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Are oil price forecasters finally right? Regressive expectations toward more fundamental values of the oil price

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Abstract

We use oil price forecasts from the Consensus Economic Forecast poll to analyze how forecasters form their expectations. Our findings seem to indicate that the extrapolative as well as the regressive expectation formation hypothesis play a role. Standard measures of forecast accuracy reveal forecasters' underperformance relative to the random walk benchmark. However, this result appears to be biased due to peso problems.

JEL classification: F31, D84, C33

Keywords: Oil price, survey data, forecast bias, peso problem

Non-technical summary

Oil price movements between 2005 and mid-2008 have motivated researchers to look into oil prices in more detail. So far, the literature has either focused on the predictive power of oil price futures (Pagano/Pisani, 2009) or empirically analyzed oil price movements within a micro-structural model based on heterogeneous agents (Reitz/Slopek, 2009). Since expectations are the major driving force in speculative markets, knowledge of how expectations are formed seems to be key for understanding how such markets function. This paper analyzes the expectation formation process in the crude oil market by means of survey data.

To this end, we compare the Consensus Economics forecasts with actual price movements in the oil market. We provide evidence that oil price forecasters form extrapolative as well as regressive expectations, i.e., forecasts are based on the recent oil price change and current oil price misalignment. The latter is calculated by assuming that the fundamental value of the oil price depends on excess capacity in global oil production, which has been eroded in recent years by the remarkable growth in oil demand from emerging economies, especially China. This argument has frequently been put forward (Hamilton, 2008; Hicks/Kilian, 2009) and accounts for the fact that political events such as wars or embargoes do not exhibit a systematic influence on oil prices (Barsky/Kilian, 2004; Kilian, 2008). Though we find that the forecast error is uncorrelated to the previous oil price change and contemporaneous misalignment, the results indicate that oil price projections are systematically biased in that they tend to underestimate future oil price changes. Additionally, we find that forecasters do not outperform a random walk forecast.

To provide an explanation for the bias in expectations, we analyze whether the empirical results are subject to a peso problem. A peso problem arises

whenever the ex-post frequencies of regimes within a sample differ substantially from their ex-ante probabilities. Indeed, oil price forecasters seem to systematically consider the possibility that the oil price will ultimately converge to its equilibrium level. Ex post, forecasters seem to expect a lower oil price than actually occurred most of the time, although they use the full set of information. Of course, in line with the forecasters' downward bias in expectations, the regime shift occurred and the oil price returned to its fundamental value.

The results may have implications for monetary policy since central banks generally consider oil price expectations when assessing future inflation dynamics (Castro, 2008). Providing an economically meaningful rationale for the bias in forecasters' oil price projections, we challenge the standard argument against the use of survey data in monetary policy analysis.

Nicht-technische Zusammenfassung

Die Ölpreisentwicklung zwischen 2002 und 2008 hat die wissenschaftliche Forschung zu der Frage getrieben, wie der rasante Anstieg des Ölpreises und deren anschließender Fall zu erklären sei. Dabei wurde zum einen analysiert, wie gut der Terminmarkt den Ölpreis vorhersagen kann (Pagano/Pisani, 2009), zum anderen wurde untersucht, wie sich die Ölpreisdynamik mit Hilfe von Modellen mit heterogenen Erwartungen abbilden läßt (Reitz/Slopek, 2009). Da Erwartungen elementar für die Preisbildung auf spekulativen Märkten sind, soll im vorliegenden Papier die Erwartungsbildung auf dem Ölmarkt mittels Umfragedaten analysiert werden.

Die Studie basiert auf den Umfragedaten von Consensus Economics, die monatlich zwischen 1989 und 2008 erhoben wurden. Es wird gezeigt, dass die Ölpreisprognosen sowohl auf extrapolativen als auch regressiven Erwartungen basieren. Das heißt, die Vorhersagen beinhalten die Ölpreisentwicklung der Vergangenheit als auch die gegenwärtige Abweichung zum Fundamentalwert. Letzterer wird modelliert als Funktion der weltweit stark zugenommenen Ölnachfrage, insbesondere aus Schwellenländern wie China. Die Literatur (Hamilton, 2008; Hicks und Kilian, 2009) verweist häufig auf den Zusammenhang zwischen Ölnachfrage und der Ölpreisentwicklung und misst diesen permanenten Nachfrageschocks höheren Erklärungsgehalt bei als bspw. politischen Ereignissen, Kriegen oder Embargos (Barsky and Kilian, 2004; Kilian, 2008). Obwohl gezeigt werden kann, dass der Prognosefehler unabhängig von der Ölpreisentwicklung der Vergangenheit und dem Grad der Abweichung vom Fundamentalwert ist, liegen die Ölpreisvorhersagen systematisch unter dem später realisierten Ölpreis. Daneben zeigen die Ergebnisse, dass die Ölpreisprognosen nicht besser sind als die naive Random Walk Prognose.

Vor dem Hintergrund dieser Ergebnisse wird abschließend analysiert, ob die Ölpreisprognosen einem so genannten Peso-Problem unterliegen. Ein Peso-Problem tritt immer dann auf, wenn die ex-post Wahrscheinlichkeit für ein bestimmtes Ereignis sich von der ex-ante Wahrscheinlichkeit unterscheidet. Tatsächlich bestätigen die Ergebnisse, dass die Prognostiker eine plötzliche Rückkehr des Ölpreises zum Fundamentalwert nicht ausschließen. Bis zum Auftreten des Regimewechsels identifizieren die Schätzroutinen ex post einen systematischen Vorhersagefehler. Ölpreisvorhersagen können demnach ökonometrisch verzerrt erscheinen, obwohl sie alle verfügbaren Informationen beinhalten.

Die Analyse hat wirtschaftspolitische Konsequenzen, insbesondere wenn die Ölpreisentwicklung und die Erwartungen über zukünftige Ölpreise in die geldpolitische Beurteilung von Inflationsgefahren einfließen (Castro, 2008). Mit der Erklärung, wie es zu rationalen Verzerrungen von Ölpreis-Prognosen kommen kann, scheint ein häufig vorgebrachtes Argument gegen die geldpolitische Verwendung von Umfragedaten – dass sie nämlich irrational seien – entkräftet zu sein.

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1 Introduction

During the time period between 2002 and 2008 the oil price increased tremendously from a level of US$ 20 per barrel to an all time high of US$ 145 per barrel in July 2008. This oil price shock hit the oil importing nations heavily, and some economists view this development as one of the causes of the current worldwide recession (Hamilton, 2009). In turn, the sharp drop of the oil price down to US$ 30 per barrel in December 2008 implies a heavy burden for exporting nations such as Russia or Dubai, which have experienced a severe deterioration in their terms of trade. These sharp movements of the oil price were unforeseen by many economists (Brown et al., 2008). As a consequence, some research institutes have stopped forecasting the oil price as an ingredient of their macroeconomic models. Instead, it is assumed that the oil price follows a random walk, which means that the current oil price level will serve as the best predictor of the oil price in the future (Fricke, 2009).

In addition to the lack of predictability, there is evidence that the oil market is frequently subject to speculative bubbles which drive the oil price away from its equilibrium level. For instance, Reitz/Slopek (2009) find that the interaction of chartists and fundamentalists on oil markets is a source of substantial and enduring oil price misalignments. Since speculative trading is solely based on market participants' forecasts, an understanding of the

[1]We thank Heinz Herrmann, Felix Höffler, Johannes Mayr and Martin Weale for helpful comments on an earlier draft of the paper. We are also grateful to Michael Dear for copy-editing the manuscript. The views expressed here are those of the authors and not necessarily those of the Deutsche Bundesbank or its staff.

expectation formation is crucial for assessing its role in the price setting in the oil market.

A related strand of literature investigates whether futures prices are a useful measure of oil price expectations. Assuming rational expectations, futures prices should be unbiased predictors of future spot prices. Empirical tests of the unbiasedness hypothesis have been inconclusive so far. Whereas Moosa/Al-Loughani (1994) find that futures prices are neither unbiased nor efficient predictors of future spot prices, Chernenko et al. (2004) and Chinn et al. (2005) are not able to reject the unbiasedness hypothesis. Coimbra and Esteves (2004) identify a downward bias, which increases in the forecast horizon. To account for these mixed results, Knetsch (2007) suggests that convenience yields should be considered in the present-value model of oil prices. Alternatively, expectations can be directly measured by means of survey data which include oil price expectations. Since oil price expectations drive the actual oil price as well as the futures oil price, such an analysis is crucial in order to understand how the oil market functions.

This paper uses survey data to analyze the expectation formation process of oil price forecasters. To this end, we compare the Consensus Economics forecasts with actual price developments in the oil market. Survey data have already been used to analyze the expectation formation process in financial markets. Taylor/Allen (1992), Ito (1990) and Menkhoff (1997) analyze short-term and long-term foreign exchange rate forecasts for the time period between May 1985 and June 1987. While the former show bandwagon behavior, medium-term exchange rate forecasts exhibit a stabilizing feature. Lux (2009) develops a methodology for estimating the parameters of dynamic opinion or expectation formation processes with social interactions. Using the business climate index of the ZEW survey, he provides strong evidence of social interaction as an important element in respondents' assessment of the business climate. MacDonald/Marsh (1993) examine the efficiency of oil market expectations published in the Consensus Economics Forecast poll. For the sample period between October 1989 and March 1991, they show that oil price forecasters form stabilizing expectations, but provide biased and inefficient projections. However, their analysis is limited to 18 months, whereas our analysis covers a period of nearly 20 years. When analyzing and evaluating professional forecasts, we find that peso problems may account for forecasters' biased expectations towards the equilibrium oil price. This supports the finding of a rational bias in macroeconomic forecasts (Laster et al., 1999). The results may have monetary policy implications, since central banks generally consider current and expected oil price movements when assessing future inflation dynamics (Castro, 2008).

The remainder of the paper is structured as follows. In the next section, we describe the data set, while section 3 examines the expectation formation process of oil price forecasters. In section 4, we examine the question of whether expectations are formed rationally. Specifically, we test whether forecasts fulfill the rationality conditions of unbiasedness and orthogonality. In section 5, we apply various methods to shed some light on the forecast accuracy of oil price forecasts. Section 6 examines the oil price forecasts, allowing for regime shifts, and analyzes the so-called "peso problem". Section 7 concludes.

2 The Data Set

In this paper, we use the mean of the three-month oil price forecasts published in the Consensus Economic Forecast poll. The poll started in October 1989, and our sample period ends in December 2008. Table 1 shows the main features of the data set. An average of 75 forecasters participated in the poll while the actual number of participants in the poll

Table 1: Summary Statistics of the Expected and Actual Oil Price

	Average
Actual Oil Price	33.8
Expected Oil Price	32.1
Standard Deviation	2.5
Time Period	Oct 1989 – Dec 2008
Number of Forecasters	75.2
Max.	128
Min.	45

Note: "Standard Deviation" is the average standard deviation of the aggregated forecasts as published in the Consensus forecast poll; "Max." ("Min.") is the maximum (minimum) number of participants.

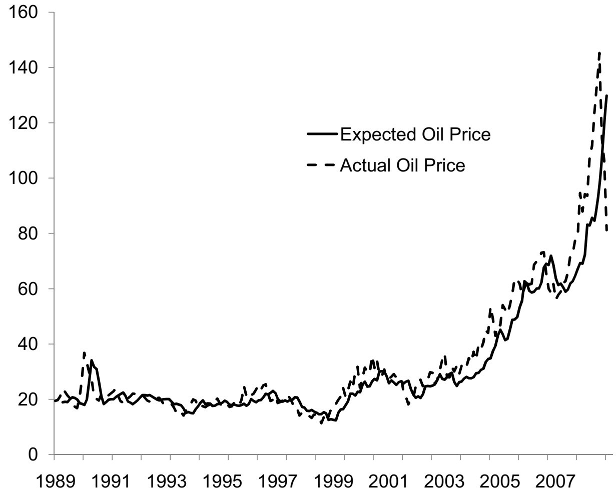
varies between 45 and 128 forecasters. The participants of the Consensus Economic Forecast poll work for investment banks, commercial banks and consultancies.[2] The Consensus Economics Forecast poll has been used by other studies. Analyzing GDP and inflation forecasts, Blix et al. (2001) and Batchelor (2001) have found that Consensus Economic forecasts are less biased and more accurate in terms of mean absolute error and root mean squared error compared to OECD and IMF forecasts.

The analysis of oil price expectations is especially appealing since the oil market has recently been undergoing persistent dynamics. Figure 1 shows the actual oil price (dotted line) and the oil price forecast (solid line) for the time period under consideration. The vertical distance between the two series reflects the forecast error. At first glance, Figure 1 shows that oil price forecasts in the 1990s seem to be a good indicator of the future oil price. But since the oil price began to increase in 2002, oil price forecasts have been, on average, lower than the actual oil price, indicating that the oil forecasters underestimated the oil price development. In our subsequent analysis, we

[2] A complete list of participating institutions is available upon request.

analyze oil price forecasts in more detail. We only use forecasts made in January, April, July, and October for the period between 1989 and 2008, thereby avoiding the problem of serial correlated forecast errors. Hence, the forecast horizon has already expired when the next forecast is made and subsequent forecasts should be independent from each other.[3]

Figure 1: Actual Oil Price and Mean Forecast



Notes: The solid shows the mean of the oil price forecast for the time of the forecast while the dotted line reflects the actual oil price.

3 Examination of the Expectation Formation Process

3.1 Extrapolative Expectation Formation Hypothesis

This section examines the expectation formation process. We begin by investigating whether the data supports the hypothesis that market participants have extrapolative expectations. Given the structure of the survey, this would

[3]We also used different forecast frequencies (e.g., February, May, August and November). However, the results do not change qualitatively and are available upon request.

be the case if the expected change of the oil price is a function of the past oil price movement. More specifically, we estimate the following expectation formation process:

$$E_t[s_{t+1}] - s_t = \alpha + \beta(s_t - s_{t-1}) + \epsilon_t. \tag{1}$$

Here, s_t ($E_t[s_{t+1}]$) denotes the log of the (expectation of the future) oil price at time t. Since we use non-overlapping forecasts, the time frequency $t+1$ refers to a three-month period. In addition, ϵ_t symbolizes the error term. If we find that β is positive, this would indicate that, whenever the oil price increased during the previous three months, forecasters expect a further increase for the future. In this case, expectations would show *bandwagon behavior*. However, if β is negative, this would indicate that an increase in the past causes forecaster to expect a decrease during the next period *(contrarian behavior)*.

The estimates of equation (1) – shown in Table 2 (Specification I) – imply that forecasters form contrarian expectations. The slope coefficient is significantly negative and takes a value of about $-.20$. This means that, for example, a ten percent increase in the oil price over the last three months leads forecasters to expect a 2.0 percent decrease over the next three months. The constant term ($\hat{\alpha}$) takes a value of $-.01$ and is also highly significant. Obviously, the forecaster expects – on average – the oil price to decrease by one percent each quarter.

Table 2: Regression Results for the Extrapolative and Regressive Expectation Hypothesis

Specification	I	II	III
$\hat{\alpha}$	-.0103***	-.0515***	-.0454***
	(.0054)	(.0066)	(.0055)
$\hat{\beta}$	-.1977***	–	-.1777***
	(.0292)		(.0291)
$\hat{\gamma}$	–	-.0496***	-.0311***
		(.0138)	(.0117)
Adj. R^2	.3737	.1371	.4215
Various Test	F(1,74) = 45.75	F(1,74) = 12.92	F(2,73) = 28.32
Statistics	Prob > .0000	Prob > .0006	Prob > .0000
Observations	76	76	76

Note: Regression results for the equation (3) $E_t[s_{t+1}]-s_t = \alpha+\beta(s_t-s_{t-1})+\gamma(s_t-f_t)+\epsilon_t$; standard error in parentheses; *** (**) and * indicate significance at the 1% (5%) and 10% levels, respectively; correlation coefficient between $(s_t - s_{t-1})$ and $(s_t - f_t)$ is .2577 and not significantly different from zero.

3.2 Regressive Expectation Hypothesis

In order to investigate the regressive expectation hypothesis, we could test whether deviations from the equilibrium level also influence oil price expectations. Of course, this creastes the nontrivial problem of specifying an equilibrium oil price level. Hamilton (2008) argues that the global demand for oil, especially from China, is the key determinant among others, such as commodity price speculation, time delays or geological limitations on increasing production, OPEC monopoly pricing, and an increasingly important contribution of the scarcity rent. Hamilton (2008) concludes that the strong growth in demand from China has substantially driven the oil price in the past decade. This view is supported by Hicks/Kilian (2009) who find that news about global demand presages much of the surge in oil prices from mid-2003 until mid-2008 and much of its subsequent decline. Their measure of global demand shocks is based on revisions of professional real GDP growth forecasts. In particular, Hicks/Kilian (2009) show that forecast revisions were associated with a hump-shaped response of the oil price. Kilian (2009) disentangles oil price shocks crude in oil supply shocks, shocks to the global demand for all commodities and demand shocks that are specific to the crude oil market. He concludes that the recent increase in crude oil prices was driven primarily by global aggregate demand shocks.

To some extent, this runs counter to the common belief that highly political events, such as wars or embargoes, are the main forces driving the oil price. However, Barsky/Kilian (2004) argue that such exogenous shocks are but one of a number of different determinants of oil prices and that their impact may differ greatly from one episode to another in an unsystematic way. Beyond the fact that orthogonal oil supply shocks may not distort oil price regressions, the authors stress that political disturbances do not necessarily cause oil price surges and major oil price increases may occur in the absence of such shocks. The small impact of oil production shortfalls on oil prices is confirmed in great detail in Kilian (2008).

Although there is now little doubt that persistent shifts in the excess demand for oil are the major fundamental driving force of the past decade's oil prices, the important question remains as to which variable should be used to capture demand dynamics. We tested the following oil market candidates. First, we divided global consumption of crude oil by non-OPEC crude oil production. The variable accounts for the fact that global demand has remained strong yet overall non-OPEC production growth has slowed. This imbalance increases reliance upon OPEC production and/or inventories to fill the gap ($OPEC^{reliance}$). A second variable as a proxy for diminishing excess capacity or, more generally, market tightness is proposed by Anderson (2005). The author suggests that Chinese oil imports (IMP^{China}) account for a major share of world excess demand for oil and is strongly correlated with excess demand from other important emerging countries, thereby exerting upward price pressure due to increasing demand.[4] Finally, a more forward-looking measure of market tightness comprises the ratio of world oil reserves and daily world oil consumption ($Reserves$) and gives the number of remaining days before oil resources are expected to be depleted.

World oil consumption, production and reserves were provided by the Energy Information Administration, while Chinese imports of oil are taken from the OECD Annual Statistical Bulletin (2008). Yearly data are interpolated to a quarterly frequency assuming an I(1) process. Quarterly US$ market prices of West Texas Intermediate (WTI) are taken from the IMF's International Financial Statistics. The data set comprises the period from 1990 to 2008. Following the Engle-Granger methodology, we separately regress oil prices on the fundamental variables.

$$s_t = \alpha + \beta f_t + \epsilon_t \tag{2}$$

The regression results shown in Table 3 are based on ordinary least squares. Standard errors are adjusted for heteroskedasticity and serial correlation using the Newey/West (1987) correction of the covariance matrix. Since the constant is statistically insignificant, we re-estimated the model without intercept.

The Dickey-Fuller test statistics reveal stationarity of regression residuals only for IMP^{China}.[5] Moreover, the adjusted R^2 statistics confirm the finding that only IMP^{China} explains a significant percentage of the oil price variance. From these estimation results we conclude that, empirically, the

[4]Cooper (2003) provides evidence that the demand for crude oil is highly insensitive to changes in oil prices. Based on this view, we argue that the causality runs from changes in China's demand for crude oil to the oil price rather than from oil prices to China's oil demand.

[5]The respective MacKinnon (1991) five percent critical value is -2.80.

Table 3: Oil-Price Fundamentals

Fundamental	$OPEC^{reliance}$	IMP^{China}	$Reserves$
β	1.75***	0.48***	0.23***
	(0.03)	(.005)	(.004)
Adj. R^2	0.29	0.65	0.25
ADF	-1.78	-3.04	-1.71

Note: Regression results for the equation $s_t = \beta f_t + \epsilon_t$; standard error in parentheses; *** (**) and * indicate significance at the 1% (5%) and 10% levels, respectively. ADF denotes the Dickey-Fuller test statistic of the regression residuals. The respective MacKinnon (1991) five percent critical value is -2.80.

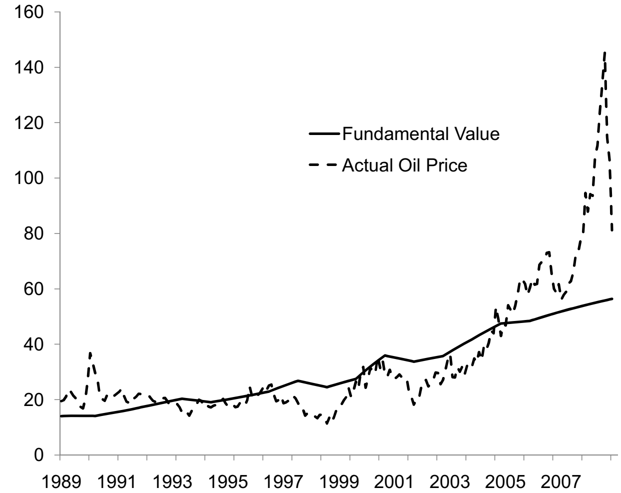
fundamental value f_t is meaningfully approximated by China's oil imports.

A graphical representation of the fundamental oil price series can be found in Figure 2. Although Figure 2 reports substantial deviations between the two series for the time period between 2005 and 2008, the actual oil price (s_t) tends to fluctuate around the fundamental value (f_t). We use the fundamental oil price series as a measure of the equilibrium oil price. Hence, the deviation of the actual oil price from its equilibrium value is a second explanatory variable. We therefore estimate the following equation:

$$E_t[s_{t+1}] - s_t = \alpha + \beta(s_t - s_{t-1}) + \gamma(s_t - f_t) + \epsilon_t. \tag{3}$$

where $(s_t - f_t)$ is the log difference between the current oil price and the equilibrium level. The γ-coefficient measures the extent to which forecasters expect the oil price to return to its equilibrium level. If γ turns out to be negative (positive), forecasters do (not) expect the oil price to move to the equilibrium, a phenomenon referred to as *(de)stabilizing behavior*. However, if γ is not different from zero, forecasters do not respond in their expectations to deviations from the equilibrium oil price level.

Figure 2: Actual Oil Price and Fundamental Value



Notes: The fundamental value (solid line) of the oil price is calculated as described in subsection 3.2.

As can be inferred from Table 2 (Specification II), the estimated regressive coefficient is indeed significantly negative and takes a value of $\hat{\gamma} = -.049$. This implies that forecasters expect the gap between the actual oil price and its equilibrium value to be closed by 4.9 percent each quarter. As a robustness check, we estimate β and γ simultaneously (Table 2, Specification III). The estimated $\hat{\beta}$ and $\hat{\gamma}$ coefficients are still in the same range as before and multi-collinearity between both independent variables does not seem to be an issue given the small and insignificant correlation coefficient of about .25.

Forecasters obviously rely on recent oil price changes and misalignments when building (stabilizing) oil price expectations. However, if the oil price time series follows the characteristics of a random walk, this forecasting behavior should translate into systematic forecast errors, which is in contrast to the efficient market hypothesis. As a consequence, the following section applies an unbiasedness test and also deals with the orthogonality condition to test the rational expectation hypothesis.

4 Tests for Rationality of Expectations

To examine the question of whether expectations are formed rationally, we follow Ito (1990), MacDonald/Marsh (1996), and Elliot/Ito (1999) in applying two criteria: unbiasedness and orthogonality.

4.1 Unbiasedness

To investigate whether oil price forecasts represent unbiased predictors of future oil price changes, we estimate the following relationship:

$$s_{t+1} - s_t = \alpha + \beta(E_t[s_{t+1}] - s_t) + \epsilon_{t+1} \quad (4)$$

Unbiasedness prevails if $\alpha = 0$ and $\beta = 1$. Note that in this case oil price changes are not necessarily forecasted accurately but the forecast errors do not show any systematic pattern.

In a first step, we estimate equation (4) using an OLS model. The results – summarized in Table 4 – indicate that the constant (i.e., $\hat{\alpha}$) is significantly different from zero. However, it can be inferred from the standard errors that $\hat{\beta}$ is not different from unity. The significant $\hat{\alpha}$-coefficient implies that expectations are not an unbiased predictor of the future development.

4.2 Orthogonality

We now turn to the test for orthogonality. It examines whether or not forecast errors are related to information on oil price changes available at the time of the forecast. As a representation for the latter we use two arguments, namely

Table 4: Test of Unbiasedness

$\hat{\alpha}$	.0490*
	(.0268)
$\hat{\beta}$	.6645
	(.3697)
Adj. R^2	.0289
Observations	76

Note: Regression results for the equation $s_{t+1} - s_t = \alpha + \beta(E_t[s_{t+1}] - s_t) + \epsilon_{t+1}$; standard error in parentheses; *** (**) and * indicate significance at the 1% (5%) and 10% levels, respectively; for $\hat{\beta}$ this applies for H_0: $\hat{\beta} = 1$.

the previous oil price change $(s_t - s_{t-1})$ as well as the difference between the actual oil price level from its fundamental value $(s_t - f_t)$. Hence, we estimate

$$s_{t+1} - E_t[s_{t+1}] = \alpha + \beta(s_t - s_{t-1}) + \gamma(s_t - f_t) + \epsilon_{t+1} \tag{5}$$

Orthogonality implies that $\alpha = \beta = \gamma = 0$ so that neither the constant term nor any other available information explains the forecast error. Table 5 reports that $\hat{\alpha}$ takes a positive value of about .065. This implies that the forecast error is, on average, positive. Forecasters – on average – expected the oil price to be 6.5 percent lower than it actually was. This finding is also in line with the information given in Table 1: While the actual average oil price is US$ 33.80 per barrel, the average of the expected oil price takes the value of US$ 32.10 per barrel. Hence, the expected oil price level was 5.3 percent lower than the actual oil price.

Interestingly, the estimated $\hat{\beta}$ and $\hat{\gamma}$-coefficients are not significantly different from zero. This implies that forecasters take all the information regarding the previous oil price change and the misalignment into account when predicting the oil price. In summary, we find that oil price forecasters use the full information set consisting of the previous development and the misalignment. However, we also document that forecasters produce a significant forecast

Table 5: Test of Orthogonality

Specification	I	II	III
$\hat{\alpha}$	.0652***	.0633***	.0675***
	(.0213)	(.0225)	(.0236)
$\hat{\beta}$	-.0720	–	-.0836
	(.1240)		(.1347)
$\hat{\gamma}$	–	-.0002	.0118
		(.0474)	(.0513)
Adj. R^2	.5633	-.0137	-.0223
Observations	75	75	75

Note: Regression results for the equation $s_{t+1} - E_t[s_{t+1}] = \alpha + \beta(s_t - s_{t-1}) + \gamma(s_{t-1} - f_t) + \epsilon_{t+1}$; standard error in parentheses; *** (**) and * indicate significance at the 1% (5%) and 10% levels, respectively.

error since the oil price forecasts are – on average – significantly lower than the realized oil price. In order to solve this puzzling feature, the next section analyzes the forecast accuracy in more detail by comparing the price forecasts with a naive random walk model.

5 Expectations and Forecast Accuracy

In order to assess the accuracy of forecasters' predictions, we employ two types of tests. The first test is based on the forecasts' mean squared error ratio (MSER) relative to a naive random walk forecast, as is done by Mark (1995) and Faust et al. (2003). The related P-value tests whether the MSER is significantly different from unity using the framework of Diebold/Mariano (1995). The advantage of this approach lies in its applicability for a variety of accuracy measures and their distributions.[6] As is done by Mark (1995), the truncation lag is calculated using the data-dependent formula provided by Andrews (1991).

[6]Earlier tests, such as the one introduced by Christiano (1989), suffer primarily from non-normal asymptotic distributions when analyzing nested models.

The second test employed here is the projection statistic introduced by Evans/Lyons (2005). The forecasters' predictions are regressed on realized changes in the (log) spot oil price

$$E_t[s_{t+1}] - s_t = \alpha + \beta(s_{t+1} - s_t) + \epsilon_{t+1} \qquad (6)$$

where ϵ_{t+1} is a white-noise disturbance term. Forecasters' performance against a driftless random walk can be examined by simply testing the β-coefficient for statistical significance. Obviously, to generate meaningful forecasts, it should possess a positive sign. If, otherwise, the forecasters had no predictive power for future changes of the oil price, or if the latter does follow a random walk, it is only ϵ_{t+1} that drives $E_t[s_{t+1}] - s_t$. Note that if the oil price indeed follows a random walk, it cannot be correlated with $s_{t+1} - s_t$, since the forecasts are calculated using data up to period t. As in Evans/Lyons (2005), equation (6) is estimated using Newey/West (1987) estimators to deal with potentially remaining serial correlation in the residuals.

Table 6 reports the results of both the Diebold and Mariano test and the Evans and Lyons projection statistic. The estimated figures suggest that the accuracy of forecasters' predictions is negligible. The mean squared error of forecasters' predictions significantly exceeds the mean squared error of the no-change forecast. Moreover, the β-coefficient of the Evans/Lyons (2005) regression is positive but small.

In summary, we find that forecasters – on average – do not outperform a random walk forecast. However, the puzzling feature remains that the forecasts fully include information on the previous oil price development and the misalignment yet are biased in the sense that forecasters expect a lower oil price than actually occurred. One possible explanation for this puzzling feature is the so-called "peso problem" which is analyzed in the next section.

Table 6: Test of Forecasting Accuracy

$MSER$	1.132
	(.8896)
$EL-\alpha$	-.0471***
	(.0064)
$EL-\beta$	.0630**
	(.0311)
Adj. R^2	.0418
Observations	76

Note: The P-value of the $MSER$ indicates the significance value for H_0: forecasters' performance equal to random walk versus forecasters' performance better than random walk; $EL-\alpha$ and $EL-\beta$ refer to the estimated coefficients of the Evans and Lyons (2005) regression; standard error in parentheses; *** (**) and * indicate significance at the 1% (5%) and 10% levels, respectively.

6 Does Forecasting Accuracy Suffer from Peso Problems?

Peso problems are sometimes defined as arising when the distribution of the asset price includes a low-probability but major-impact regime that generates extreme asset price returns (Krasker, 1980). Because this regime has low probability, it is unlikely to be observed in small samples. Thus, peso problems may be defined as arising whenever the ex-post frequencies of regimes within a sample differ substantially from their ex-ante probabilities. When a peso problem is present, the sample moments do not match the population moments agents use when forming expectations (Bekaert et al., 2001). However, the possibility that this regime shift may occur definitely affects forecasters' expectations. Regarding the oil market, we may interpret the lack of forecasting accuracy and negative bias in forecasters' prediction – particularly in the period between 2005 and mid-2008 – as the result of the incorporated possibility that the oil price will suddenly to its fundamental value.

In order to assess the relevance of a peso problem inherent in forecasters' expectations, we conduct the following experiment. As in Froot/Thaler (1990), we assume that forecasters have in mind two possible states of the future oil price. One state or regime consists of the idea that the oil price further follows its bubble path, and the second state implies the return to its fundamental value. Estimating a two-state Markov regime-switching model then provides us with a time-varying (smoothed) probability which forecasters have assigned to the bubble-bursting regime.[7]

The conditional mean reflects both the bubble and the bubble-bursting regime

$$E_t[s_{t+1}] - s_t = \beta_1(1-S_t)(s_t - f_t) + \beta_2(S_t)(s_{t+1} - s_t) + \sigma_1(1-S_t)\epsilon_t + \sigma_2(S_t)\epsilon_t, \quad (7)$$

where regime indicator $S_t = \{0, 1\}$ is parameterized as a first-order Markov process and the switching or transition probabilities are P and Q, respectively. Though investigating low-frequency data, we allow the conditional variance to be time-varying across regimes. Under the assumption of conditional normality for each regime, the conditional distribution of the forecasted oil price change is a mixture of normal distributions (Hamilton, 1994).

The estimated regression coefficients of the first regime reveal statistically significant expectations of oil price mean reversion. The second regime indicates random walk expectations of forecasters as the estimated coefficient turns out to be statistically insignificant. Although forecasters lack the ability to predict price changes even in a two regime framework, they seem to include a no-change scenario when forming oil price expectations. The

[7] Regime-switching models have been applied to peso-type problems by – among others – Evans (1996), Kaminsky (1993), Gray (1996) and Bekaert et al. (2001).

Table 7: Markov Switching Model

Regime	1	2
$\hat{\beta}$	-.1125***	-.0224
	(6.79)	(0.17)
$\hat{\sigma}^2$	.0017***	.0097***
	(5.20)	(4.19)
P	.9383	.9366
	(17.01)	(19.48)
Observations	73	

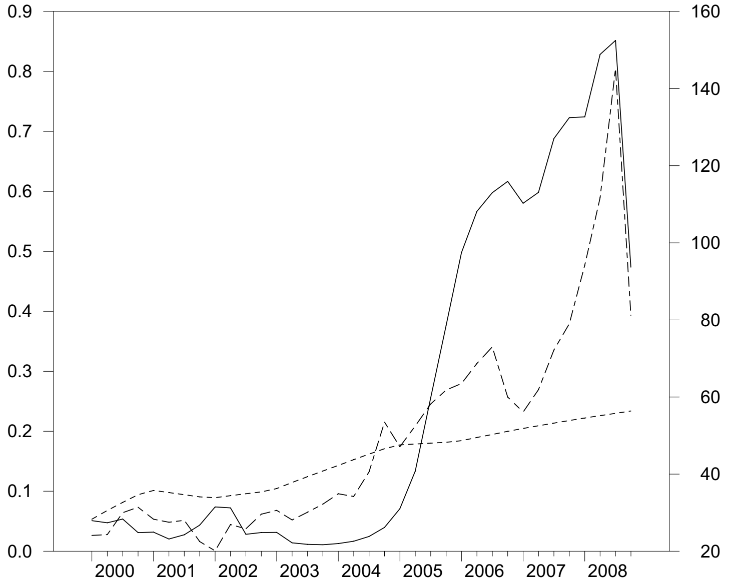
Note: The sample contains quarterly observations from 1990 to 2008; t-statistics in parentheses are based on heteroskedastic-consistent standard errors; *** (**) and * indicate significance at the 1% (5%) and 10% levels, respectively.

weighting of the regimes is represented in Figure 3.

The smoothed probabilities for the mean-reverting regime show that forecasters stuck to the no-change prediction as long as the actual oil price remained within a reasonable range around the fundamental value. Since the spot price started to increase dramatically in 2005, the implied weight on mean-reverting expectations picked up as well. Consequently, oil price predictions exhibited a persistent (negative) bias during this period. In the end, however, the oil price dropped substantially, thereby confirming the inclusion of a mean-reverting regime.

In summary, we find that oil price forecasts suffer from the peso problem, thus providing an explanation for why forecasters show a significant forecast error, i.e., they expect a lower oil price than actually occurred, even though they use the full set of information. Apparently, the forecast error is not due to irrational expectations in the sense that the forecasters neglect relevant information. The forecast error attributable instead to the existence of different regimes in the actual oil price development. Forecasters believe to

Figure 3: Smoothed Probabilities of the Bubble-Bursting Regime



Notes: The solid line shows the smoothed probabilities of the bubble-bursting regime, the dashed line shows the actual oil price, and the dotted line reflects the fundamental value of the oil price.

some extent that the oil price development will switch to another regime and converge to its equilibrium level. But if this regime shift does not occur, this yields a forecast error which is not driven by irrational expectations.

7 Conclusion

The recent roller-coaster movements in the international oil market have revealed forecasters' inability to predict major trends in the spot oil price. Using data from the Consensus Economic Forecast poll, we show that three-month oil price forecasts are inferior to the random walk benchmark by standard measures of forecast accuracy. Predictions tend to exhibit extrapolative (contrarian) as well as regressive properties leading to a downward bias of expectations in the recent period when the oil price dramatically surged. However, smoothed probabilities estimated from a two-stage regime-switching model interpret the bias as the outcome of a peso problem underlying the statistical inference. In fact, the rapid descent in the oil price in the second half of 2008 finally provided a rationale for the downward bias.

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