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OIL PRICES ASSUMPTIONS IN MACROECONOMIC FORECASTS: SHOULD WE FOLLOW FUTURES MARKET EXPECTATIONS?

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Oil prices assumptions in macroeconomic forecasts: should we follow futures market expectations?

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In macroeconomic forecasting, in spite of its important role in prices and activity developments, oil prices are usually taken as an exogenous variable for which assumptions have to be made. This paper evaluates the forecasting performance of futures markets prices against other popular technical procedure, the carry-over assumption. The results suggest that it is almost indifferent to opt for the futures market prices or the carry over assumption for short-term forecasting horizons (up to 12 months), while, for longer-term horizons, they favour the use of futures market prices. However, as futures markets prices reflect the markets expectations for the world economic activity, futures oil prices should be adjusted whenever the market expectations for the world economic growth are different from the values underlying the macroeconomic scenarios in order to assure fully internal consistency of those scenarios.

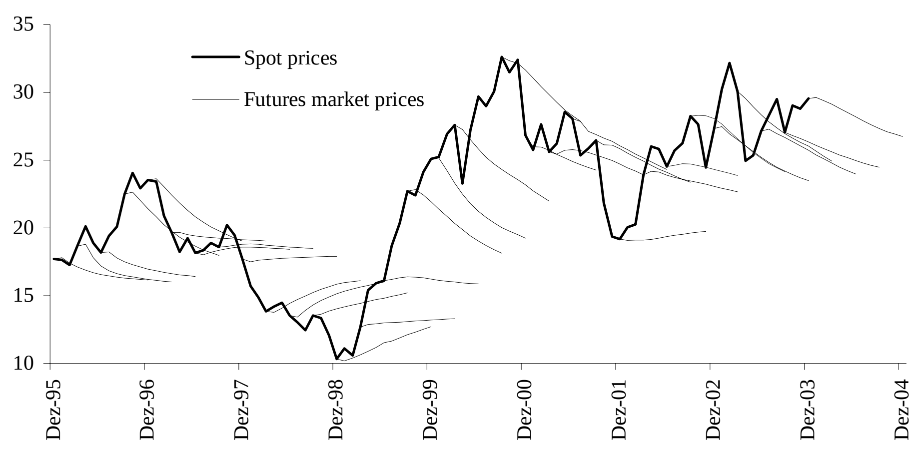
Introduction

One of the most crucial assumptions underlying macroeconomic projections is the assumed path of oil prices throughout the forecasting horizon. However, in general, oil prices are not forecasted using standard econometric techniques. Firstly, it is very difficult to estimate structural models that consider oil quantities and prices as endogenous variables. International conflicts in the Middle East and other political developments in oil exporting countries play an important role in oil markets behaviour and these factors are very difficult to considerer in a formal macroeconometric model. Secondly, even using less ambitioning techniques like univariate time series analysis, it is very difficult to identify any kind of systematic behaviour in oil prices, as they tend to follow a random walk process or a very short memory process.

Those difficulties explain why, in macroeconomic forecasting exercises the use of "technical" assumptions is so widely spread. In general, two alternative technical assumptions are considered, one being the so-called carry-over assumption ("ignorance approach") and the other being the use of futures markets prices ("market efficiency approach"). The futures market approach is the one currently used in the Eurosystem forecasting exercises (bi-annual exercise involving the European Central Bank and the euro area National Central Banks).[1] However, this approach has being misleading during the recent years. The apparent poor performance of futures market prices over the recent years is illustrated in figure 1. It can be seen that futures markets missed the direction of change in oil prices quite often.

Despite these errors, this paper shows that the alternative technical assumption (carry-over) has not proved to be better. The results suggest that it is almost indifferent to opt for the futures market prices or the carry over assumption for short term forecasting horizons while, when producing medium run projection scenarios, they tend to favour the use of futures market

Figure 1 - Spot and futures oil prices
(US$/bbl)



Source: International Petroleum Exchange

[1] See ECB(2000) for a description of these exercises.

prices information instead of the carry-over assumption. Even though, that does not necessarily imply that futures prices should be used without any kind of adjustment.

Futures markets prices reflect expectations on the future evolution of set of key variables that potentially affect the behaviour of international oil markets. One of the most important of those variables is the overall international economic activity, since the demand for oil depends on its evolution. So, one possible source of deficient forecasting of futures markets prices, maybe related with wrong expectations on economic growth. The paper shows that the errors of inferring the evolution of oil prices from the futures markets seem to be positive correlated with the errors of market expectations on the world economic growth. Therefore, in order to assure the internal consistency of the macroeconomic projection exercises, the futures markets should be used with an adjustment whenever the market expectations for the world economic growth are quite different from the values underlying those exercises. This conclusion does not necessarily mean that futures markets have worse or better abilities to predict world economic growth. The point is that expectations that are conditioned on a different evaluation on the most probable path for world GDP should not be used as an assumption.

The paper is organised as follows. The first section of the paper presents the main statistical features of oil prices time series – high volatility, lack of predictability and strong co movement between spot and futures market prices. The second section provides some evidence on the historical performance of the two above-mentioned technical assumptions. The third section explores the relation between the futures markets oil prices errors and the forecasting errors concerning the evolution of the world economy.

1. About the data

Monthly series were constructed from the daily frequency data for spot and futures prices obtained from the International Petroleum Exchange website. Series for futures market contracts with short maturities, from 1 to 3 months, are available since 1989, while series with longer maturity start later: from July 1991 (9 months); from April 1994 (12 months); from January 1998 (18 months).

Figure 2 – Spot Brent oil prices

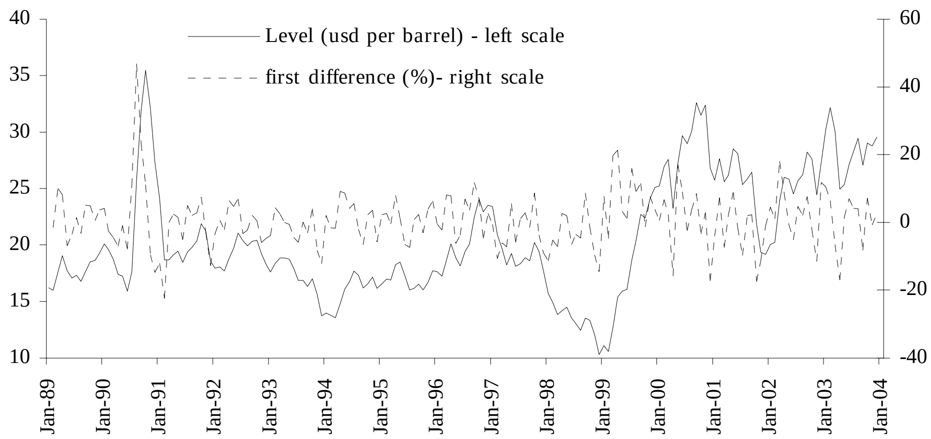


Figure 2 presents the monthly evolution of spot oil prices. At a first glance, there is no clear indication of a trend in oil prices development. Its main characteristic is the sizeable volatility exhibited by monthly variation of oil prices.[2]

1.1. Do oil prices follow a random walk process?

As the performance of futures market as a predictor to oil prices is evaluated using the carry-over assumption as a benchmark, it is important to test if oil prices follow a random-walk process, because this statistical property is the main justification to use the carry-over assumption. The available data does not provide clear evidence on this respect, showing however that the random walk assumption could not be disregarded for medium-term horizons.

We started by carrying out standard tests using end of period figures, since the use of monthly or quarterly averages could be misleading. In fact, as it is intuitive and very easy to demonstrate, the use of consecutive averages tends to refute the random-walk assumption even when the original (daily) series follows it-self a random-walk process.

The stationary of the series were tested using the usual ADF tests with variables expressed in logarithmic terms. It was considered to alternative samples: (i) a full sample, from January 1989 to December 2003; (ii) a partial sample that excludes the Golf War effects, from January 1992 to December 2003. The results presented in table 1 do not reject the hypothesis that oil prices are a non-stationary variable - integrated of order one -, suggesting the use of its first difference.

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[2] On empirical regularities of the cyclical behaviour of commodity prices see Cashin et al. (1999). On the volatility of oil prices see Wickham (1996).

Table 1 – ADF tests(1)

		Daily	End-of-month	End of quarter
Full sample:	ADF	-2.37	-2.03	-2.38
	Critical values (5%)	-2.86	-2.88	-2.91
	(1%)	-3.44	-3.47	-3.55
Partial sample:	ADF	-1.77	-1.42	-2.05
	Critical values (5%)	-2.86	-2.88	-2.93
	(1%)	-3.44	-3.47	-3.58

(1) A specification of 3 lags and constant was used for daily figures, while the ADFs tests for monthly and quarterly figures were performed with one additional lag.

Random-walk tests were based on standard autocorrelation and partial autocorrelation functions of the first difference of the oil prices expressed in logarithmic terms, using the Portmanteau and the LM autocorrelation tests. The lags chosen for these tests were 10 for daily figures, 12 for monthly figures and 4 for quarterly figures.

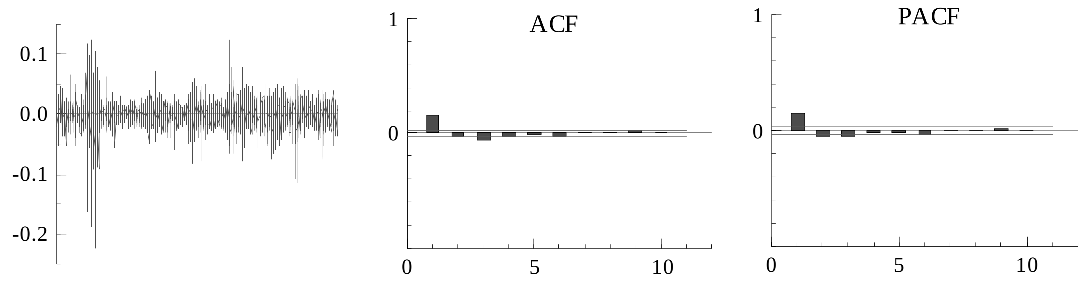
The results presented below depend crucially on the frequency considered. Considering daily figures, the random-walk hypothesis is clearly rejected in both samples. In other words, it is possible to look at prices on the previous days and forecast the following days with a time-series model.[3] Using monthly figures, the rejection of the random-walk assumption start to be unclear, depending of the confidence level adopted and of the sample used. Finally, with quarterly figures the random-walk assumption cannot also be rejected independently of the sample considered.[4] These results, although not conclusive, explain why is so popular the use of the carry-over assumption when producing macroeconomic projections.

[3] Even in this case, the forecasts would not be very different from the carry-over assumption. In fact, the process underlying this daily behaviour seems to have a very short memory – the traditional Box-Jenkins approach suggests a moving-average process of order one.

[4] The same results are obtained using quarterly averages instead of end-of-period figures.

Figure 3a -Daily data

Full sample: Portmanteau Test: $\chi^2(10)$=116.42 [0.0000]; LM Test F(10,3779)= 11.89 [0.0000]



Partial sample: Portmanteau Test: $\chi^2(10)$=137.29 [0.0000]; LM Test F(10,3020)=15.16 [0.0000]

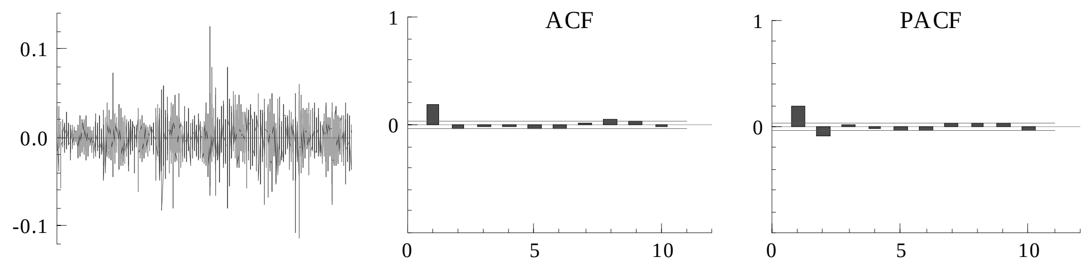
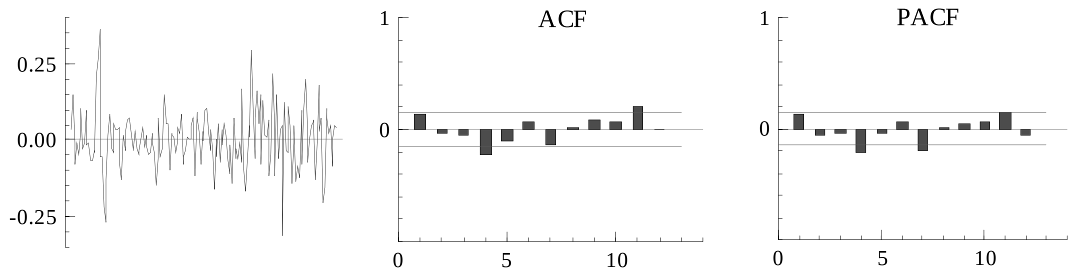


Figure 3b - End-of-month data

Full sample: Portmanteau Test: $\chi^2(12)$=29.18 [0.0037]; LM Test F(12,166)=2.28 [0.0104]



Partial sample: Portmanteau Test: $\chi^2(12)$=23.23 [0.0258]; LM Test F(12,128)=1.71 [0.0723]

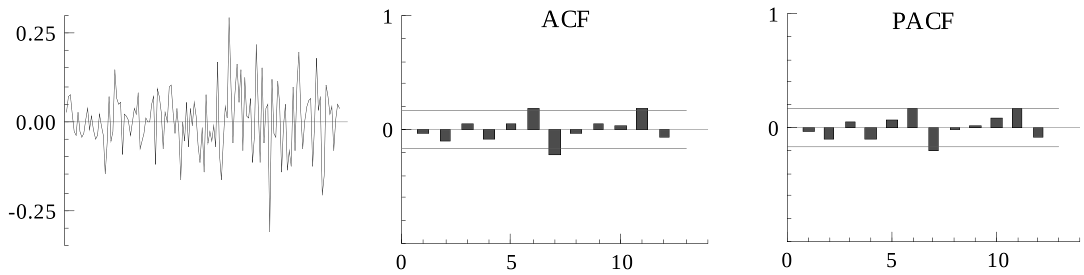
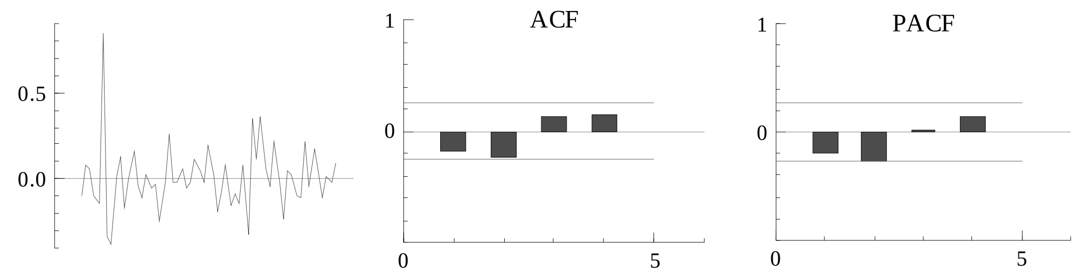
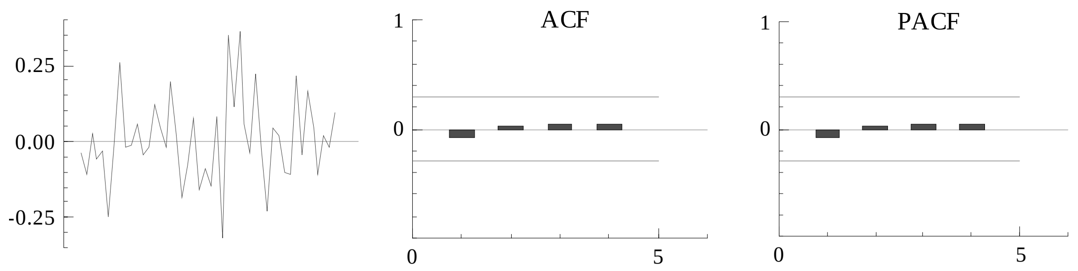


Figure 3c - End-of-quarter data

Full sample: Portmanteau Test: $\chi^2(4)$=7.57 [0.1057]; LM Test F(4,54)=1.92 [0.1200]



Partial sample: Portmanteau Test: $\chi^2(4)$=1.04 [0.9631]; LM Test F(4,40)=0.14 [0.9658]



1.2. Futures markets or carry-over, is there a big difference?

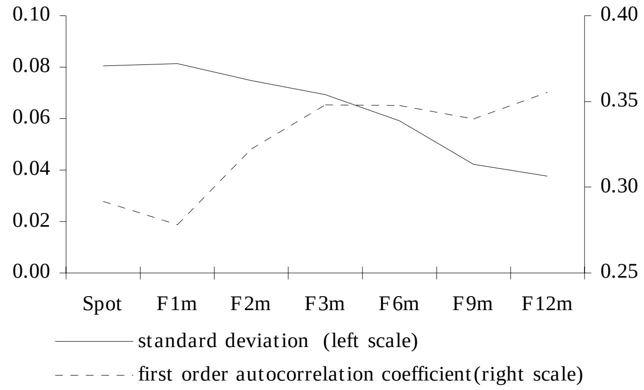
Before comparing the forecasting errors of using the carry-over or the futures markets assumptions, it seems important to compare both series. This is performed in figure 4. The graphs on the left column show the observed spot prices *vs* the forecasts based on futures market prices, illustrating that the forecasting errors tend to increase for longer horizons. The graphs on the right compare futures prices and the carry-over forecasts, showing that, for short maturities, it is almost indistinguishable the differences between forecasts based on futures or on the random walk assumptions. It seems that for those maturities all the relevant information is already reflected in the spot price, and, consequently, futures markets prices tend to follow the changes in spot price. Indeed, it is almost indifferent to choose any of the two alternative assumptions for forecasting purposes. Those differences only become perceptible for longer maturities, and therefore those differences probably will be the ones relevant to choose the best forecasting method.

The same result is illustrated in figure 5. Considering shorter horizons, the volatility and the persistence of futures and spot prices is very similar. However, as the futures markets maturity increases, its volatility tends to decline while the persistence tend to increase. That is, the variation of short-term futures prices seems to affect only partially the long-term futures prices.

Figure 4


Spot
Futures 1-month
Correlation coeficient 0.946
Futures 1-month
Carry over 1-month
Correlation coeficient 0.999
Spot
Futures 3-months
Correlation coeficient 0.769
Futures 3-months
Carry-over 3-months
Correlation coeficient 0.945
Spot
Futures 6-months
Correlation coeficient 0.581
Futures 6-months
Carry-over 6-months
Correlation coeficient 0.620
Spot
Futures 9-months
Correlation coeficient 0.535
Futures 9-months
Carry-over 9 months
Correlation coeficient 0.542
Spot
Futures 12-monts
Correlation coeficient 0.355
Futures 12-months
Carry-over 12-months
Correlation coeficient 0.401
40
35
30
25
20
15
10
89
91
93
95
97
99
01
03

Figure 5 – Brent spot and futures prices at different horizons (first difference of logs)



2. Forecasting errors: carry-over *vs* futures markets

The performance of the two alternative methods to forecast oil prices is presented in Figure 6, again with the variables expressed in logarithms. According to the available information for futures markets, three alternative samples finishing at December 2003 were considered, starting at: (i) April 1992 (maturities until 9 months); (ii) April 95 (12 months); (iii) July 1999 (18 months).

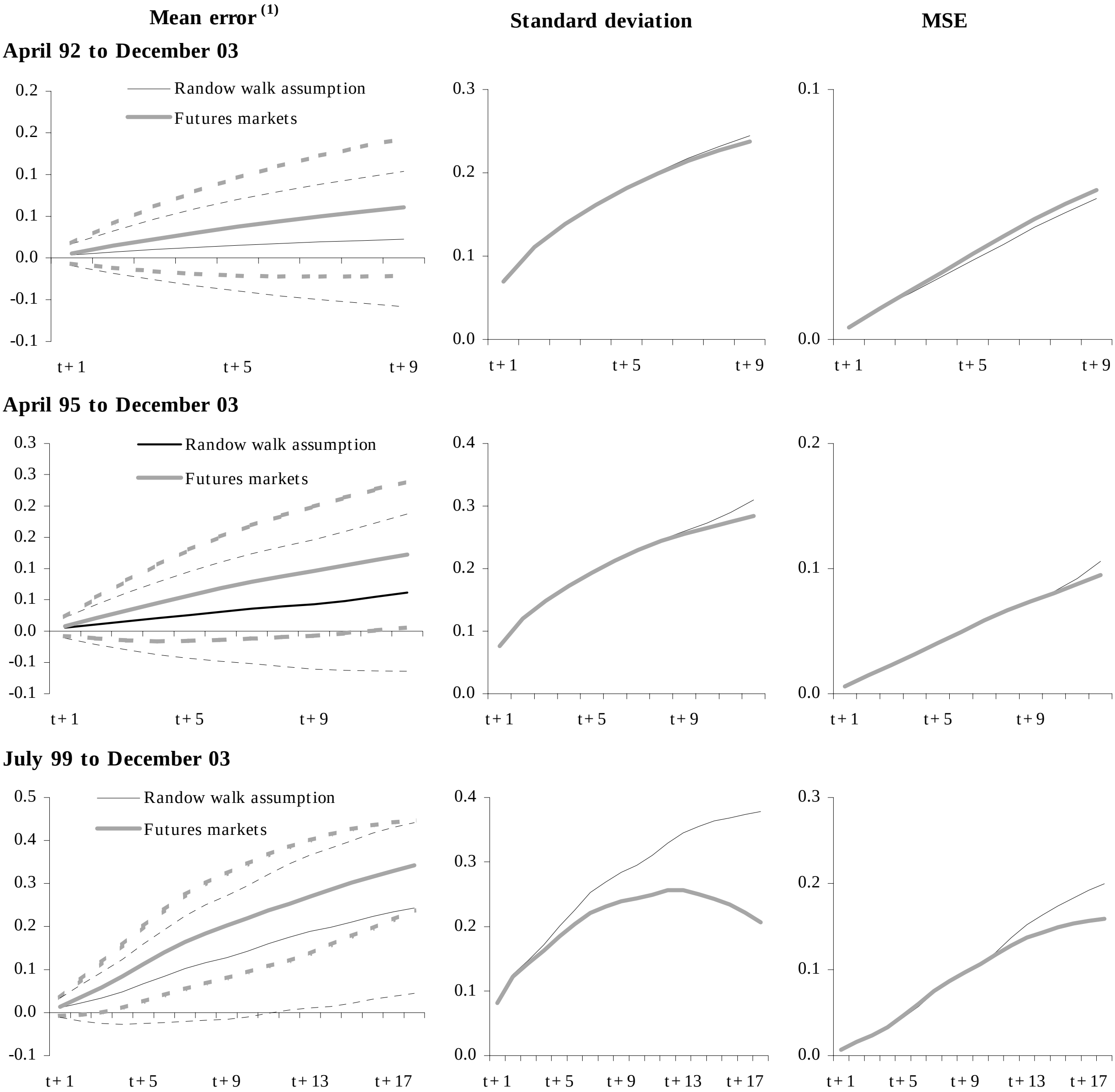
Graphs on the left side show the mean forecasting error for different sample periods and maturities. In all the cases, the mean error is not zero and increases throughout the forecasting horizon. In the three samples considered, the futures prices provided, on average, biased forecasts.[5] However, considering 90 per cent confidence intervals (dotted lines on left side graphs), the mean bias of the carry-over and the futures market forecasts are not very different from each other, and both are not statistically different from zero – the exception is the error of the futures markets in the latest sample.

The last column presents the Mean Squared Errors (MSE). Once again the results are not very different for the shorter horizons. For maturities equal or greater than 12 months, the MSE of forecasts based on futures prices tend to be lower than the implied by the random-walk assumption.

[5] Daniel (2001) found the same result for NYMEX futures oil prices using a sample period between 1990 and 2000.

Figure 6 – Futures markets vs Carry-over

(logs)



(1) The dotted lines represent the 90 per cent confidence intervals. Given the strong autocorrelation, explained by the use of overlapping data, these confidence intervals were based on the adjusted standard deviation proposed in Andrews (1991).

The results obtained confirm that the two alternative methods tend to produce, on average, very equivalent forecasts for shorter horizons. Secondly, there is some evidence that the performance of futures market prices tends to be superior to the one of the carry-over assumption for longer maturities – unfortunately, those results should be interpreted with caution, given the smaller size of the sample with longer maturities.

A simple exercise also illustrates these results. Running (OLS) regressions with spot price, using as explanatory variables the carry-over and the futures markets forecasts, it is possible to estimate the best linear combination between the two technical assumptions for each forecast horizon: $S_{t+h} = C + \alpha F_t^{t+h} + (1-\alpha)S_t$. As it can be seen in the following table, the relevance of futures markets increases for longer horizons.[6]

Table 2

	Futures markets α	Carry-over $(1-\alpha)$
T+3	0.38	0.62
T+6	0.43	0.57
T+9	0.63	0.37
T+12	1.14	-0.14

These results tend to favour the use of futures prices instead of the carry over assumption when producing medium term projections. In the short term, futures prices present levels that are very close to the latest spot price available, explaining why the markets expectations and the carry-over assumption tend to produce similar forecasts. However, for longer horizons, futures markets seem to follow a mean reversion process (see the figure 1 presented above). As the observed spot prices tend in fact to revert to the mean, then the futures markets tend to forecast better than the carry-over assumption. This feature suggests that the futures prices might be seen as a weighted average between the last available spot price and the mean, where the weight of the spot price is very high in short horizons but tends to decline with the maturity.[7]

[6] These results should be carefully interpreted, namely for shorter horizons where the futures markets and the random-walk forecasts are highly correlated. Moreover, the statistical significance of these regressions is very small, reflecting the high volatility of oil prices.

[7] The following expression might capture this idea: $F_t^{t+h} = \alpha(h)\, S_t + [1 - \alpha(h)]\, \mu_t + \varepsilon_t$, with $0 < \alpha(h) < 1$ and $\alpha'(h) < 0$, where F_t^{t+h} stands for the futures price in period t for oil delivery h periods ahead, S_t corresponds to the spot price at t, μ_t stands for the historical (moving) average and ε_t is a random residual. For each horizon (h), this expression can be seen as an error correction mechanism, that determines when the prices are above (below) the historical average, futures tend to predict the fall (rise) of oil prices. Note that μ_t and particularly S_t may reflect expectations on a set of important related variables, as world GDP growth.

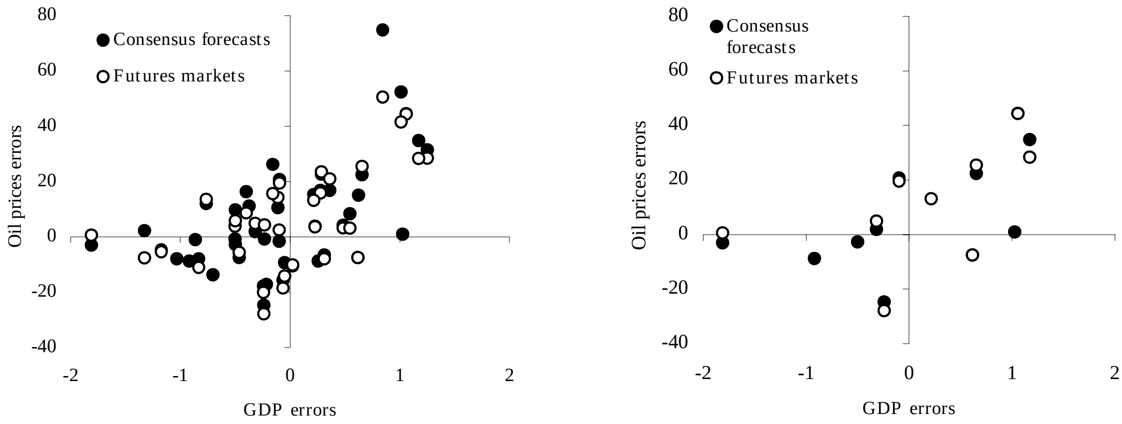
3. Oil prices and economic growth forecasting errors

Oil prices tend to reflect changes in the world demand of oil, which is usually associated with world economic activity. Hence, part of the futures market prices errors may be related with the errors concerning world GDP evolution.

In order to check if there is a relationship between forecasting errors of futures markets oil prices and of economic growth expectations, a quarterly series for the Consensus world GDP growth forecasts was gathered, starting in December 1991 to December 2003.[8] The differences between the last available estimate for annual GDP growth over the previous year and the forecasts made one year before for that period were taken as the forecast errors.[9] Using also Consensus information it was possible to build an alternative quarterly sample for market expectations on oil prices from June 1994 to December 2003. The prices expectations of the consensus database are very close to the futures market prices. In fact, considering the errors of oil prices expectations for the next 12 months, they exhibit a correlation coefficient higher than 0.95.

Figure 7 exhibits the correlation between the errors of Consensus GDP forecasts and the average forecast error of oil prices for a 12-month horizon, using quarterly overlapping data (left side of Figure 7) and end-of-year non-overlapping data (right side). Two measures of oil prices expectations are considered: the Consensus forecasts (from December 1992 to December 2003); the futures markets prices (from June 1995 to December 2003). The results suggest a positive

Figure 7



8 Although there is a Consensus forecasts for world economy growth, in order to have an extended and more homogeneous sample the G7 economic growth was assumed as a proxy.
9 In order to obtain a quarterly series, uniform quarterly year-on-year rates were assumed.

correlation between GDP and oil prices forecasts errors (all the correlation coefficients are higher than 0.53).[10]

The relationship between oil prices and GDP forecasts is considered in the following equations on Table 3, where the forecast errors on oil prices (ε^p) are explained by the forecasts errors on GDP growth (ε^y). An important remark is that these illustrative estimations are built in a partial equilibrium framework, assuming a causality relationship from world activity to oil prices – e.g. that oil prices developments do not affect instantaneously world GDP. The objective is not to study the relationship between oil prices and world GDP, but just to achieve a rule of thumb able to increase the internal consistency between macroeconomic projections and oil prices assumption. In other words, independently of who forecast better, macroeconomic exercises should not use as an assumption expectations that are conditioned on a different macroeconomic evaluation.

Table 3

Consensus expectations for oil prices	**Futures markets oil prices**
Sample: December 1992 to December 2003 (quarterly overlapping data) $\varepsilon^p_t = \underset{(1.99)}{3.13} + \underset{(7.58)}{1.00}\, \varepsilon^p_{t-1} - \underset{(3.09)}{0.39}\, \varepsilon^p_{t-2} + \underset{(3.25)}{7.52}\, \varepsilon^y_t$	-
Sample: June 1995 to December 2003 (quarterly overlapping data) $\varepsilon^p_t = \underset{(2.13)}{4.36} + \underset{(6.83)}{1.04}\, \varepsilon^p_{t-1} - \underset{(3.25)}{0.46}\, \varepsilon^p_{t-2} + \underset{(2.77)}{7.93}\, \varepsilon^y_t$	$\varepsilon^p_t = \underset{(1.72)}{3.34} + \underset{(5.85)}{0.97}\, \varepsilon^p_{t-1} - \underset{(2.46)}{0.38}\, \varepsilon^p_{t-2} + \underset{(2.46)}{6.86}\, \varepsilon^y_t$
Sample: December 1992 to December 2003 (end-of-year non-overlapping data) $\varepsilon^p_t = \underset{(1.38)}{6.84} + \underset{(2.22)}{12.78}\, \varepsilon^y_t$	-
Sample: December 1995 to December 2003 (end-of-year non-overlapping data) $\varepsilon^p_t = \underset{(1.51)}{9.54} + \underset{(1.98)}{14.39}\, \varepsilon^y_t$	$\varepsilon^p_t = \underset{(1.43)}{9.42} + \underset{(1.66)}{12.54}\, \varepsilon^y_t$

The results are very similar, confirming a positive relationship between GDP and oil prices forecasts errors.[11] This suggest that part of the errors of futures market expectations analysed in the previous section is not a "pure procedure error", but should be attributed to an error concerning the forecast of other variable. Using the equations presented above, the errors of market expectations on oil prices are adjusted by the errors on GDP (Table 4). Those results suggest that the errors of futures markets (in particular the above mentioned bias) are very connected with the errors concerning the expectations on world economic growth.

[10] The correlation seems to be particularly high for positive errors. This kind of non-linear relationship is investigated in Hamilton (2003).
[11] The absence of autocorrelation when the annual data is used confirms the intuition that the presence of autocorrelation in the previous equations comes from working with overlapping data.

Table 4 – Oil prices forecasting errors (logs)

	Carry-over	Market expectations			
		Consensus	Consensus adjusted	Futures markets	Futures markets adjusted
Sample: from December 1992 to December 2003 (end-of-year non-overlapping data)					
Average	0,062	0,073	-0,007		
Standard deviation	0,216	0,198	0,114		
MSE	0,047	0,041	0,012		
Sample: from December 1995 to December 2003 (end-of-year non-overlapping data)					
Average	0,070	0,109	-0,017	0,105	-0,014
Standard deviation	0,247	0,218	0,130	0,215	0,113
MSE	0,059	0,054	0,015	0,052	0,012

Therefore, it appears reasonable to adjust oil prices forecasts based in futures markets whenever the market expectations on economic growth are very different from the values underlying the projection exercises. Furthermore, the results suggest that this adjustment could produce significant changes in oil price assumptions. For instance, according to the regressions presented above for the futures markets forecasts, a permanent revision of 1.0 percentage point in the world economy growth could produce a revision of oil prices assumptions between 12 and 19 per cent.

Conclusions

Oil prices are very difficult to forecast given its volatility, explaining why futures markets prices are so commonly adopted as a working assumption when producing macroeconomic scenarios. This paper tries to evaluate the accuracy of this assumption.

Firstly, there is some evidence that those prices follow an almost random-walk process, what can justify the use of the carry-over as an alternative technical assumption.

Secondly, based on data from 1992 onwards, the past performance of the two above-mentioned technical assumptions is confronted. Both forecasting techniques produce very equivalent forecasts over shorter horizons. However, for longer horizons (more than 12 months), there is some evidence that futures markets did perform better, favouring their use instead of the carry-over assumption when producing medium run projections scenarios.

Finally, there is evidence of a positive correlation between futures market oil prices errors and the market expectations errors concerning the evolution of world economic activity. These results suggest an adjustment of the oil prices forecasts based on futures markets whenever the market expectations on economic growth are different from the values underlying the macroeconomic projections. The objective of this adjustment is not to increase the forecast accuracy but just to improve the internal consistency of the macroeconomic projections exercises, avoiding the use of an assumption based on a different macroeconomic evaluation.

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