DATE STAMPING HISTORICAL OIL PRICE BUBBLES: 1876 - 2014

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Abstract

This paper sets out to date-stamp periods of historic oil price explosivity (or bubbles) using the Generalized sup ADF (GSADF) test procedure suggested by Phillips et al. (2013). The date-stamping strategy used in this paper is effective at identifying periodically collapsing bubbles; a feature found lacking with previous bubble detecting methods. We set out to identify bubbles in the real price and the nominal price-supply ratio of oil for the period 1876 - 2014. The recursive identification algorithms used in this study identifies several periods of significant explosivity, and as such provides future researchers with a reference for studying the macroeconomic impact of historical periods of significant oil price build-ups.

JEL-Classification: C15, C22

Keywords: Oil-prices; Date-Stamping Strategy; Periodically Collapsing Bubbles; Explosivity; Flexible Window; GSADF Test; Commodity Price Bubbles.

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1 Introduction

This paper seeks to identify periods of mildly explosive-, or bubble-like, behaviour of the oil price during the period January 1876 to January 2014. We do so using Phillips et al. (2013) recursive Generalized Sup Augmented Dickey-Fuller (GSADF) technique on both the real price of oil and also a nominal price-quantity ratio.

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 behaviour 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]

An asset price bubble can be defined theoretically as sustained price deviations from its fundamental value. This value proves uniquely complicated to define for storable commodity price indexes, which this paper seeks to uncover for oil prices. Previous studies on uncovering commodity price bubbles have typically made use of Pindyck's (1993) convenience-yield in order to define the fundamental price of oil as the sum of discounted oil "dividends" (C.f. Areal and Balcombe (2014), Gilbert (2010) & Lammerding et al. (2013)). Such oil price dividends are 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.[2] 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 seek to characterize the time-series properties of the price of oil in order to uncover the historical periods of price movements that deviate from typical martingale behaviour. In particular, we focus on detecting temporary regime shifts from unit-root non-stationarity towards periods of mildly explosive price behaviour, followed by reversion back to a martingale process. Such periods would then be labeled as oil price bubbles, although defining it as such by making use of only the historical price series requires a deeper conceptual understanding of the techniques used in this study.

The techniques developed by Phillips et al. (2013) provide an efficient and consistent basis for identifying periods of mildly explosive departures from a unit root Data Generating Process

[1] C.f. Gürkaynak (2008) for an in-depth assessment of the performance of various bubble detection techniques.
[2] C.f. Lammerding et al. (2013) for a deeper discussion into this definition.

(DGP), but provides no causal understanding of these periods. The current paper applies caution in not defining such periods as displaying market exuberance, as is done in most other applications of these techniques when applied to price deviations from clear fundamental levels. This follows as mild explosivity in the context of oil price movement might very well indicate adjustments from previously managed or manipulated pricing schedules toward a more fundamental level, whichever way defined. To infer exuberance or bubble-like behaviour as typically defined 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. Our interpretation thus of the oil price series is that it is non-linearly related to underlying fundamentals, and we seek to identify bubble periods in the narrower sense as deviations from unit-root stationarity of the price series itself. Our estimated bubbles then represent periods of significant oil price build-up, and not necessarily exuberance.

As a vital input across nearly all spheres of economic activity, excessive build-up in the price of oil has shown historically to have a significant impact on the real economy. It is a vital input to nearly all forms of production and consumption expenditure, and has a significant impact on general price stability and forward estimates of aggregate prices in the economy. Our analysis allows for the identification of historic events that might have led to, or at least have been contemporaneous with, the explosive build-up in the real price of oil. We do not attempt to interpret the cause of the bubble episodes, or discuss their real economic impact, but merely provide a means for dating its occurrence. We strongly encourage more work to be done using our date stamping estimates to assess its historical macroeconomic impact. To the best of our knowledge, this is the first study to attempt a long dated explosivity test on the price of oil. The paper is structured as follows: section 2 discusses the relevant literature and theory of asset pricing bubbles, while section 3 presents the data used in this study. Section 4 discusses the empirical methodology followed, while section 5 discusses the results. We then conclude the paper.

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.[3] 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 behaviour.

To overcome this problem, Phillips and Yu (2011), Phillips et al. (2011) and Phillips et al. (2013) (PY, PWY and PSY respectively hereafter) developed and subsequently improved on a convincing series of rolling right-tailed sup ADF testing procedures to detect and date stamp mildly explosive pricing behaviour. 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.[4]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, and has since gained ground in its empirical applications (C.f. inter alia Bettendorf and Chen (2013), and Etienne et al. (2014)).

Several studies (C.f. inter alia Lammerding et al. (2013), Shi and Arora (2012) and Tsvetanov et al. (2013)) have sought to identify periods of mildly explosive oil price behaviour using Pindyck's (1993) convenience yield. This cost-of-carry equation is used in order to approximate the fundamental value of the oil price,[5] to which PSY, (2013)'s estimation procedure have been applied to identify bubble periods. 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. Tsvetanov et al.

[3]C.f. Branch and Evans (2010) 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.

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

[5]Intuitively, this approach approximates the fundamental values as taken from the current and expected discounted convenience yield that accrues from holding oil inventories.

(2013) also find evidence of mildly explosive pricing behaviour studying spot and futures prices, extending their futures analysis across the maturity yield up to 24 months.

In these studies the authors use daily futures prices from contracts traded on the New York Mercantile Exchange (NYMEX) for WTI[6] prices, and ICE[7] Futures Europe for Brent prices. The starting points are all after April 1983 for WTI and 1989 for Brent crude prices due to data availability on futures contracts. As our study is based on prices dating back to 1876, we cannot use futures data to approximate a convenience yield. In this study we use a longer dated series for oil prices and set out to identify historical periods of explosivity.

3 Data description

This study uses the monthly WTI crude oil price for the period 1876 - 2014, obtained from the Global Financial database. [8] US CPI data, also obtained from the Global Financial database, is then used to calculate the real oil price for this period. Similar to Phillips and Yu (2011), we approximate oil-supply from the US inventory of crude oil. The inventory data is obtained from the US Department of Energy.[9]

As can be seen in figure 3.1, the real oil price has shown considerable variation both before and after the price fixing period between 1941 - 1973.[10] Over the two subsamples 1876 - 1940 and 1973 - 2014, the real price of oil averaged respectively \$16.78 and \$23.97. The period after 1973 was much more volatile,[11] with oil cartel influence and supply shocks causing great fluctuations in the real price of oil.

The nominal price-supply ratio, as seen in figure 3.2, shows great variation after the price fixing period. In particular, several periods of potentially large deviation of the price from its underlying (supply) can be clearly seen during the late 1970s and middle 2000s.

Combining the real oil price and nominal price-supply measures, our analysis provides an indication both of price explosivity relative to aggregate prices in the economy and in terms of the unit price of oil paid by consumers.

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[6] West Texas Intermediate

[7] Inter-Continental Exchange.

[8] Listed as WTI-Cushing, Oklahoma.

[9] Department of Energy, Monthly Energy Review, series: US Crude Oil ending stocks non-SPR (thousands of barrels).

[10] In December 1941 the Wartime Price and Trade Board announced a complete control of all oil prices would come into force. This control was subsequently lifted in 1973.

[11] The standard deviations before and after the price fixing period are 5.75 and 11.42, respectively.

Figure 3.1: Real Oil Price, 1876 - 2014

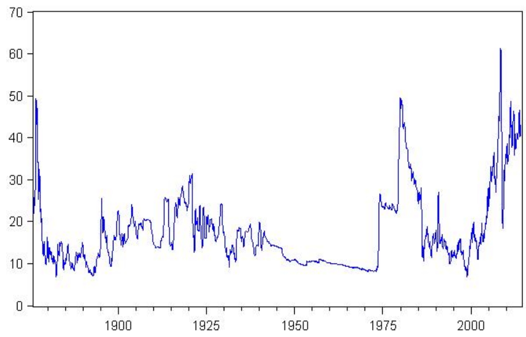
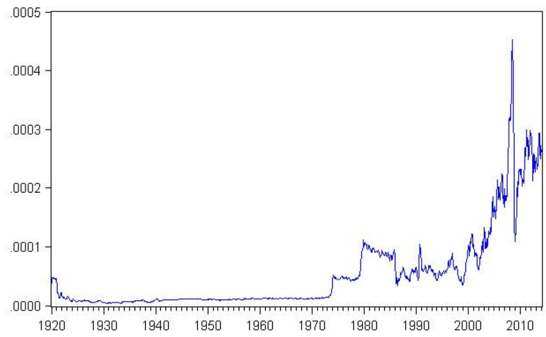


Figure 3.2: Price-Supply Ratio, 1920 - 2014



4 Theoretical Framework and Methodology

The techniques used in this study builds upon the work pioneered by PY, (2011) and PWY, (2011), and specifically the generalized form of the SADF (GSADF) technique as suggested by PSY, (2013). The latter was designed to overcome the PY and PWY procedures' lack of power in identifying a second bubble if it is dominated by the first. To do so, PSY develop in their paper a flexible moving sample test procedure that is able to consistently detect and date-stamp multiple bubble episodes and seldom give false alarms, even in modest sample sizes. The PSY approach achieves this by recursively implementing an ADF-type regression test using a rolling window procedure. More specifically, we consider an ADF regression for a rolling interval beginning with a fraction r_1 and ending with a fraction r_2 of the total number of observations, with the size of the window being $r_w = r_2 - r_1$.

Let:

$$y_t = \mu + \delta . y_{t-1} + \sum_{i=1}^{p} \phi_{rw}^{i} \delta . y_{t-i} + \epsilon_t \tag{4.1}$$

where μ, δ & ϕ are parameters estimated using OLS, and the usual $H_0 : \delta = 1$ then tested against the right sided alternative $H_1 : \delta > 1$. The number of observations taken into account by 4.1 is $T_w = [r_w T]$, where [.] is the integer part. The ADF statistic corresponding to 4.1 is denoted by ADF_{r1}^{r2}.

PSY, (2013) formulated a backward sup ADF test where the endpoint of the subsample is fixed at a fraction r_2 of the whole sample and the window size is expanded from an initial fraction

r_0 to r_2. The backward sup ADF statistic is then defined as:

$$SADF_{r_2}(r_0) = sup_{r1 \in [0, r_2 - r_0] ADF_{r_1}^{r2}} \tag{4.2}$$

The generalized sup ADF (GSADF) is then constructed by repeatedly implementing the SADF test procedure for each $r_2 \in [r_0, 1]$. The GSADF can then be written as follows:

$$GSADF(r_0) = sup_{r_2 \in [r_0, 1]} SADF_{r_2}(r_0) \tag{4.3}$$

The rational behind using a supremum of a recursively estimated ADF statistic is the observation that asset price bubbles generally collapse periodically, with conventional unit root tests then having limited power in detecting such bubbles (Evans, 1991). Homm and Breitung (2012) argued that the sup ADF test procedure delivers a fairly efficient bubble-detection technique when dealing with one or two bubble periods.

This process can be understood as a recursive regression process calculated by 4.1 using OLS with the initial fraction $r_w = r_0$, and then expanding the sample window forward until $r_w = r_1 = 1$, which is the full sample. The initial minimum fraction is selected arbitrarily while keeping in mind that we need to ensure estimation efficiency. This process is then repeated for each possible fraction, and an ADF statistic calculated as ADF_{r_k} for all values of $k \in (r_0, r_1)$. This procedure results in a sequence of ADF statistics. The supremum value of this sequence (SADF) can than be used to test the null hypotheses of unit root against its right-tailed (mildly explosive) alternative by comparing it to its corresponding critical values. Significant ADF statistics are indicated by $\delta_{r_1, r_2} > 1$, which we could then label as explosive (bubble) periods. The GSDAF approach defined above uses a variable window width approach, allowing starting as well as ending points to change within a predefined range $[r_0, 1]$, and thereby allowing the identification of several bubble periods consistently in a sample.

The procedure described above is used to test whether a certain time series exhibits explosive patterns, interpreted as bubbles, within a given sample. If the null hypothesis of no bubbles is rejected, the PSY procedure enables us, as a second step, to consistently date-stamp the starting and ending points of this (these) bubble(s). The starting point of a bubble is defined as the date, denoted as T_{r_e} (in fraction terms), at which the backward sup ADF sequence crosses the corresponding critical value from below. Similarly, the ending point of a bubble is defined as the date, denoted as T_{r_f} (in fraction terms), at which the backward sup ADF sequence crosses the corresponding critical value from above.

Formally, we can define the bubble periods based on the GSADF test by[12]

$$\hat{r_e} = \inf_{r_2 \in [r_0,1]} \left\{ r_2 : BSADF_{r_2} > cv_{r_2}^{\beta_T} \right\}$$
$$\hat{r_f} = \inf_{r_2 \in [\hat{r_e},1]} \left\{ r_2 : BSADF_{r_2} > cv_{r_2}^{\beta_T} \right\} \quad (4.4)$$

Where $cv_{r_2}^{\beta_T}$ is the $100(1-\beta_t)\%$ critical value of the sup ADF statistic based on $[T_{r_2}]$ observations.[13] The BSADF(r_0) for $r_2 \in [r_0, 1]$ is the backward sup ADF statistic that relates to the GSADF statistic by noting that:

$$GSADF(r_0) = \underset{r_2 \in [r_0,1]}{sup} \left\{ BSADF_{r_2}(r_0) \right\} \quad (4.5)$$

We face several challenges dating historic oil price bubbles. Firstly, as we do not have sufficiently long dated forward price data, we cannot rely on estimates of the convenience yield. As such we base our analysis on two measures: firstly that of defining periods of explosivity in the real oil price and also of explosivity in the nominal price to supply ratio. The motivation for the first approach is to identify periods of significant build-up in the price of oil relative to the general price level. The second considers the price per quantity of oil supplied as the fundamental level from which nominal prices deviate over time.

Another challenge faced in our estimation is dealing with the long period of oil price fixing from 1941 – 1973. Finding any bubble episodes in this period for either of our measures would merely suggest general price inflation build-ups or supply shocks. We therefore carry out our estimations on three different periods within our sample. These include the period prior to oil price fixing in 1941, [14] the period after the oil price fixing period (Starting in 1978 to avoid falsely identifying price corrections as bubbles shortly after 1973) and then also the full-sample.

5 Empirical results

The results for the recursive GSADF estimates are contained in tables B.3 to B.8 in the appendix. The estimates are based on the three sample periods discussed in the previous section,

[12]For a more in-depth discussion of this process of bubble identification, ref to Phillips and Yu (2011), Phillips et al. (2011) and Phillips et al. (2013).

[13]We set β_t to a constant value, 5%, as opposed to letting $\beta_T \to 0$ as $T \to 0$.

[14]Starting in 1876 for the real oil price measure, and 1920 for the price supply ratio.

and the results show that for all but one of our samples we find strong evidence of the existence of oil price explosivity. [15]

Identifying intra-sample periods of oil price explosivity is done by comparing the calculated GSADF statistics to the corresponding critical values obtained from Monte Carlo replications on the partial sum of 1000 independent standard normal draws. The minimum size of the variable window widths are set to 36. We also used a fixed lag length of zero, as recommended by PSY, (2013).[16] The results of our tests can be viewed on figures A.1 to A.6, which report the recursive GSADF and the corresponding critical values. As discussed, we label periods as explosive when the BSADF estimates exceed the critical values.

Tables 5.1 and 5.2 below summarize the periods identified by the right tailed GSADF procedure as bubble periods for both the real price of oil and the price-supply ratio, for the pre- and post price fixing periods. We include the full sample bubble periods in the appendix. Although PSY, (2013) suggest using a minimum bubble duration of $log(T)$, [17] we include bubble periods identified that are longer than one month in length in our final date stamping tables.

Considering first the real oil price bubbles in table 5.1, we decided to remove a signficant bubble period detected by our estimations, but which does not correspond to a significant price build-up. This was done for the period 1909m01 - 1911m03, where we found the real and nominal prices to be flat and not indicative of a bubble, with both nominal and real oil prices only starting to rise dramatically after 1912m01 (with a clear bubble formed in 1912m11). For the periods included in the table, we see significant pre-1941 build-ups from 1895m01 - 1895m05 (with a real and nominal price change each of 82%) and 1899m11 - 1900m03 (with a real and nominal price change of 9.8% & 11.3%, respectively).[18] The 20 month bubble between 1912m11 - 1913m10 identified corresponds to a 52% and 55% change in the real and nominal prices respectively.

For the period after 1973, we include in our table the bubble identified for the period 1979m04 - 1982m03 by the full sample estimate in table B.1. [19] The bubble so identified saw a 53.9% real price and 108% nominal price increase for the four year period. We also removed the bubble identified for the period 1986m02 - 1986m11, as it showed a modest 3% and 4% respective real

[15] Only for the price-supply ratio for the period 1920 – 1941 there was no significant bubble episode detected

[16] Adding more lags does not significantly alter the results.

[17] This would imply a length of 5 - 7 months in our sample.

[18] The real and nominal price changes here and hereafter are considered as the price prior to the bubble formation and the price at its collapse.

[19] Due to the minimum window estimate, our trimmed sample beginning in 1978m12 did not pick up this clear bubble

and nominal price build-up. The reason for exclusion is that in 1985m11 we see a significant drop in nominal and real oil prices to 1986m03 of 58%, after which we see a slight recovery, labeled incorrectly using the BSADF test as a period of explosivity.

Subsequent sizeable bubble periods identified are between 2005m08 - 2005m09 and 2006m4 - 2006m08 (with a 9.2% and 14% real price build-up, respectively). Thereafter, we see that in the build-up to the global financial crisis, the real and nominal prices for the explosive period between 2007m10 - 2008m08 are 39% and 46% respectively.

In our summary of price-supply explosivity in table 5.2, we see mostly short duration bubbles as compared to the real price estimates. We decided to include the period between 1939m12 - 1940m02 (which suggests a 14% rise in the price-supply ratio), despite the GSADF test suggesting no significant bubbles for the pre-1941 period.

We also see that our estimations starting in 1978 do not include the bubble in 1979 again due to the minimum window size, and as such we include the bubble period starting in 1979m01 and ending 1979m12, where we see a 133% rise in the ratio. We also exclude the 1986m02 - 1986m04 period of explosivity defined in our BSADF estimates, as it falsely detects a bubble, with our estimates suggest a near 20% decline in the ratio.

The explosive periods identified in the ratio in 2000 needs to be interpreted with caution. The bubble identified in 2000 follows a significant build-up of the ratio in 1999m02, reaching a peak in 2000m09 (this period saw a 238% increase in the ratio), with explosivity only detected in 2000m02. We also see an explosive build-up in 2005m08 - 2005m09, where the ratio increased by 15%, corresponding to the increase seen in the real oil price for this period. The build-up to the global financial crisis also led to an explosive price-supply ratio period from 2007m09 - 2008m09, corresponding to a 51% rise in the ratio.

Table 5.1: Real oil price Bubbles:
(1876 - 1941) & (1978 - 2014)

Starting Date	Ending Date	Duration (months)
1895M01	1895M05	5
1899M11	1900M03	5
1903M11	1903M12	2
1912M11	1913M10	12
1979m04	1982m03	36
1986M02	1986M11	10
2005M08	2005M09	2
2006M04	2006M08	5
2007M10	2008M08	11

GSADF Test statistics and critical values derived using the RTADF EViews add-in (Caspi, 2013).

Table 5.2: Price-Supply Ratio Bubbles:
(1920 - 1941) & (1978 - 2014)

Starting Date	Ending Date	Duration (months)
1939M12	1940M02	3
1979m01	1979m12	12
1986M02	1986M04	3
2000M02	2000M03	2
2000M09	2000M10	2
2005M08	2005M09	2
2007M09	2008M09	13

GSADF Test statistics and critical values derived using the RTADF EViews add-in (Caspi, 2013).

6 Conclusion

The aim of this paper is to provide a basis for effectively time-stamping periods of oil price explosivity for the period 1876 - 2014. We make use of Phillips et al. (2013)'s right-tailed recursive GSADF approach in order to approximate the starting and ending points of historic oil price bubbles. As we do not have long dated futures prices, we cannot estimate the convenience yield for oil prices, and as such set out to identify periods of explosivity in terms of aggregate price levels as well as relative to supply.

The GSADF procedure provides an effective means of identifying periods of explosivity by recursively adjusting the moving window estimation sample for the right-tailed sup ADF testing procedures. Phillips et al. (2013) show in their paper the ability of these techniques to effectively identify multiple periodically collapsing bubbles in a longer dated series. The detection strategy is based on a righ-tailed variant of the standard Augmented Dickey Fuller (ADF) test, with the alternative of a mildly explosive series. The GSADF statistics are compared to the corresponding calculated critical values, after which we date-stamp these periods using the backwards sup ADF (BSADF) statistic.

Our results suggest the presence of multiple periods of significant explosivity in both the real price and the price-supply ratio of oil. These estimates can be viewed on figures A.1 - A.6, with BSADF values exceeding critical values indicating explosivity. The results of our date-stamping procedures are summarized in tables 5.1 and 5.2, respectively. In this paper we do not interpret the factors that might have caused or have been contemporaneous with the build-up of oil prices, but rather provide future researchers with a reference for periods of high historical oil prices.

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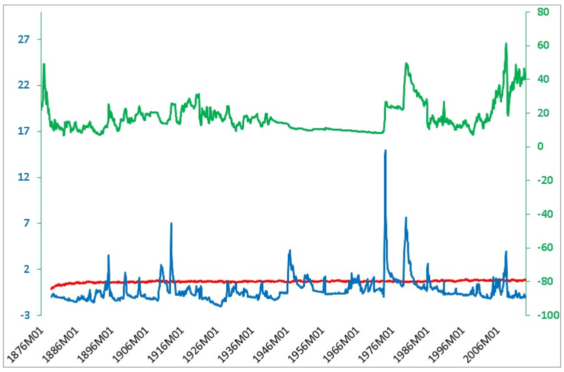
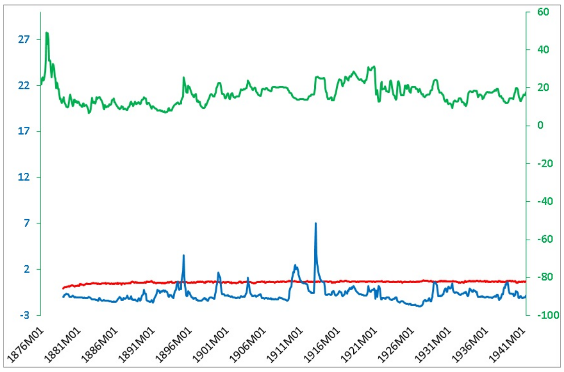
A Appendix: Figures

Figure A.1: Real Oil Price, 1876 - 2014



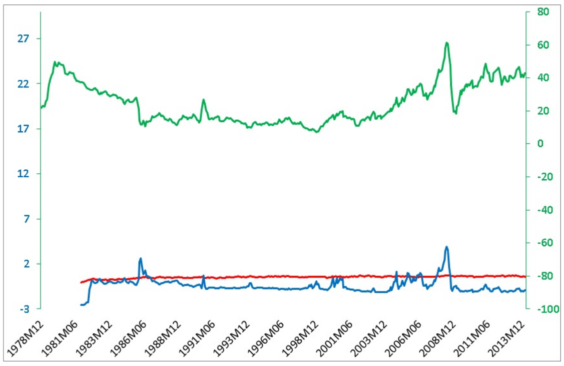
— Real Oil Price
— BSADF
— 95% Critical Values

Figure A.2: Real Oil Price, 1876 - 1941



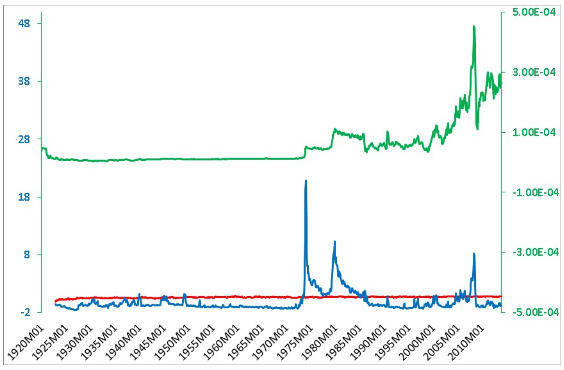
— Real Oil Price
— BSADF
— 95% Critical Values

Figure A.3: Real Oil Price, 1978 - 2014



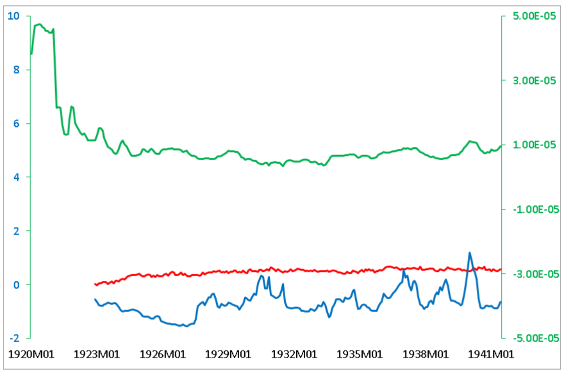
— Real Oil Price
— BSADF
— 95% Critical Values

Figure A.4: Price-Supply Ratio, 1920 - 2014



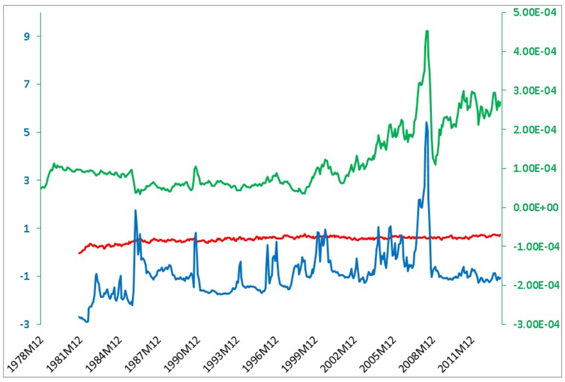
— Price-Supply Ratio
— BSADF
— 95% Critical Values

Figure A.5: Price-Supply Ratio, 1920 - 1941



— Price-Supply Ratio
— BSADF
— 95% Critical Values

Figure A.6: Price-Supply Ratio, 1978 - 2014



— Price-Supply Ratio
— BSADF
— 95% Critical Values

B Appendix: Tables

Table B.1: Real oil price Bubbles: (1873 - 2014)

Starting Date	Ending Date	Duration (months)
1895M01	1895M05	5
1899M11	1900M03	5
1909M11	1911M01	15
1912M11	1914M02	16
1946M05	1948M10	30
1951M01	1952M10	22
1956M10	1956M12	3
1964M07	1964M11	5
1965M06	1965M07	2
1966M02	1966M07	6
1969M01	1969M02	2
1970M06	1970M11	6
1973M10	1977M03	41
1977M09	1977M12	4
1979M04	1982M03	36
1986M02	1986M07	6
2005M08	2005M09	2
2006M07	2006M08	2
2007M10	2008M08	11

Cross Sectional Dispersion vs Time Series Volatility of the S&P 500, 1981 – 2008, with 21-day smoothing. Source: ?.

Table B.2: Price-Supply Ratio Bubbles: (1920- 2014)

Starting Date	Ending Date	Duration (months)
1939M12	1940M02	3
1945M01	1945M02	2
1945M06	1945M08	3
1949M02	1949M06	5
1973M06	1973M07	2
1973M09	1984M12	136
1985M02	1985M04	3
1985M07	1985M12	6
1986M02	1986M04	3
2000M02	2000M03	2
2004M09	2004M10	2
2005M07	2005M10	4
2006M04	2006M08	5
2007M07	2008M09	15

GSADF Test statistics and critical values derived using the RTADF EViews add-in (Caspi, 2013).

Table B.3: GSADF Statistic for real oil-prices (1876 - 2014):

	Critical Level	t-Statistic	p-value
GSADF Statisic		14.9630	0.000
Critical Value	99%	3.3605	
	95%	2.8731	
	90%	2.5790	

Table B.4: GSADF Statistic for real oil-prices (1876 - 1941):

	Critical Level	t-Statistic	p-value
GSADF Statisic		6.9968	0.000
Critical Value	99%	3.0450	
	95%	2.5009	
	90%	2.2439	

Table B.5: GSADF Statistic for real oil-prices (1978 - 2014):

	Critical Level	t-Statistic	p-value
GSADF Statisic		3.9460	0.000
Critical Value	99%	2.0251	
	95%	2.2271	
	90%	2.8835	

Table B.6: GSADF Statistic for oil price-supply ratio (1920 - 1941):

	Critical Level	t-Statistic	p-value
GSADF Statisic		20.8414	0.000
Critical Value	99%	3.1018	
	95%	2.6244	
	90%	2.3995	

Table B.7: GSADF Statistic for oil price-supply ratio (1920 - 1941):

	Critical Level	t-Statistic	p-value
GSADF Statisic		1.2066	0.3680
Critical Value	99%	2.5859	
	95%	2.0408	
	90%	1.7865	

Table B.8: GSADF Statistic for oil price-supply ratio (1941 - 2014):

	Critical Level	t-Statistic	p-value
GSADF Statisic		5.4255	0.000
Critical Value	99%	2.9019	
	95%	2.2689	
	90%	2.0426	