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Oil prices: The role of refinery utilization, futures markets and non-linearities ☆

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ABSTRACT

We test the hypothesis that real oil prices are determined in part by refinery capacity, non-linearities in supply conditions, and/or expectations and that observed changes in these variables can account for the rise in prices between 2004 and 2006. Results indicate that the refining sector plays an important role in the recent price increase, but not in the way described by many analysts. The relationship is negative such that higher refinery utilization rates reduce crude oil prices. This effect is associated with shifts in the production of heavy and light grades of crude oil and price spreads between them. Non-linear relationships between OPEC capacity and oil prices as well as conditions on the futures markets also account for changes in real oil prices. Together, these factors allow the model to generate a one-step ahead out-of-sample forecast that performs as well as forecasts implied by far-month contracts on the New York Mercantile Exchange and is able to account for much of the $27 rise in crude oil prices between 2004 and 2006.

1. Introduction

Causes for the rapid rise in the price of crude oil between 2004 and the summer of 2006 are the subject of debate. Some of the debate focuses on changes in the so-called downstream sector especially the refining

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sector. The number of refineries in the United States has not increased since 1981 (Annual Energy Review, 2006), and in the spring of 2007, a significant fraction of refining capacity was closed due to unscheduled maintenance (New York Times, 2007). Under these conditions, a lack of spare refining capacity is seen as one cause for the on-going rise in the price of crude oil and refined petroleum products.

Other hypotheses for the sharp rise in oil prices include the lack of spare production capacity, a non-linear relationship between oil prices and supply, and changed perceptions of the balance between supply and demand. Although a linear relationship can be a reasonable approximation under normal circumstances, extreme events may shift the market equilibrium between supply and demand towards different types of market functioning in which prices are much more sensitive to shocks than under normal conditions. On the supply side, non-linearities may be caused by lags associated with building additional extraction and refining capacity (Kaufmann and Cleveland, 2001; Kaufmann, submitted for publication). Given these constraints, oil prices would be more sensitive to supply as production approaches capacity. Finally, expectations about the supply/demand balance, as reflected by conditions in the futures market, may affect current prices.

Hypotheses that refining capacity, non-linearities, and expectations, have an important effect on oil prices are consistent with the performance of models that exclude their effect. For instance, the model by Dees et al. (2007), which specifies crude oil prices as a function of OPEC capacity, OECD crude oil stocks, OPEC quotas and cheating by OPEC on those quotas, performs well in-sample (1986–2003), but consistently under-predicts real oil prices out-of-sample, 2004–2006 (Fig. 1). This bias indicates that the model omits variables that are largely responsible for the increase in oil prices between 2004 and 2006.

In this paper, we test the hypothesis that real oil prices are influencedby by refinery capacity, non-linearities in supply conditions, and/or expectations about supply/demand balances and that observed changes in these variables can account for the rise in prices between 2004 and 2006. To do so, we expand the equation described by Kaufmann et al. (2004) to include observations for US refining utilization rates

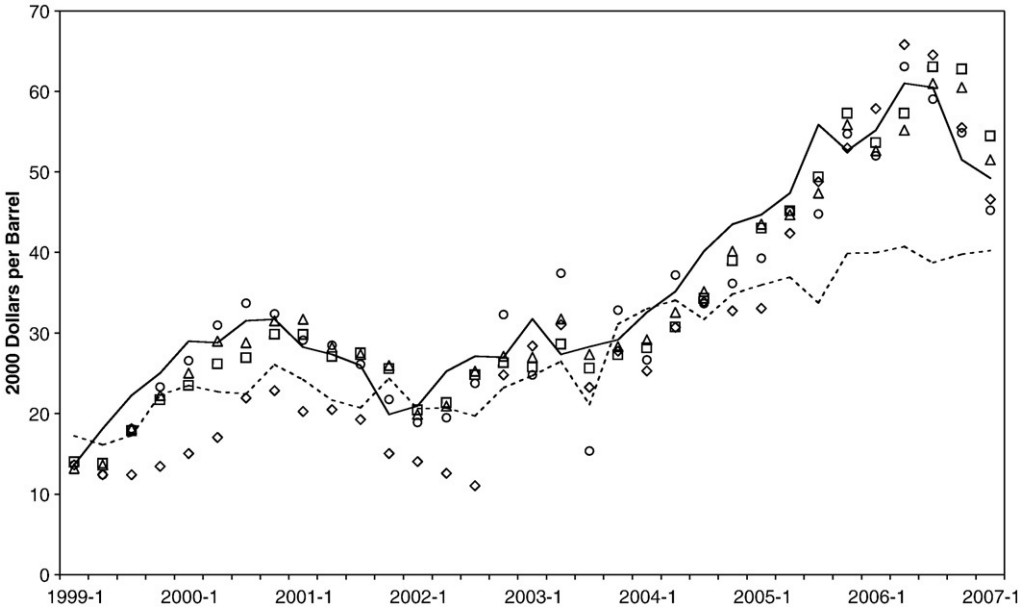

Fig. 1. The observed value of the near month contract on the NYMEX (solid line). The forecast for the average prices for US crude oil imports generated by a model that omits the effects of refinery utilization, non-linearities, and market conditions in the NYMEX (dotted line). The one-step ahead out of sample forecast generated by the econometric model (Eqs. (1) and (2)) is given by open circles (root mean square error = 4.07), the forecast implied by the near month contract on the NYMEX is given by the open squares (root mean square error = 3.54), a random walk, as given by the lagged value of the near month contract on the NYMEX (mean square error = 3.08). Open diamonds represent the price simulated by the econometric model with information about the exogenous variables only (root mean square error = 6.87).