Oil Market Dynamics

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Keywords

Overview

After bouncing around $20 per barrel throughout the 1990s, oil prices started on a steady upward trend after 2000, reaching a record high in mid-2008. With the onset of the global recession, prices collapsed to $40 at the end of 2008. By the end of 2009, prices had risen to $75 per barrel, and then moved up again to over $100 per barrel in 2011. There are several studies that show deterioration in the performance of empirical models of oil prices in the 2000s. Kaufmann (2011) shows that a cointegrating relationship between oil prices and market fundamentals breaks down in 2001, in 2004, and then later in 2007 – 2009. Kaufman (2010) suggests that the long-run relationship between spot and futures prices changed after September 2004. Parsons shows that the term structure of oil prices changes around 2003, from one where short-term factors were important to one where longer-term changes become more important. To better understand the changing dynamics of the oil market, we first test for a structural break in oil prices and find that the WTI oil price has changed from a stationary series to an I(1) series around 2004, i.e. from an environment where shocks were transitory to one where shocks change the price permanently. To explain the structural change in oil prices, we build a dynamic dominant firm model, with OPEC the dominant firm and the rest of world (ROW) a competitive fringe. The model is a dynamic optimization model where the competitive fringe takes the price as given, while OPEC takes the competitive fringe's output as given and maximizes profits. OPEC's production costs are modeled such that production becomes more expensive as OPEC gets closer to its maximum production capacity. Although OPEC's capacity increased in the 2000s, excess capacity has remained low because of increased demand from emerging markets**.** We hope to show through our model that increased demand from emerging markets has pushed OPEC more and more toward their maximum capacity, increasing production costs and rendering them unable to bring prices down by increasing output.

Methods

We provide both empirical and theoretical evidence of a structural change in the crude oil price generating process. The empirical testing procedure is carried out in two stages. Our data are weekly WTI spot prices and 6-month, 12-month, 18-month future prices from May 31, 1989 to June 24, 2011, deflated by the CPI. First, we implement a test for a change in persistence, to check for a change in the degree of integration of oil prices. We apply nine test statistics developed by Harvey, Leybourne and Taylor (2006) to test for a possible change in our sample. To better understand this apparent change in the persistence of oil prices, we build an observed components model for oil spot and futures prices. The components include a permanent (or trend) and stationary components for the oil spot price while futures prices are the (rational) expectation of spot prices plus a time varying risk component. Estimating this model by maximum likelihood, we find strong evidence of an increase in the relative variance of innovations to the permanent component at roughly same time period as identified in the change in persistence tests.

To understand why oil prices should exhibit such changes in persistence and volatility, we build a model of oil supply based on dominant producer (OPEC) that faces a competitive fringe (the rest of the world).   The model is a dynamic optimization model where the competitive fringe takes the price as given, while OPEC takes the competitive fringe's output as given and maximizes profits. OPEC's production costs are modeled such that production becomes more expensive as OPEC gets closer to its maximum production capacity. The model allows OPEC to undertake investment to add to capacity, which brings production costs down. But the change in capacity evolves slowly so that an increase in world oil demand relative to the supply of the competitive fringe

can result in a surge in oil prices. We solve the dynamic optimization problem of OPEC and the competitive fringe and the decision rules form the basis for estimating and simulation behavioral equations of the model.

Results

Our empirical results strongly support the existence of a break-point in WTI prices. The nine test statistics from the testing WTI spot prices strongly support the existence of a break point in its persistence. Our results show that WTI price series changed from a stationary series to an I(1) series in early 2004. This implies that any shock to oil prices were temporary before 2004, while shocks afterwards were permanent. The results for 6-month and 12-month future prices are also statistically significant, though a little weaker compared to that for spot prices. Estimates from the structural model of oil prices show that the trend component became more volatile compared to before 2004, confirming a structural change in oil price behaviour.

We do not have results from the optimization part of the paper yet. Our expectation is that the combination of increased demand from emerging markets (which we model through increased GDP in our demand function) and declining excess production capacity in OPEC (which we model through OPEC production costs) will enable us to explain the change in the persistence of oil prices in 2004.

Conclusions

We find that the nature of WTI oil prices changed in the past 20 years, going from a stationary series to one that is not stationary. Our empirical results strongly suggest that the break happened in 2004. We try to explain this structural change in oil prices with a dominant firm model of the oil market. We find that increased demand from emerging markets, which accelerated in the mid 2000's and declining OPEC excess capacity are the main reasons for this change. [The model results are not finished yet.]

References

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