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Date stamping historical periods of oil price explosivity: 1876–2014☆

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ABSTRACT

This paper sets out to date-stamp periods of historic oil price explosivity using the Generalized sup ADF (GSADF) test procedure developed by Phillips, Shi, and Yu (2013). The date-stamping procedure used in this paper is effective at identifying periodically collapsing bubbles; a feature found lacking with previous bubble detection methods. We set out to identify periods of oil price explosivity relative to the general price level and oil inventory supplies in the US since 1876 and 1920, respectively. The recursive identification algorithms used in this study identify multiple periods of price explosivity, and as such provides future researchers with a reference for studying the macroeconomic impact of historical periods of significant oil price build-ups.

1. Introduction

The occurrence of bubble episodes in asset markets have been studied extensively, both theoretically and empirically, and have spurred divergent debates on its implications on rationality and market efficiency. Economists have long debated whether to reconcile bubble-like behavior with rational expectations of future prices, leading to divergent views on suitable policy responses following its detection. To this end, various econometric techniques have been proposed for date stamping past bubble periods as well as suggesting mechanisms for early detection of its formation.[1]

This paper sets out to identify periods of mildly explosive behavior of the oil price during the period January 1876 to January 2014. We do so using Phillips, Shi, and Yu's (2013) recursive Generalized sup Augmented Dickey–Fuller (GSADF) technique applied to test for significant deviations of the nominal price of oil from its prior levels relative to the general price level in the US and the US inventory supply stock. This technique allows the detection and date-stamping of periods where the price behavior, relative to general prices and oil supply, resembles an explosive series.[2] In this study we define such explosivity as temporary regime shifts from unit-root non-stationarity toward periods where the root significantly exceeds unity, followed by reversion back to a martingale process. After date-stamping, we contextualize the identified periods of explosiveness in terms of contemporaneous events that may have contributed to the said price surges.

Most applications of the techniques developed by Phillips et al. (2013) and used in this study, interpret such defined periods of explosiveness as bubble-periods. An asset price bubble can be defined theoretically as sustained price deviations from an identified fundamental value. We, however, apply caution as to the interpretation of our results, defining such periods as explosive as opposed to indicative of an oil price bubble.

Our caution in defining explosivity measured in this paper as bubbles follows for several reasons. Firstly, defining a fundamental level proves uniquely complicated for storable commodities. Similar studies into the explosiveness of commodity prices have typically made use of

☆ The views expressed in this paper are those of the authors, and do not necessarily reflect that of the Bank of Israel.
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[1] C.f. Gürkaynak (2008) for an in-depth assessment of the performance of various bubble detection techniques.

[2] Phillips and Magdalinos (2007) elaborate on the limit theory of mildly explosive behavior, referred to in this paper merely as explosivity.

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Table 1
Real oil price explosivity.

Sample: 1876M01 2014M03		
Included observations: 1659		
Starting date	Ending date	Duration (months)
1895M01	1895M05	5
1899M11	1900M03	4
1909M11	1911M01	15
1912M11	1914M02	16
1946M05	1948M10	30
1951M01	1952M10	22
1964M07	1964M11	5
1966M02	1966M07	6
1970M06	1970M11	6
1973M10	1977M03	41
1979M04	1982M03	36
1986M02	1986M07	6
2007M10	2008M08	11

Table 2
Nominal price and inventory quantity ratio explosivity.

Sample: 1920M01 2014M02		
Included observations: 1129		
Starting date	Ending date	Duration (months)
1949M02	1949M06	5
1973M09	1984M12	136
1985M07	1985M12	6
2005M07	2005M10	4
2006M04	2006M08	5
2007M07	2008M09	15

Pindyck's (1993) convenience-yield in order to define the fundamental price of, e.g., oil. This is measured as the sum of discounted oil "dividends", which is in turn approximated for by the benefit to holding inventories per unit of commodity over a defined period to which a futures contract has been written on the underlying asset.[3] This can be thought of as analogous to the dividend earned on holding a share. In this study, as we lack longer dated futures contract data, we define the underlying fundamental levels of the oil price as relative to the general price level and the inventory supply level in the US (supply ratio hereafter).

We also apply caution to labeling the identified periods of explosivity as bubbles, as such periods might rather be indicative of adjustments from previously managed or manipulated pricing schedules toward a more fundamental level (whichever way defined). To infer exuberance, or bubble-like behavior, would require the implicit assumption that the price was at its fundamental level prior to explosivity. This is clearly not plausible in the strongly manipulated oil price market for a commodity with a particularly hard to define fundamental level. Our interpretation thus of the oil price series is that it is non-linearly related to underlying fundamentals.

Despite our caution on interpretation, our results should still prove useful. This follows as the price of oil and its derivatives are an important input into nearly all spheres of modern economies. Regnier (2007), e.g., also shows that production prices for commodities closely track the oil-price, which would imply a significant impact on general price stability in the economy should the latter experience periods of explosivity. While commodity markets, and in particular the oil market, have well functioning derivative markets that allow effective hedging, large price fluctuations remain costly to households in the economy who participate chiefly in consuming oil derivative products in the form of fuel and gas. By identifying significant build-ups in the price of oil relative to other prices in the economy and relative to the supply, our results provide researchers with a reference to assess the macroeconomic impact of historical periods of oil price explosivity.

The paper is structured as follows: Section 2 discusses the relevant literature and theory of asset pricing explosivity, while Section 4 presents the data used in this study. Section 3 discusses the empirical methodology followed, while Section 5 discusses the results. The dates identified by our GSADF approach as representing periods of oil price explosivity are summarized in Tables 1 and 2.

2. Literature overview

The inflationary build-up of asset prices, more loosely defined as asset price bubbles, has long interested economists and led to the development of a vast literature aimed at explaining its existence and facilitating its timely detection and prevention. The difficulty in testing for the presence of bubbles lies in modeling its explosivity and labeling its occurrence. Traditional unit root and co-integration tests aimed at identifying such periods, as e.g. proposed by Diba and Grossman (1988), may not bear out the existence of bubbles when they are periodically collapsing.[4] As Evans (1991) points out, when seeking to identify multiple periodically collapsing bubbles within a single data set using stationarity tests, the process is greatly complicated and exposed to the possibility of identifying pseudo stationary behavior.

To overcome this problem, Phillips and Yu (2011), Phillips, Wu, and Yu (2011) and Phillips, Shi, and Yu (2013) (PY, PWY and PSY, respectively, hereafter) developed and subsequently improved on a convincing sequence of rolling right-tailed sup ADF testing procedures to detect and date stamp mildly explosive pricing behavior. Homm and Breitung (2012) compared several widely used techniques for identifying bubbles and found that the PWY (2011) strategy performs the best. PSY (2013) extended the methodologies of PWY (2011) and PY (2011) in that it recursively identifies explosivity as rejecting the null hypothesis of unit-root non-stationarity for the right-tailed alternative of explosivity. They found this strategy to significantly outperform previously used right-tailed ADF estimations in identifying multiple bubbles using Monte Carlo simulations. In particular, the PSY (2013) approach overcomes the earlier mentioned problem of detecting multiple episodes of periodically recurring explosivity (a particularly useful feature, as in our study we identify several), and has since gained ground in its empirical applications (c.f. inter alia Bettendorf and Chen (2013), and Etienne et al. (2014)).

Most studies focussing on commodity price explosivity have sought to identify such periods using Pindyck's (1993) convenience yield (c.f. inter alia Lammerding et al. (2013), Gilbert (2010); Areal et al. (2014) and Shi and Arora (2012)). This cost-of-carry equation is then used to approximate the fundamental value of the oil price,[5] to which PSY's (2013) estimation procedures have been applied to identify significant deviations from it. Lammerding et al. (2013) separate the fundamental level from the unobserved "bubble" component by expressing the standard present-value model of discounted future oil dividends in state space form. They then approximate two distinct Markov Switching phases to distinguish between the stable and explosive phases of the bubble process. Their approach uncovers robust evidence of speculative bubbles present in oil price dynamics. Shi and Arora (2012) apply three different regime switching bubble-identifying procedures, finding evidence of a short-lived real oil price bubble between 2008 and 2009.

In these studies the authors use daily futures prices from contracts traded on the New York Mercantile Exchange (NYMEX) for West

[3] C.f. Lammerding et al. (2013) for a deeper discussion into this definition.

[4] C.f. Branch and Evans (2011) for a detailed description of the rational price bubble literature; Gürkaynak (2008) also provides a thorough account of the broad literature on empirical tests for bubbles.

[5] Intuitively, it approximates the fundamental value of oil from the current and expected discounted convenience yield that accrues from holding oil inventories.

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