing indicators for the oil industry. These contracts form a key part of the so called Brent complex that is used to price two thirds of world's internationally traded Crude oil.

This paper proceeds as follows: in the second section it tests whether futures prices have information content and if there are time-varying risk premiums. In section three, some cointegration and market efficiency tests are performed. Section four concludes the paper.

2. Methodology and empirical results

Subsection 2.1 illustrates the Fama (1984) approach. Subsection 2.2 shows how the sampling has been done. Section 2.3 presents empirical results.

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[1] Most of efficiency studies that use co integration techniques are based on a model that relates the spot price at time t and the Futures price at time t-1 maturing at time t. Testing for efficiency is then conducted by regressing futures prices on spot prices and verifying whether these futures are unbiased estimators (statistically different from one) and also whether the intercept would be statistically indistinguishable from zero.

2.1. The Fama (1984) approach

The Fama (1984) approach is used in the next subsection, which consists basically in using two regressions:

$$S_T - S_t = \alpha_1 + \beta_1 \lfloor F_{t,T} - S_t \rfloor + \varepsilon_1(t,T) \quad (1)$$

$$F_{t,T} - S_T = \alpha_2 + \beta_2 \lfloor F_{t,T} - S_t \rfloor + \varepsilon_2(t,T) \quad (2)$$

where S_T is the realized spot price at time T, $F_{t,T}$ is the price of the futures contract for month T at time t, $\varepsilon_1(t,T)$ and $\varepsilon_2(t,T)$ are the residuals of the regressions.

If β_1 is significantly different from zero then the basis observed at instant t contains information about changes in the spot rate[2]. Likewise, if β_2 is significantly different from zero then the basis contains information about the risk premium realized on T.

2.2. Data

The data used in this paper has been collected on the Bloomberg database for all futures contract series up to 3 months and for the spot price. These contracts on Brent Crude Futures are traded at the International Petroleum Exchange (IPE).

Trading on these contracts ceases at the close of business on the business day immediately preceding the 15th day prior to the first day of the delivery month, if such 15th day is a banking day in London[3].

The series for futures contract prices was built by using the closing price of the day immediately after the cessation of trading of contracts, which could be thought as the first available forecast for subsequent months. This sampling approach guarantees that the data does not overlap and it does not suffer from the econometric problems

[2] The basis, $F_{t,T} - S_t$, is defined as the difference between the futures price and the spot price, both at time t.

[3] If the 15th day is a non-banking day in London (including Saturday), trading shall cease on the business day immediately preceding the first business day prior to the 15th day.

described in Hansen and Hodrick (1980) and West (1997)[4]. Nonetheless, it sacrifices observations.

The measurement of the basis is made as the difference between the futures prices and the spot price on that particular day. Using expiry dates for Brent Crude, the basis is calculated for the day immediately after the expiration of contracts. The change of spot prices is then calculated as the difference between the spot price on the day of cessation of trading on contracts and the spot price in the previous month.

The data spans the period from January 1990 to December 2000, which means that there are 132 observations for the one-month contract, 66 for the two-months-contract and 44 for the three-months contract. All variables are in natural log levels.

The chart below shows the evolution of spot and one-month futures prices during the 90's. Notice that, during lasting periods of upward price movements, futures prices tend to underestimate the realized spot prices, while during periods of downward movements, futures prices tend to overestimate spot prices (this behavior is also present in figures for the two and three-months contracts as presented below). However, there seems to be a clear relationship between these prices in the sense that they seem to move together.

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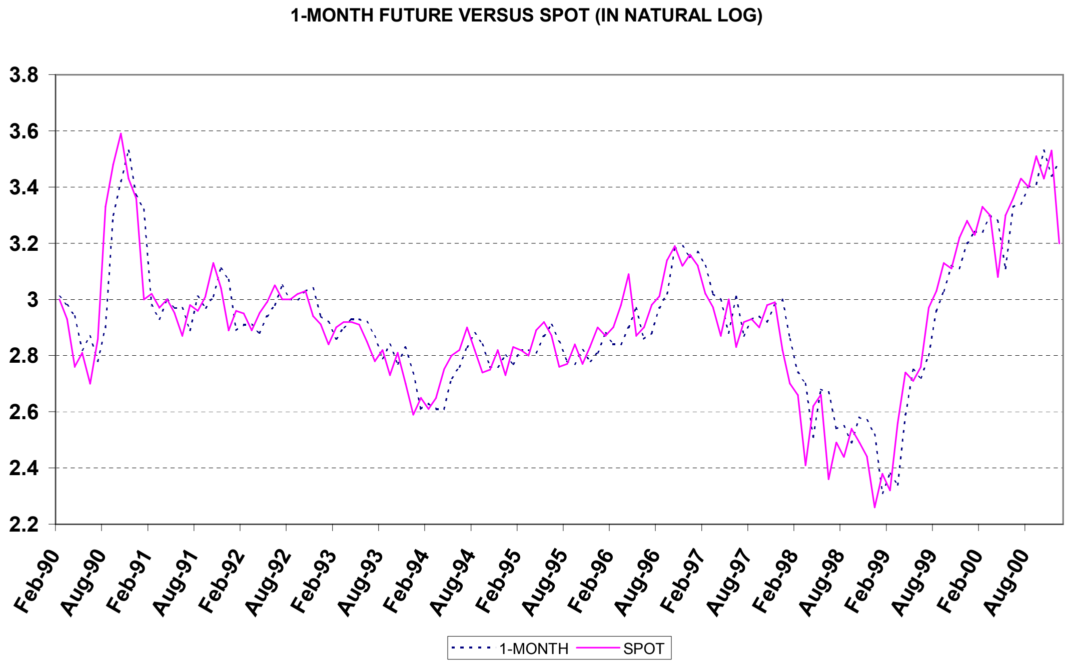
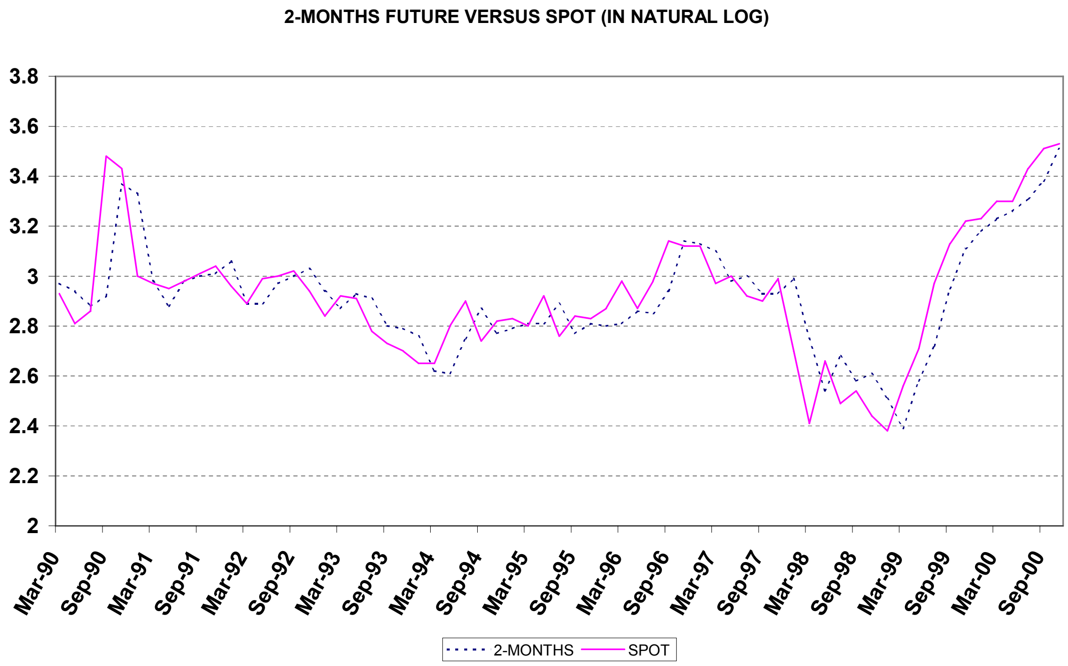
[4] Standard errors from regressions with overlapping observations must be corrected for auto-correlation. In general, researchers use the Generalized Method of Moments estimator, using lagged explanatory variables as instruments, and correcting the covariance matrix for the MA error as suggested in Hansen (1982), with the modification due to Newey and West (1987) to ensure that the variance-covariance matrix is positive definite or as suggested in West (1997).

Figure 1



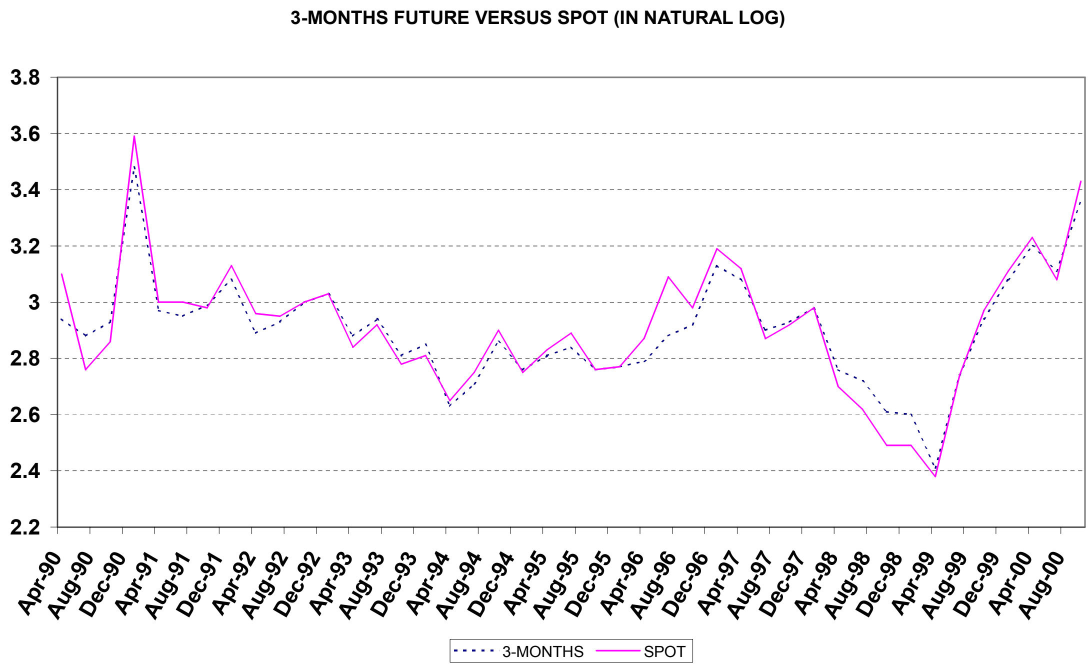
In the chart below the evolution of the two-months futures contract and spot prices can be seen.

Figure 2



In figure 3, the evolution of the three-months futures contract is depicted. This contract seems to share the same features as the previous two.

Figure 3



Figures 1,2 and 3 show that realized spot prices and expected prices (given by the futures contracts) may share some common trends and thus (at least to some extent) futures prices could be used as predictors for spot realized prices.

From the figures presented above it is clear that there is a positive average bias in upward price movements and a negative bias in downward movements. The average bias (defined as the average difference between one-month futures and spot prices) equals minus US$ 1,77 if one restricts attention to upward movements and is equal to US$ 1,15 for downward movements.

In the next subsection some tests are performed to assess whether these futures prices can be used to predict realized spot prices.

2.3. Empirical Results

It is worth mentioning that in order for equations (1) and (2) to be meaningful, and not spurious, a necessary condition would be that the basis, $F_{t,T} - S_t$, the ex-post premium $F_{t,T} - S_T$, and the change in spot prices $S_T - S_t$ are stationary.

This hypothesis has been tested using Augmented Dickey and Fuller (1979, 1981) unit root tests for all maturities. By minimizing the Schwarz information criterion and testing if residuals were white noise an optimal number of lags for the unit root tests was found[5]. In all cases empirical evidence suggests that these variables are stationary. We have performed robustness tests using different information criteria to choose the optimal number of lags and also using and intercept, both and intercept and a trend and also running unit root tests with neither an intercept nor a trend[6].

The next step is to perform regressions given in equation (1). In the table below results for these regressions are shown, which are called forecast power regressions, for contracts up to 3 months. As can be seen the adjusted R^2 increases from one to two months and decreases slightly from two to three months.

Table 1. Forecasting Power Regressions

Contract	Intercept α_1	Slope β_1	Adjusted R^2
One-month	-0.00365	0.81857*	15.57%
	(0.0108)	(0.1470)	
Two-months	0.01025	0.95326*	19.58%
	(0.0201)	(0.2721)	
Three-months	0.01828	1.01927**	19.02%
	(0.0323)	(0.3096)	

* Rejection of the null with 99% confidence
** Rejection of the null with 95% confidence
Newey-West HAC standard errors
Standard errors in parentheses

From table 2 it can be concluded that there is information content in the basis that helps to predict future realized spot prices. The significance of the slope for these regressions leads to conclude that futures prices can be used to predict realized spot prices. Nevertheless, the basis have a relative higher variability than those of realized changes in spot prices as can be seen by a slope smaller than one. This issue will be addressed in what follows.

[5] A maximum of 6 lags was used in all unit root tests.
[6] These tests are available upon request from the author.

The expectation hypothesis states that futures prices are market expectations of future spot prices, which implies the coefficient restrictions $\alpha_1 = 0, \beta_1 = 1$. In what follows some tests on this hypothesis are performed, test of the joint hypothesis of $\alpha_1 = 0, \beta_1 = 1$. The F statistics are given in the table below for the joint hypothesis as well as the Chi-square statistics for null of an intercept equal to zero and slope equal to one, respectively. None of these assumptions can be rejected.

Table 2. Wald Tests

Contracts	H0: $\alpha_1 = 0$	H0: $\beta_1 = 1$	H0: $\alpha_1 = 0, \beta_1 = 1$
One-month	0.140260	1.226977	0.684152
	(0.70)	(0.27)	(0.50)
Two-months	0.336888	0.039857	0.209523
	(0.56)	(0.84)	(0.81)
Three-months	0.335360	0.003886	0.168966
	(0.57)	(0.96)	(0.82)

p-values are given in parentheses

The F-statistics is reported for the joint hypothesis of $\alpha_1 = 0, \beta_1 = 1$. For all contracts this assumption is not rejected. However, the standard errors of these regressions could be biased as the regressions have low Durbin-Watson statistics for the first two contracts, 1.76 and 1.61, respectively and a high Durbin-Watson of 2.19 for the third regression[7].

From the results above we can conclude that futures prices are unbiased predictors but have a low explanatory power as can be seen by the low adjusted R^2. In order to improve these statistics we follow the approach of Kellard et al. (1999). More explanatory variables are added, which are lags for both the basis and the changes in spot price. We used the Schwarz information criterion, which is a parsimonious selection criterion, to choose the number of lags. The estimated equation is given by:

$$S_T - S_t = \alpha_1 + \beta_1 [F_{t,T} - S_t] + \sum_{i=1}^{p} \phi_i (S_{T-i} - S_{t-i}) + \sum_{i=1}^{p} \theta_i (F_{t-i,T} - S_{t-i}) + \varepsilon_1(t,T) \quad (3)$$

[7] Serial correlation tests were performed for the errors in these regressions and the null of absence of autocorrelation was rejected in all cases. Thus we have used Newey-West (1987) corrected standard errors.

Results are shown below. For all contracts the lag 1 was chosen. Our results indicate that the coefficients on the basis remained relatively stable.

Another condition for efficiency of futures prices is that the lagged terms in expression (3) should be jointly insignificant. We performed an F-test for jointly significance of these parameters for the three forecasting power regressions. In all cases, the F-tests show evidence suggesting that these coefficients are not statistically different from zero, which corroborates the previous finding indicating that these contracts may be after all, efficient.

Table 3. Forecasting Power Regressions

	One-month	Two-months	Three-months
α	-0.0033	0.0085	0.0243
	(0.0102)	(0.0186)	(0.0370)
β	0.8609*	1.0194*	0.9921*
	(0.1280)	(0.1847)	(0.3460)
ϕ_1	0.0948	0.1919	-0.1126
	(0.0919)	(0.0901)	(0.1571)
θ_1	-0.1713	-0.2850	-0.0496
	(0.1743)	(0.2022)	(0.3068)

* Rejection of the null with 99% confidence.
** Rejection of the null with 95% confidence.
*** Rejection of the null with 90% confidence.
Newey-West HAC standard errors, Standard errors are given in parentheses.

Table 4 shows results for the unbiasedness hypothesis tests. Results remain qualitatively the same for the first two contracts. However, the null of a slope equal to one is rejected with 90% confidence for the 3-months contract.

Table 4. Wald Tests

Contracts	H0: $\alpha_1 = 0$	H0: $\beta_1 = 1$	H0: $\alpha_1 = 0, \beta_1 = 1$
One-month	0.1176	0.5869	0.3535
	(0.73)	(0.44)	(0.70)
Two-months	0.2280	0.0051	0.1151
	(0.63)	(0.94)	(0.89)
Three-months	0.4280	0.0004	0.2172
	(0.51)	(0.98)	(0.80)

***Rejection of the null with 90 % confidence.
p-values are given in parentheses

We turn now to equation (2), the premium regression, as the left side of this equation can be seen as the realized premium. Results are given in table 5. The significance of the slope can be interpreted as a time-varying risk premium.

Table 5. Premium Regressions

Contract	Intercept α_2	Slope β_2	Adjusted R^2
One-month	0.003650 (0.0108)	0.181426 (0.1470)	0.17%
Two-months	-0.010259 (0.0201)	0.046738 (0.2721)	-1.52%
Three-months	-0.018288 (0.0323)	-0.019275 (0.3962)	-2.42%

Newey-West HAC standard errors

For one, two and three-months contracts we cannot reject the null of a slope statistically different from zero. Also the two and three-months regressions have negative adjusted R^2s as the R^2s of these regressions is very low and close to zero. If one allows for lagged premiums and lagged basis terms the adjusted R^2s are improved up to 20%, but the coefficients on the basis are still insignificant. The interpretation is that the risk-premium is not time varying[8].

An interesting point to notice is that if one restricts attention to sub-periods as the last two years of rising oil prices the unbiasedness hypothesis is rejected. Only when we use the full sample unbiasedness cannot be rejected. These facts are shown in table 6. In the first column the sample used in order to perform the forecasting power regressions is shown. In the second and third columns the coefficients with asterisks denoting significance are presented. Finally, in the last two columns a Wald test is done on the coefficients and we can see that unbiasedness is rejected for the second and third sub-periods. These sub-periods were chosen using the graph of oil prices. In 1994 the oil price reached a low, followed by a historical low in the beginning of 1999. By

[8] It is important to notice that the fact that the slope coefficient is not statistically different from zero does not rule out the possibility of a time-varying risk premium. This is certainly a necessary, but far from sufficient, condition. There are many ways for the risk premium to vary through time besides a simple linear dependence with the basis.

inspection of Figure 1 we can see that when the trend ex-post proves positive futures prices seem to underestimate realized oil prices.

Table 6. Forecasting power regressions for sub-periods (one-month future)

Sample	Intercept α_1	Slope β_1	H0: $\beta_1 = 1$	H0: $\alpha_1 = 0, \beta_1 = 1$
01/90 to 01/94	-0.0099	0.9408*	0.2284	0.1406
	(0.0195)	(0.1237)		
01/90 to 01/99	-0.0123	0.6882*	3.3181***	2.1371
	(0.0113)	(0.1711)		
01/94 to 01/99	-0.0085	0.3197	7.0405*	3.9785*
	(0.0114)	(0.2563)		
01/99 to 12/00	0.0359***	1.8861*	2.5286	3.8634
	((0.0206)	(0.5572)		

* Reject the null with 99% confidence
** Reject the null with 95% confidence
*** Reject the null with 90% confidence
Newey-West HAC standard errors in parentheses.

The conclusion that can be made using previous reported results is that the one, two and three-months contracts have information content on realized spot rates and that these contracts are efficient predictors of the future spot rate. Nevertheless, if the sample is divided into sub-periods (of lasting upward or downward movements) the unbiasedness hypothesis is rejected. However, one cannot tell a priori if the upward or downward trend is going to persist and in this sense if a correction for the predictions of futures prices would be needed.

In the next section some further tests to assess whether the futures prices series cointegrate with futures spot rates are made. The Engle and Granger (1987) and Johansen's (1988) approach are followed.

3. Cointegration between futures and spot realized prices

In this section spot prices for a given month are regressed on futures prices. However, when the variables are no stationary for regression in levels to make sense it must be interpreted as a possible co integrating relation.

$$S_T = a + bF_{t,T} + \zeta_t \tag{4}$$

In the next subsection we use the Engle-Granger approach to test for cointegration between spot and futures prices. The Johansen (1988) methodology is used in subsection 3.2. Finally, unbiasedness tests are performed in the last subsection. As these methods are frequently used in the financial literature only a short account will be given.

3.1. The Engle-Granger (1987) approach

In table 7 results for the one and two-months futures series and spot prices for monthly and bimonthly frequency are shown. These series are I (1) (integrated of first order)[9]. In this table the null of a unit root against an I(0) alternative is tested and is rejected only for the three-months contract. Augmented Dickey and Fuller tests were used choosing the lag lengths in order to minimize the Schwarz information criterion (SIC).

Table 7. Unit root Tests in levels

Contract	With intercept	With intercept and trend	None	Lags
Spot (monthly)	-2.5330	-2.5092	-0.1398	0
Spot (bimonthly)	-1.8444	-1.8001	0.2159	0
Spot (quarterly)	-2.8404***	-2.7129	0.0318	0
One-month	-2.1537	-2.1500	0.0450	0
Two-months	-1.4893	-1.4871	0.3990	0
Three-months	-2.3328	-2.2293	0.2842	0

*** Rejection of the null with 90% confidence.

Table 7 shows that we cannot reject the null of non-stationary time series for the one and two-months series. However, we reject the null for the three-months contract. Thus we can test for cointegration among one and two-months contracts and future spot prices[10].

In the table below results for the regression given in (4) are shown. As it can be seen from table 8, the regression for the one-month contract seems to fit well than for the two-months contract. The coefficients on the slope are close to one and the intercept is statistically insignificant.

[9] Phillips and Perron (1988) unit root tests were performed and results were qualitatively the same.

[10] Using Dickey and Pantula (1987) we found that these series have the same integration order, namely I (1). However, Flores and Szarfarz (1996) have shown that two series that have different orders of cointegration could co integrate, so this is not a necessary condition for cointegration.

Table 8. Cointegration Regressions

Contract	Intercept	Slope	Adjusted R^2
One-month	0.078525	0.971888*	80.98%
	(0.121034)	(0.041264)	
Two-months	0.122782	0.961548*	68.92%
	(0.234912)	(0.080417)	

* Rejection of the null with 99% confidence.
Standard errors are given in parenthesis.

Regressions in table 8 can't be used to infer whether futures prices are biased predictors of realized spot prices by means of a Wald test on the coefficients ($a = 0$ and $b = 1$) as the variables are I (1) these tests do not have the usual distributions. Furthermore, it is necessary to answer whether these are spurious regressions (which may be the case as the variables involved are I(1)) or if they are indeed cointegrating relations.

The next step to be taken is to use the Engle and Granger (1987) approach and test whether the residuals ζ_t are stationary I(0) by means of the following regression:

$$\Delta\hat{\zeta}_t = \gamma\hat{\zeta}_{t-1} + \sum_{i=1}^{k}\alpha_i\Delta\hat{\zeta}_{t-1} + \eta_t \qquad (5)$$

where $\hat{\zeta}_t$ are the residuals for regressions given in 4.

As this regression is based on residuals of another regression the distribution of the test statistic for unit roots is not the same as in the case of the ordinary Dickey and Fuller regression. MacKinnon's (1991) critical value response function is used to calculate the critical values. The response function is given by:

$$c(\alpha, n) = \kappa_\infty + \frac{\kappa_1}{n} + \frac{\kappa_2}{n^2} \qquad (6)$$

where $c(\alpha, n)$ is a one-sided $\alpha\%$ critical value for a sample of size n.

Using the table given in MacKinnon (1991) critical values were derived for 99%, 95% and 90% levels of confidence, respectively. As it can be seen in table 9 the residuals are I (0) for the one-month contract but not for the two-months.

Table 9. Unit Root Tests		
Contracts	Levels	Critical values (95% and 90%)
One-month	-6.3984*	-4.08401 -3.43964 -3.11561
Two-months	-3.7161*	-3.98356 -3.3845 -3.07809

* Rejection of the null with 99% confidence

From table 9 it can be concluded that both the one and two-month contract cointegrate with realized spot prices. However, it would be interesting to check for the robustness of these results using the Johansen (1988) approach.

3.2. Empirical results using the Johansen (1988) methodology

We employ the Johansen (1988) cointegration approach using both the trace and maximum statistics[11]. Results are shown in table 10. As it can be seen the assumption of no-cointegration is rejected for the one and two-month contracts[12].

Table 10. Johansen Cointegration Tests (Trace Statistics)					
	Eigenvalues	H0	λ_{trace}	$CV_{(trace,5\%)}$	$CV_{(trace,1\%)}$
One-month	02283	r = 0	33.4356*	12.53	16.31
	5.50E-06	r ≤ 1	0.0007	3.84	6.51
Two-months	0.2649	r = 0	19.7811*	12.53	16.31
	0.0062	r ≤ 1	0.3915	3.84	6.51

* Rejection of the null with 99% confidence

In the next table results for the maximum eigen value statistic are shown. This statistic is used to improve the power of the test by limiting the alternative to a cointegrating rank just one more than under the null. This statistic is given by:

[11] The reader is referred to Johansen (1988), Enders (1995) and Hamilton (1994) for a summary of this procedure.

[12] For these tests the lag length of the VAR has been chosen to be one as it minimizes the Schwarz Information Criteria.

$$\lambda_{\max} = -n \ln\left(1 - \hat{\lambda}_i\right) \tag{7}$$

where this statistics tests the null of rank equal to r against the alternative of r+1.

Table 11. Johansen Cointegration Tests (Max Statistics)

	Eigenvalues	H0	λ_{max}	$CV_{(max,5\%)}$	$CV_{(max,1\%)}$
One-month	02283	r = 0	33.4349*	11.44	15.69
	5.50E-06	r ≤ 1	0.0007	3.84	6.51
Two-months	0.2649	r = 0	19.3896*	11.44	15.69
	0.0062	r ≤ 1	0.3915	3.84	6.51

** Rejection of the null with 95% confidence

As can be seen in the table above results remain qualitatively the same. Empirical results suggest that the residuals are not normally distributed using a multivariate version of the Jarque-Bera normality test. However, Cheung and Lai (1993) show that the trace statistic is reasonably robust to departures from normality. Furthermore, tests on the residuals suggest that residuals have some degree of heteroscedasticity, however the literature on cointegration has found that Johansen (1988) test is robust to heteroscedascity. The cointegrating vectors are shown below.

Table 12. Cointegrating Vector
$(aS_T, bF_{t,T})$

Contracts	a	b
One-month	1.0000	-0.9981
Two-months	1.0000	-1.0006

These results show that there is a simple model relating one and two-month futures to spot prices and hence there is information content in either series that helps to predict the other series. Particularly, we could test whether futures prices are biased predictors of realized spot prices. This is done in the next subsection.

3.3. Market Efficiency tests

This subsection tests whether futures prices are efficient predictors of realized spot prices. In the table below the joint hypothesis of $a = 0$ and $b = 1$ is tested within the Johansen approach, using a Likelihood Ratio test, which yields a Chi-square statistic with one degree of freedom. Crowder and Hamed (1993) argue that the joint restriction of market efficiency and risk neutrality implies coefficients of $a = 0$ and $b = 1$. If futures prices contain all relevant information to forecast next period spot price then futures prices should be an unbiased predictor of the future spot price.

Table 13. Unbiasedness Tests: Johansen methodology

Contracts	Chi-Square Statistic	p-value
One month	0.8986	0.3432
Two-months	0.0434	0.8348

The conclusion is clear-cut, one and two-month futures prices are unbiased predictors of realized spot prices as these series cointegrate and using likelihood ratio tests one cannot reject the null that the cointegrating vector is given by (1, -1). This conclusion reinforces the conclusions made using Fama-type regressions.

4. Conclusions

This paper examined the information content in futures prices and found evidence, using the Fama (1984) approach and some extensions, that futures prices can be used to forecast spot realized prices and if short-term contracts are used, these forecast are efficient. However, explanatory power of futures prices is low (around 20%) for changes in spot prices.

The unbiasedness hypothesis cannot be rejected by usual econometric methods, when the full sample is used. However, when the sample is divided into sub-periods, unbiasedness is rejected, there is a positive average bias in upward price movements and a negative bias in downward movements.

Additionally, a time-varying risk premium does not seems to be present in the futures contracts prices, as the coefficient for the basis in the premium regressions is highly insignificant.

Cointegration tests show that only the one-month futures series can be said to cointegrate with the realized spot rate. Using the Engle-Granger evidence was found that realized spot prices and 1-month futures prices cointegrate which mean that, at least in the long run, they will move together. Furthermore, using the Johansen (1988) technique evidence strengthening the results was found.

Further research in the lines of Hansen and Hodrick (1980) and West (1997) using overlapping data could be interesting, in order to increase the sample and study the behavior of longer term contracts such as the six and twelve-months contracts. This will be left for further research.

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