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Smooth transition regime shifts and oil price dynamics

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ABSTRACT

The interaction between rational hedgers and informed oil traders is parameterized and tested empirically with the help of a complex non linear smooth transition regime shift CCC-GARCH procedure. In spite of their gyrations, futures price changes are usually self-correcting. Well informed producers and consumers will ensure that crude oil prices – and thus the prices of the corresponding futures contracts – fluctuate within a long run equilibrium range determined by market fundamentals. During a steep price upswing, however, shifts in positions in the futures markets by well informed optimizing agents that usually dampen price changes, result in destabilizing positive feedback trading. Futures price changes that can be classified as speculative are due to destabilizing hedgers' reactions to movements in the variability of the return of their covered cash position. The paper provides in this way an innovative interpretation of the 2008 oil price bubble.

1. Introduction

Oil futures are not easily analyzed since they are affected by both real and financial factors. Their dynamics reacts to fundamentals via a long run relationship with crude oil cash prices (the basis) and to hedging and speculative financial factors. A clear-cut distinction between hedging and speculation, moreover, is not always drawn. In a classic paper Johnson (1960) suggests that hedging and speculation in futures markets are interrelated. Speculation is mainly attributed to traders' expectations on futures price changes that bring about a shift in the optimal hedging ratio, a pattern that is related to the hypotheses of this paper. Ward and Fletcher (1971) generalize this approach to both long and short hedging and find that speculation is associated with optimal futures positions (short and long) that are in excess of the 100 percent hedging level.

This paper does not attempt to explain the determinants of equilibrium futures and spot oil prices. It focuses on the impact of hedging on futures price behavior and tries to shed light on the controversy about the role of speculation in the oil market prompted by the recent price upswing.

The 2007–2008 "oil bubble" has attracted a great deal of attention. It has been attributed to various causes, such as the entry of financial entities prone to adopt a speculative behavior (Cifarelli and Paladino, 2010; Master, 2008), to fundamental variables, such as a weak dollar and a low elasticity of supply in the face of a rapidly growing demand from Asia and other developing countries (Hamilton, 2009; Kesicki, 2010), or to a combination of these hypotheses (Kaufmann, 2011, among others). Most analyses focused on spot (cash) pricing and disregarded the central role of futures contracts and of their specific use as hedging instrument.

In this paper the main interactions between rational hedgers, informed oil producers, and oil consumers, are parameterized and tested empirically using a logistic smooth transition regime switching procedure. Feedback trading is found to be a by-product of the dynamic behavior of a futures pricing model in which oil producers and traders play a dominant role. In it futures price changes that can be classified as speculative are mostly due to hedgers' reaction to movements in the variability of the return of their covered cash position. It may happen that shifts in positions in the futures markets by well informed optimizing agents, that usually dampen price changes, bring about destabilizing positive feedback trading, often attributed in spot markets (see e.g. Ellen ter and Zwinkels, 2010, among others) to trend extrapolating chartists.

Noise trading in futures contracts, per se, does not seem to play a relevant role. Informed arbitrageurs ensure mean reversion of futures returns about a long run moving average. It is oil producers and consumers that do, in some cases, generate a speculative positive feedback trading behavior.

The paper identifies a stylized dynamic reaction pattern in the futures oil market. Every week economic agents rebalance their optimally hedged position in order to minimize its variance, going long or short

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in the futures market as a response to shifts in their cash demand, shifts that are related to current or previous periods' standardized price changes.

The reaction of traders and producers to volatility shifts in the oil market is modelled using a complex non linear logistic smooth transition regime shift CCC-GARCH approach. In this way the literature is extended by adding a dynamic component to the standard hedge ratio computation.

The evolution over time of the weighted coefficient of the volatility of the return of the hedging position is analysed and the reaction of economic agents to the recent oil price gyrations is carefully assessed. It turns out that the informed hedgers' strong and stabilizing reaction during the 2006 cycle is less incisive during the second larger 2007–2008 cycle. An increase in market uncertainty, possibly due to the entry of institutional investors in the commodity markets, is clearly detected. It reduces the informational advantage of informed market makers. The hesitations and uncertainties that characterize oil trading during a bubble are apparent, since destabilizing hedging positions, which result in positive feedback trading, become more frequent. The dynamics of the model suggest that spot price shifts bring about subsequent possibly destabilizing futures prices adjustments. The paper corroborates thus the interpretation of the decoupling of oil pricing from fundamental valuation set out by Sornette et al. (2009).

The analysis is organised as follows. Section 2 introduces the theoretical framework, based on a dynamic model of futures pricing which takes into account some stylized characteristics of spot and futures oil trades. The empirical evidence is presented in Section 3 using a nonlinear logistic smooth transition CCC-GARCH(1,1) parameterization. Section 3.1 provides an estimation of the oil spot and futures price dynamics. Section 3.2 analyses the behavior of the weighted coefficient of the variability of the return of the hedging position. Section 4 concludes the paper.

2. A Dynamic Model of Futures Pricing

It is assumed, following Westerhoff and Reitz (2005), that futures prices are set in an order driven market with heterogeneous agents.[1] Futures price changes from t to t + 1 are a positive function of excess demand by fundamentalist (rational) arbitrageurs and by oil traders, consumers and producers, involved in dynamic hedging.

$$f_{t+1} = f_t + a_1\left(D_t^F + D_t^H\right) + e_{t+1} \tag{1}$$

where f_t is the logarithm of the futures price F_t and a_1 is a positive reaction coefficient. D_t^F and D_t^H denote the excess demand of fundamentalists and hedgers.

Informed arbitrageurs base their expectations on futures price movements on the divergence between a long run (normal) equilibrium futures price rate of change based on oil market fundamentals and the current futures price rate of change

$$D_t^F = a_2\left(r_{ft}^F - r_{ft}\right) \tag{2}$$

where $r_{ft} = \Delta \log F_t = \Delta f_t$ and r_{ft}^F is the equilibrium futures price rate of change. It will be assumed that $r_{ft}^F = (\sum_{i=0}^{N-1} r_{ft-i})/N$. Coefficient a_2 is positive since current returns are believed to converge to their long run equilibrium value. Fundamentalists increase (reduce) futures demand if the current rate of return lies below (above) its long run equilibrium fundamental value r_{ft}^F and generate a dynamic mean reverting behavior.

Hedging transactions by oil producers and consumers are intended to reduce the risk of unwanted crude oil price changes. An investor who takes a long (short) position of one unit in the cash market will hedge by taking a short (long) position of β units in the corresponding futures market, which he will buy (sell) back when he sells (buys) the cash. The hedge ratio β can be seen as the proportion of the long (short) cash position that is covered by futures sales (purchases).

The return of this hedging position r_{Ht} is given by

$$r_{Ht} = r_{ct} - \beta r_{ft} \tag{3}$$

where the crude oil rate of return is the logarithmic first difference of the crude oil price C_t ($r_{ct} = \Delta \log C_t = \Delta c_t$).

The variance of the hedged position is given by

$$\sigma^2_{r_H t} = \sigma^2_{r_c t} + \beta^2 \sigma^2_{r_f t} - 2\beta \sigma_{r_c t} \sigma_{r_f t} \rho_{r_c r_f t} \tag{4}$$

where $\sigma^2_{r_c t}$ is the variance of r_{ct}, $\sigma^2_{r_f t}$ is the variance of r_{ft}, and $\rho_{r_c r_f t}$ is the correlation between r_{ct} and r_{ft}.

The optimum hedge ratio β is derived from the first order condition of the hedging position variance minimization and reads as

$$\beta = \frac{\sigma_{r_c t}\sigma_{r_f t}\rho_{r_c r_f t}}{\sigma^2_{r_f t}} \tag{5}$$

The optimum hedge ratio depends upon both the covariance between the changes in futures and cash prices, $\sigma_{r_c r_f t} = \sigma_{r_c t}\sigma_{r_f t}\rho_{r_c r_f t}$, and the variance of the futures price changes.[2]

In order to analyze the reactions of hedgers to shifts in commodity returns, the hedging model is extended by introducing a dynamic component. The expected utility of hedgers is assumed to be an inverse function of the variability of their optimally hedged position. The variance of the returns of this position can be rewritten, replacing in Eq. (4) the optimal hedge ratio β by its determinants, set out in Eq. (5), as

$$\sigma^2_{r_H t} = \sigma^2_{r_c t} - \frac{\left(\sigma_{r_c r_f t}\right)^2}{\sigma^2_{r_f t}} \tag{6}$$

The demand of futures contracts of a trader wishing to minimize the variance of her optimally hedged position is defined as

$$D_t^H = b^H \sigma^2_{r_H t-j} = b^H \left[\sigma^2_{r_c t-j} - \frac{\left(\sigma_{r_c r_f t-j}\right)^2}{\sigma^2_{r_f t-j}}\right] \qquad j = 0, \dots, \nu. \tag{7}$$

A time lag is introduced since a shift in a hedged position will require a costly and possibly time consuming decision process. The sign of the b^H coefficient may change over time and calls for an accurate investigation.

An increase in $\sigma^2_{r_H t}$ may be due to a rise in the variance of the cash price rate of change and/or to a decrease in the correlation between cash and futures returns, which we decide to disregard.[3] An increase in $\sigma^2_{r_c t}$ can in turn be produced either by an increase or by a decrease in crude oil prices. b^H is expected to be negative if the cash price rate of change is positive and positive if the cash price rate of change is negative. Long positions in a commodity (by producers) are associated with short positions in futures contracts, whereas short positions in a commodity (by e.g. traders or consumers) are covered by long positions in futures contracts.

[1] Westerhoff and Reitz, among others, draw a distinction between two categories of speculators, chartists (feedback traders), and fundamentalists. Such an approach does not fit well with the specific use of futures contracts for hedging purposes.

[2] We are using here the standard optimum hedge ratio coefficient, adapted to a conditional volatility context by Baillie and Myers (1991) and Kroner and Sultan (1993) among many others.

[3] Eq. (6) can be rewritten as $\sigma^2_{r_H t} = \sigma^2_{r_c t}\left(1 - \rho^2_{r_c r_f t}\right)$ where $\rho_{r_c r_f t} = \sigma_{r_c r_f t}/\sigma_{r_c t}\sigma_{r_f t}$. The correlation between cash and futures returns is large and stable in the case of the liquid close to maturity Futures Contract 1 used in the paper.