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The impact of monetary policy on oil process parameters and market expectations

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ABSTRACT

Following record low interest rates and a depreciating US dollar, crude oil prices came under increasing pressure during the period 2003M5–2007M10. Oil price process parameters changed dramatically toward consistently rising prices. Short-term forecasting implied the persistence of the observed trend, as market fundamentals and underlying monetary policy were supportive of these trends. Market expectations derived from option prices anticipated further surge in oil prices and indicated a significant probability of right tail events. A tightening of monetary policy may be essential for restoring stability to oil markets and in turn for sustained economic growth.

1. Introduction

During the period 2003–2007, the path of crude oil prices appeared to be on an upward trend. All the more worrisome was the fact that oil price increases took place during a period of rising trends in general commodity prices, speculation in housing, equity, and credit markets, and a depreciating US dollar. The fast rise in commodity prices, including oil, could be seen as delayed effect of highly expansionary monetary policy during 2001–2004, as key interest rates were forced down to record post-WWII lows. Such monetary expansion led to high world economic growth and consequently higher world demand for oil

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and non-oil commodities. As the supply of crude oil and other commodities are rigid or increase at a slower pace than demand, the result was the highest level of commodity price inflation in the post-WWII era. With real interest rates turning low or negative, pressure on real aggregate demand, and therefore on oil markets, might not subside. Relaxation of monetary policy during August to December 2007 set off a new spiral in commodity price inflation and currency depreciation.[1]

In this paper we analyze oil price developments during 2000M1–2007M10. To analyze the effect of monetary policy, we examine two sub-periods with very different oil market fundamentals, 2000M1–2003M4 and 2003M5–2007M10. We assume oil prices are driven by Levy processes (LP) of generalized hyperbolic (GH) type and use daily data to estimate the parameters of these processes. Combining features of normal and stable distributions and offering more flexibility than Poisson-type processes, which were used to model large finite jumps, GH distributions have gained wide popularity for modeling stock market indices.[2] We demonstrate that normal inverse Gaussian (NIG) process closely fits oil price returns during 2000M1–2003M4 and 2003M5–2007M10; parameters of the process have, however, changed: mean return increased due to persistence in an upward trend, and kurtosis has declined due to higher predictability in oil prices. Estimated parameters of the NIG process are in conformity with findings for the empirical distribution of oil price returns. To be applicable for pricing derivatives, statistical distributions had to be adjusted for market price risk and turned into martingale processes. This is done through applying the Esscher transform to the statistical process. Besides estimating the distribution of oil price returns from time-series data, the distribution of the returns was also estimated from cross-section data from call and put option prices (for options on November 2, 2007 for end-December 2007). Implied risk-neutral distribution based on NIG shows that traders were expecting further rise in oil prices and were assigning significant probabilities for right tail events.

The paper is structured as follows: in Section 2, we review the literature on the relationship between monetary policy and oil prices. In Section 3, we examine daily oil prices during 2000M1–2007M10; in Section 4, we present the normal inverse Gaussian (NIG) distribution; in Section 5, we present the statistical estimation of the NIG distribution based on daily oil price data for 2000M1–2003M4 and 2003M5–2007M10; in Section 6, we derive the risk-neutral distributions from statistical LP by applying the Esscher transform to these processes; in Section 7, we derive density forecast from oil options prices; and our conclusions follow in Section 8.

2. Relationship between monetary policy and oil prices

During 2000M11 2004M6, the federal funds rate in the United States was lowered progressively from 6.51% in 2000M11 and was maintained at about 1% during 2003M7 2004M6. In parallel, LIBOR fell from 6.7% in 2000M11 to 1.08% in 2003M6 and remained close to 1% until 2004M3. The Euro inter-bank money rate fell from 5.09% in 2000M11 to 2.13% in 2003M7 and remained close to 2% until 2005M10. The Japanese call money rate was near zero during 2000M1 2007M1.[3] In response to overly expansionary policy by the US Fed, the US dollar depreciated significantly during 2002M2 2008M7. Interest rates cannot be forced down to such record low levels without the central bank injecting as much liquidity as needed to keep interest rates depressed at targeted levels. Very low interest rates and a fast depreciating dollar were

[1] During August to December 2007, some key discount rates were cut, large volume of liquidity was injected by major reserve banks, and successive cuts in the federal funds rate were implemented. Indeed, as cuts in interest rates were priced in before their announcements, pressure on oil prices increased prior to the actual implementation of these cuts.

[2] In view of their success in modeling financial time-series, many authors have advocated Levy processes of the hyperbolic type. Barndorff-Nielsen (1977), Barndorff-Nielsen and Blaesild (1983), Bibby and Sorensen (1997), Bibby and Sørensen (2003) Eberlein and Keller (1995), and Prause (1999) have proposed the hyperbolic distribution for modeling LP. Barndorff-Nielsen (1995 and 1997), and Rydberg (1997) proposed the normal inverse Gaussian (NIG) distribution; and Madan et al. (1998) applied the variance gamma distribution. GH processes have become appealing for their ability to account for salient features of high frequency financial time-series, namely asymmetry, frequent small and large jumps, and to reduce the smile in option prices (Eberlein et al., 1998). To the extent that GH distributions were constructed as mixtures of variance-mean normal distribution with time-varying stochastic variance, or equivalently, as Brownian motion subordinated to increasing positive stochastic processes, they can account for stochastic volatility and allow the attenuation of the smile in short-term options (Carr et al., 2003).

[3] The lowest interest rates were in Japan, encouraging large carry trade in yens, and in turn contributing to higher credit financing in many countries. In 2007 the yen carry trade, estimated at $5.9 trillion, with yen loans of an additional $1.2 trillion, was considered by many to be a "weapon of mass destruction."