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Explosive oil prices☆

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ABSTRACT

Spectacular oil price increases occur on a regular basis; the most recent one is dated July 2008. This paper puts forward the notion that extreme oil price movements of this type can be described as temporary explosive. The paper applies a forward recursive unit root tests and finds evidence of explosive behavior in the following periods: 1990/1991, 2005/2006, and 2007/2008. Currently existing oil price models are not capable of appropriately describing this type of behavior. A thorough discussion of the underlying reasons of these price hikes indicates these oil price episodes — even though extreme — are mainly fundamentally explained. This finding is insufficiently acknowledged in the literature on speculative oil price bubbles. Thus, policy interventions as response to extreme movements of this kind need to be very carefully thought through.

1. Introduction

Heavy disruptions of the global oil market occur with considerable regularity. Among the manifold examples are the two oil crises, the OPEC collapse, the oil price hike associated with Gulf War II in 1990/1991 and, finally, the episode in July 2008 when oil prices reached a record level of more than 140 USD per barrel. Every one of these disruptions has led to heated debates in both the public and academic arenas. Considerable effort has been made to understand both the macroeconomics and the behavior of oil prices, and this work is well justified for at least two reasons. First, crude oil is still an important economic input factor and there is a widespread notion that virtually all economic recessions are associated with increases in oil prices. Second, crude oil is a fossil resource, the combustion of which is one of the main drivers of climate change.

Not only these disruptions occurred very frequently, also the behaviour of oil prices changed dramatically various times; see Fig. 1. Prior to 1986, oil prices moved essentially horizontally, interrupted only by a few shifts never experienced before: dramatic increases 1973/1974 as well as 1979/1980 and a dramatic collapse 1986. Subsequently, the horizontal movement continued, however with a considerably higher volatility. During the beginning of the 2000s, then, a steady increase began, culminating in the oil price record high observed 2008. More recently, oil prices were remarkably stable at around 100 USD per barrel before 2014 a dramatic collapse occurred. These major changes in oil price behavior is usually referred to as structural break; sudden extreme movements are often called jumps. There are, however, two oil price episodes which do seem to be different: in both 1990/1991 and 2008 the oil price movements can certainly also be described as dramatic. In both cases, however, the observed increase is followed by a subsequent collapse. In addition to this, it took the oil price considerable time to reach its respective peak: in 1990/1991 more than three months, in 2008 even longer. This behaviour is conceptually different from permanent structural breaks, a mere increase in volatility or the occurrence of individual, isolated jumps.

This paper empirically examines this type of behavior and employs the concept of temporary explosiveness to capture this behavior. The empirical strategy consists of a forward recursive application of an augmented Dickey–Fuller unit root test. In each step, the null of a unit root is tested against the alternative of explosiveness. The key result of this exercise is that there is evidence of temporary phases of explosiveness in 1990/1991 as well as in

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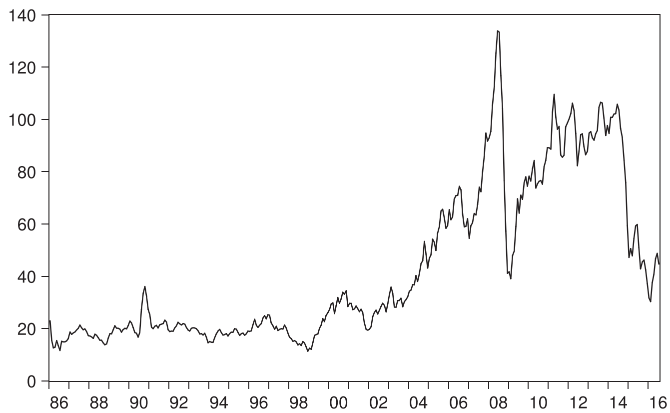

Fig. 1. Crude oil prices.

2005/2006 and 2007/2008. The procedure applied in this paper has been borrowed from Phillips et al. (2011); daily as well as monthly oil price data spanning from 1986–2016 are used in the study.[1] As these steep temporary increases followed by subsequent collapses are conceptually different from from existing oil price descriptions, this empirical finding, standing alone, makes a contribution to the empirical literature on oil price behavior. This literature is epitomized by time series applications such as Lee et al.'s (2006) rather traditional "deterministic vs stochastic trends" paper or Gronwald's (2012) and Lee et al.'s (2010) jump model applications.

A thorough discussion of possible explanations for the identified explosive phases and their relation to the literature on speculative bubbles in oil prices are the second contribution this paper makes. Influential papers such as Kilian and Murphy (2013), Juvenal and Petrella (2014), and Knittel and Pindyck (2016) show that these oil price surges are mainly explained by fundamental factors and that speculative activity only plays a minor role.[2] As the 2004–2008 oil price hike coincided with the so-called financialization of oil futures markets, many believe that this has to be viewed as a driving force behind the hike. Empirical support for this publicly popular claim, however, is practically nonexistent, see Irwin and Sanders (2012) as well as Sanders and Irwin (2014).[3]

To summarize, it is demonstrated that extreme price movements can be captured appropriately by the concept of temporary explosiveness. In addition, these extreme movements can very well have a fundamental explanation: they are a result of the interaction of, first, a change in the relationship between fundamentals of crude oil supply and demand and, second, low price elasticities of oil supply and demand. This is an important message to the general public as it often seems to be believed that extreme price movements can only have non-fundamental causes. However, also a number of academic studies insufficiently acknowledges this finding. Papers including Phillips and Yu (2011), Shi and Arora (2012) and Brooks et al. (2015) deal with speculative bubbles in crude oil prices. The main weakness of these papers, however, are inappropriately modelled fundamental values of oil prices. In addition, the exchange between these strands of literature seems to be overall insufficient. Due to the political dimension of the debate on speculative bubbles particular caution and empirical rigour is essential.

The remainder of the paper is organized as follows. Section 2 outlines the empirical method employed in the paper. Sections 3 and 4 present and discuss the empirical results. Section 5 offers some concluding remarks.

[1] Data source: Federal Reserve Bank of St. Louis.

[2] See the original papers for exact defintitions of "speculative activity". Section 4 explains the empirical procedures applied in these papers in more detail.

[3] For an excellent overview of this literature, see Fattouh et al. (2013).

2. Testing for explosiveness

The statistical properties of daily as well as monthly oil prices are investigated here using a forward recursive application of an augmented Dickey–Fuller unit root test. The null of a unit root is tested against the alternative of an explosive root. Thus, the following equation is estimated:

$$x_t = \mu_x + \delta x_{t-1} + \sum_{j=1}^{J} \phi_j \Delta x_{t-j} + \epsilon_{x,t}, \quad \epsilon_{x,t} \sim \text{NID}\left(0, \sigma_x^2\right). \qquad (1)$$

The hypothesis $H_0\colon \delta = 1$ is tested against the alternative $H_1\colon \delta > 1$.[4] Initially, a subset of the sample with $\tau_0 = nr_0$ observations is used. In each subsequent regression, this subset is supplemented by successive observations, giving a sample of size $\tau = nr$ for $r_0 \leq r \leq 1$. This procedure yields a sequence of t-statistics with corresponding p-values. These sequences are used to identify origination $\hat{r}_e$ and collapse dates $\hat{r}_f$ of explosive behavior in the data:

$$\hat{r}_e = \inf_{s \geq r_0} \left\{ s : \text{ADF}_s > \text{cv}_{\beta_n}^{\text{adf}}(s) \right\}$$

$$\hat{r}_f = \inf_{s \geq \hat{r}_e} \left\{ s : \text{ADF}_s < \text{cv}_{\beta_n}^{\text{adf}}(s) \right\}$$

This procedure is derived from a test for periodically collapsing bubbles recently proposed by Phillips et al. (2011) as a further-development of cointegration-based tests for the existence of bubbles. This paper uses nominal daily as well as nominal monthly oil prices from 1986 to 2016 (West Texas Intermediate) to test for explosiveness in oil prices.[5] The following section presents the empirical results.

3. Results

This section presents the results obtained from applying the test procedure outlined above to daily as well as monthly oil prices. Initially, the results for daily data are considered. The upper panel of Fig. 2 displays oil prices as well as the sequence of p-values; p-values below 5% indicate rejection of the null hypothesis. As explained above, for periods in which the null of a unit root is rejected, oil prices are said to exhibit explosive behavior.[6] This is found to be the case in the following periods: 1990/1991, 2005/2006 as well as 2007/2008. While the phase associated with Gulf War at the end of 1990 is of relative short duration, the two recent ones are about a year long. Analysis of monthly oil prices generally confirms these results (see Fig. 2, lower panel).[7]

The finding of temporary phases of explosiveness adds to the vast literature on short-run as well as long-run oil price behavior.

[4] Note that this is a standard unit root test except for the formulation of the alternative hypothesis. Rather than testing the null of a unit root against a stationary alternative, the alternative in this case is explosive.

[5] See Section 4 for a discussion of the differences between explosiveness and bubbles.

[6] A consistent estimation of the precise origin and collapse date of the explosive behavior would require a significance level asymptotically approaching zero, see Phillips and Yu (2011) and Phillips and Wu (2009). This paper, however, is more interested in the general behavioral pattern of oil prices. Research in that area is still ongoing and existing procedures are rather ad-hoc. Some alternative procedures have been applied as robustness check; the results are overall consistent with the results presented here. These results are available from the author upon request.

[7] Note that, at least in theory, the method applied in this paper would also allow one to capture "negative explosiveness" or "explosiveness in reverse". Fig. 2 indicates that the p-values begin to decrease in 2014. However, they are still considerably larger than any conventional significance level. Thus, there would be insufficient evidence to conclude that "negative explosiveness" is present. In other words, the observed oil price declines are not large enough.