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Speculative behaviour and oil price predictability

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ABSTRACT

We develop two- and three-state regime switching models and test their forecasting ability for oil prices. We use the deviations of market oil price from fundamental values as the main explanatory variable in our models, while additional potential predictors enrich our specification. Our findings suggest that the regime-switching models are, in general, more accurate than the Random Walk model in terms of both statistical and economic evaluation criteria for oil price forecasts.

1. Introduction

Oil price is a key variable in macroeconomic projections affecting inflation and economic activity. Clearly, the predictability of the price of oil is of great interest to policymakers, central banks, CEOs and international investors. Strategic and investment decisions of airline, automobile and energy companies are based on scenarios built on forecasts for the future path of oil price. Even homeowners have in mind some kind of expectations about the future price of oil when deciding about energy-saving investments. Moreover, energy and especially crude oil futures have become widespread investment vehicles among traditional and alternative asset managers, mainly due to their equity-like return, their inflation-hedging properties and their role in risk diversification.

The recent surge in oil prices (and other commodities as well) between 2003 and 2008 has sparked a public debate on the determinants of the price of crude oil. Fundamental-based explanations of oil price movements are attributed to oil supply shocks, oil demand shocks driven by global economic activity, and oil-specific demand shocks. Oil supply shocks stem from reduced oil production of oil-exporting regions, while an oil demand shock is mainly caused by unexpected world economic activity. Finally, an oil-specific demand shock may be triggered by either changing expectations about oil fundamentals or financial speculation. It seems that the literature has reached a consensus on the drivers of the oil price boom that took place until mid-2008. Specifically, Hamilton (2009a,b), Kilian (2009), Kilian and Hicks (2013), Juvenal and Petrella (forthcoming) and Kilian and Murphy (2014) find that the recent oil price rise is mainly attributed to strong oil demand confronting stagnating global oil production. With respect to oil-specific demand shocks, these can be decomposed into an oil-specific shock which captures changes in oil demand unrelated to economic activity, and a destabilising financial shock. Lombardi and Van Robays (2011) attempt such a decomposition and model the destabilising financial shock as a shock that creates a perturbation in the futures market due to increased demand for futures contracts that moves the futures price away from its efficient level. Such financial shocks may emerge due to the increasing financialisation of oil futures markets measured by the sharp rise in speculative open interest and speculative market shares (see among others Mayer, 2010; Irwin and Sanders, 2011; Tang and Xiong, 2011; CFTC, 2011; Fattouh et al., forthcoming). However, it is not clear whether the way market participants act is due to the lack of a fundamental basis in supply and demand or whether it represents the mechanism by which market fundamentals are incorporated in competitively determined prices. Kilian and Murphy (2014) and Kilian and Lee (2014) argue that financialisation in oil futures markets should be modelled as part of the endogenous propagation of shocks to fundamentals rather than an exogenous intervention.

Speculative behaviour, however, can generate bubbles. In the case of rational bubbles, these are generated by endogenous responses to the fundamentals that drive asset prices (Branch and Evans, 2011). The literature mainly focuses on speculative bubbles in the stock market, while there is little evidence on oil markets. We mention three related studies, which explicitly test for speculative bubbles in oil prices by making use of the recently proposed Supremum Augmented Dickey

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Fuller (SADF) approach (proposed by Phillips et al., 2011). Specifically, Gilbert (2010) and Homm and Breitung (2012) cannot detect speculative bubbles in oil prices consistently. By contrast, Phillips and Yu (2011) succeed in detecting explosive behaviour in monthly oil prices, normalised by US inventories, between March and July 2008. Applying the duration dependence test, Went et al. (2012) provide further evidence in favour of speculative bubbles in oil prices. Einloth (2009) also attributes part of the oil price movements in recent years to speculation. More recently, Lammerding et al. (2013) draw on the relationship between oil prices and oil dividends and establish a state-space framework from which they extract the bubble component as an unobservable variable. They additionally assume the bubble to evolve over time as a two-state Markov-switching process with two distinct regimes; namely one in which the bubble evolves over time as a stable process and one in which the bubble exhibits explosive dynamics. The authors follow a Bayesian approach, implementing a fully-fledged Markov-Chain-Monte-Carlo (MCMC) estimation framework and find evidence of two distinct bubble episodes in the oil market.

In this study, we employ and develop models of speculative behaviour in the oil market building on the existence of a bubble. We follow Pindyck (1993) and infer the fundamental value of crude oil from the current and expected discounted convenience yield that accrues from holding inventories based on a non-arbitrage condition between oil spot and futures prices. Any deviation of current values from fundamental values is termed 'bubble' and may summarise a variety of shocks as outlined before. The bubble component can be in one of two or three regimes giving rise to our two- and three-state Regime-Switching (RS) models along the lines of the models developed by Van Norden and Schaller (1993, VNS hereafter) and Brooks and Katsaris (2005, BK hereafter). The authors link speculative behaviour in asset returns to RS models. Specifically, VNS show that a two-regime speculative behaviour model, in which the bubble is allowed to switch between a survival and a collapse state, has significant explanatory power for stock returns. BK incorporate a third regime in the VNS model to allow for the bubble growing at a steady rate of return bridging the gap between VNS and Evans (1991), who allow the bubble to switch between the dormant and the explosive state. Recently, Shi and Arora (2012, SA hereafter) extended the VNS and BK models to oil prices and found a reasonably good fit of the data along with evidence of a speculative bubble over the late-2008/early-2009 period. A word of caution is in order here. We should note that our models do not allow us to attribute the source of a bubble to specific characteristics of the oil market and as such we cannot infer whether a bubble is based on fundamental or non-fundamental factors. In any case, we do not attempt to discriminate between the two hypotheses.

The aforementioned studies focus on the in-sample ability of RS models to capture the dynamics in the price of the asset under scrutiny, ignoring the out-of-sample predictive power of the models. However, the evaluation and comparison of forecasting models based on their in-sample performance are sensitive to outliers, unmodelled structural changes, model misspecification and data-mining (Inoue and Kilian, 2004; Stock and Watson, 2007; White, 2000). As a means of protecting against all these backdrops of in-sample forecasting experiments, we examine the out-of-sample performance of the candidate models. To be more specific, we augment both the VNS and BK models by adding a variety of variables that serve as predictors of the future dynamics in the oil price and investigate the forecasting performance of these specifications. Following BK and SA, we employ the abnormal futures trading volume as a signal of market expectations governing both the mean and the probability equation of the surviving regime. This variable can be thought of as a destabilising financial shock in the context of Lombardi and Van Robays (2011). In a similar manner, we incorporate the variables proposed by Kilian and Murphy (2014), which are linked to oil supply shocks, oil demand shocks and oil-specific (speculative) demand shocks. Widening the information set (see also Juvenal and Petrella, forthcoming), we also employ macroeconomic and financial variables that act complementarily to measures of economic activity and financial conditions.

The forecasting performance of our models is evaluated in both statistical and economic terms. Economic evaluation is desirable since the oil market and the commodities markets have attracted the interest of large financial institutions, hedge funds and investment funds in general. Commodities are included in investment portfolios in order to diversify risk (Gorton and Rouwenhorst, 2006). To anticipate our key results, the RS models appear to generate more accurate forecasts of the oil price, in both statistical and economic evaluation terms, relative to the Random Walk (RW) benchmark. Specifically, the RS models considered in this study outperform the RW model and the improvement in the accuracy of the oil price forecasts is statistically significant in all cases. Moreover, their superiority over the RW model is even stronger in economic evaluation terms. Finally, many of the predictors examined in this study appear to improve the forecasting accuracy of the RS models.

In the literature there are many studies that focus on oil price forecasts but, to the best of our knowledge, none of them employs the class of RS models considered in our study. For example, Knetsch (2007) generates forecasts of the price of oil by means of a convenience yield forecasting model. His approach leads to more accurate forecasts of oil prices compared to direct forecasts from futures prices of the commodity but fails to beat the RW model (based on the root mean squared error criterion). Similarly, Alquist and Kilian (2010) provide evidence that forecasts from oil futures prices tend to be less accurate than forecasts from the RW model. Wu and McCallum (2005) argue that the accuracy of oil price forecasts can be improved by taking into account the relationship between current spot and futures prices instead of considering only the raw futures price. Baumeister and Kilian (2012) organise a forecasting exercise in real-time terms and provide evidence supporting the ability of Vector AutoRegressive (VAR) models to generate reliable forecasts of the real price of oil, while Baumeister and Kilian (2014) examine the predictability of the oil price from a central banker's point of view. Finally, Alquist et al. (2013) provide a stimulating review on the predictability of oil prices.

The remainder of this paper is organised as follows. Section 2 introduces the regime-switching models used in this study, describes our approach to construct fundamental values and outlines the rationale behind the choice of predictors included in our models. Section 3 describes the dataset and reports the empirical findings of the study. Finally, Section 4 concludes.

2. Economic modelling and econometric specification

In this section, we initially provide a brief description of the three-state RS model of BK, which we augment with various predictors of oil prices. The selection of these predictors is based on the existing literature on the determinants of oil prices. We also describe two restricted versions of the three-regime model that we consider in our study and apply an arbitrage relation to compute the convenience yield, which allows us to obtain fundamental values.

2.1. Speculative behaviour and regime-switching models

Consider a simple asset pricing model where risk-neutral investors choose between holding an asset that yields $(1 + r)$ and a risky asset, in our case oil. The investors' first order conditions imply that the price of the asset, P_t, is given as follows:

$$P_t = \frac{1}{1+r} E_t(P_{t+1} + D_t),$$

where D_t is some payoff in the form of dividends (stock market), convenience yield (oil and commodity markets) etc. One possible solution of