DYNAMIC MODEL OF STRATEGIC SUPPLY

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Overview

After relatively steady oil prices in the 1990s, strong economic growth and rising demand for oil pushed the price of oil to record highs in 2008. Oil prices stayed in a narrow range around $100 after 2010, but these high prices led to development of higher cost oil supplies, especially shale oil in the United States. Increased supply from North America and a strategic decision by OPEC to maintain market share caused prices to plunge to below $50 at the end of 2014. To keep oil prices from rising back up again, and to keep shale producers at bay, OPEC and some non-OPEC producers have agreed to output cuts that now extend through mid-2018, with a majority of the cust being made by Saudi Arabia. Meanwhile, the robust growth of the global eoconomy has led to the firming of oil prices in late 2017 and a recovery in U.S. shale output. There are many studies that have extensively analysed the oil market and OPEC market structure, starting after the oil embargo of 1973. However, none of these studies have been consistently able to explain either OPEC market structure or the developments in the global oil market. Our paper goes a long way toward analyzing both OPEC market structure and oil price developments since 1990.

Methods

In our paper, we analyze the world oil market in a dynamic general equilibrium setting, modelling Saudi Arabia as the dominant firm and the rest of the world as a competitive fringe. Among OPEC members, Saudi Arabia is the country with any excess capacity, and has essentially been directing OPEC behavior. The rest of OPEC members have been taking the price as given and producing at maximum capacity.

We consider three market regimes: a price taking competitive market, and two different versions of a market composed of a strategic, dominant firm with many competitive fringe producers. We model the dominant firm as a Stackelberg leader, taking the fringe response into consideration. In our dynamic setting we provide two alternatives to the static, dominant firm-competitive fringe Nash outcome: one with time consistency and one with time inconsistency. In the time-consistent case, the dominant firm always looks forward at each optimality decision and takes the past as given. In the time-inconsistent case, the dominant firm recognizes the intertemporal production reaction of the fringe and commits to a production path throughout the time horizon; this case is termed the 'commitment case.' Another difference from a classic Stackelberg setting is that we model the rest of the world as competitive price takers, rather than the usual Stackelberg followers who would be Cournot players.

We model a dynamic demand function, one which has a low price elasticity of demand in the short run, but converges to the long-run demand function in the longer term. The model has separate costs for production and investment. The investment cost covers depreciation, and new exploration and development costs. Capacity utilization enters the model by increasing production costs as utilization increases. Production costs are quadratic, while investment costs are exponential. This allows us to capture the low price elasticity of supply of fringe producers. We experiment with temporary and permanent shocks to demand, supply and costs. The dynamic model allows us to consider the effects of factors such as growing demand, technological progress, changing market share of the dominant firm, changing capacity utilization, and intertemporal investment decisions on world oil prices and production. We use the model to explain oil price fluctuations over the 1991-2017 period. We estimate the model parameters using Bayesian methods and then back out under-lying "shocks" to demand and costs that are responsible for oil price and quantity fluctuations over the sample. We find that the time consistent Stackelberg model matches the data well and can explain the price and output movements in the world oil market.

Results

We find that our model does a good job in explaining global oil price and output movements. For oil prices, permanent demand shocks are the most important factor in explaining the price movements since 2000. China became a member of the WTO in 2001 and has become a bigger player in the world market. The permanent demand shocks illustrate the increased significance of China in the global market. In addition to China, many other emerging market economies saw increased GDP growth and increased demand for oil. These are all consistent with permanent demand shocks. We also find temporary demand shocks contributed negatively to oil prices in the early 2000s. These were most likely mirroring the recession in the US and Europe in the early 2000s. In the late 2000's, we find that initially both permanent and temporary demand shocks contribute positively to price, then temporary demand shocks start contributing negatively, reflecting the financial collapse and global recession. After 2014, we see that both temporary demand shocks and fringe supply shocks contributed negatively to oil prices.

Without any shocks, the model predicts overall oil output to grow, but not as strongly as the actual output data. In the early 2000's, fringe supply shocks contributed positively to global output, with temporary demand shocks contributing negatively. After the early 2000's permanent demand shocks are again the largest positive contributor to output.

These results are from the time-consistent model. We are currently working on results from the committement model. We will then check to see which model does the best job of explaining oil price and output movements.

Conclusions

We have developed a dynamic, stochastic general equilibrium moded to study oil market dynamics. The framework includes a dominant firm and a competitive fringe, with adjustments to productive capacity and strategic considerations for the dominant producer. We estimate key parameters and back out the driving forces that underlie oil price and output dynamics. We find that demand shocks dominate price fluctuations. Both demand and supply shocks contribute equally to output movements. Recent price declines are due to demand shocks and an endogenous output response, consistent with the increase in unconventional oil from US shale producers.

References

The references are too long to fit here. They are available from the authors.