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Are There Bubbles in the Sterling-dollar Exchange Rate?
New Evidence from Sequential ADF Tests

Timo Bettendorf
Wenjuan Chen

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Timo Bettendorf
University of Kent

Wenjuan Chen*
Freie Universität Berlin

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Abstract

There has been mixed evidence regarding the existence of rational bubbles in the foreign exchange markets. Standard unit root and cointegration tests are criticized for their low power to detect rational bubbles that periodically collapse. This paper introduces recently developed sequential unit root tests into the analysis of exchange rates bubbles. Our results show that explosiveness in the nominal Sterling-dollar exchange rates is fully explained by the relative prices of traded goods.

Keywords: exchange rates, rational bubbles, sequential unit root test
JEL classifications: C1, F3

1 Introduction

Numerous empirical studies have attempted to investigate the existence of rational bubbles in the foreign exchange market. However, results regarding the existence of rational bubbles have been mixed [1].

In empirical studies on rational bubbles in asset prices, stationarity tests are first recommended by Hamilton and Whiteman (1985) and Diba and Grossman (1988) as an indirect way to obtain evidence for rational bubbles. If asset prices are explosive while their fundamentals are nonexoplosive, it provides indirect evidence for existence of bubbles in asset prices. However, periodically collapsing bubbles can not be detected by standard unit root and cointegration tests, as asset prices with periodically collapsing bubbles look very much like an unit root process, see Evans (1991).

New tests have been created to overcome the difficulty of detecting periodically collapsing bubbles [2]. Homm and Breitung (2012) investigate several tests designed for detecting rational bubbles. They find that the sequential unit root test by Phillips, Wu, and Yu (2011) has the highest power for detecting periodically collapsing bubbles among the alternative tests.

This paper is the first that applies the sequential unit root tests to shed new light on the debate on the existence of rational bubbles in the foreign exchange rates. We have found evidence of explosive behavior in the nominal Sterling-dollar exchange rates. However, following the decomposition proposed by Engel (1999), we demonstrate that the real exchange rates in terms of traded goods are nonexplosive while the real exchanges in terms of non traded goods remain explosive. It implies that the relative prices of traded goods are the main driving factor behind the explosiveness in the nominal exchange rates between the British pound and the U.S. dollar.

The remainder of the article is organized as follows: Section 2 describes the rational bubble model of the foreign exchange rate. Section 3 briefly introduce

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[1] Meese (1986) provides significant evidence in support of the bubble hypothesis by applying the Hausmann (1978) specification test. In contrast, West (1987) applies the volatility test and finds no evidence of bubbles. Wu (1995) also rejects the existence of bubbles in the foreign exchange rate using state space analysis.

[2] For example, Hall, Psaradakis, and Sola (1999) develop a Markov switching unit root tests.

the econometric methods that we have applied. Section 4 presents the evidence on the explosiveness of the Sterling-dollar exchange rate. Section 5 summarizes.

2 Rational Bubbles in Exchange Rate Dynamics

As stated by Obstfeld and Rogoff (1996), the nominal exchange rate must be viewed as an asset price. We assume the following present value model of exchange rate in line with Leon-Ledesma and Mihailov (forthcoming):

$$s_t = \gamma \sum_{j=0}^{k} (1-\gamma)^j E_t[f_{t+j}] + (1-\gamma)^{k+1} E_t[s_{t+k+1}], \tag{1}$$

where s_t is the nominal exchange rate at time t, and f_t is the market fundamental at time period t. γ denotes the discount factor. By imposing the transversality condition

$$\lim_{k \to \infty} (1-\gamma)^k E_t[s_{t+1}] = 0,$$

we assure that the exchange rate will only depend on future expected fundamentals in the long run. However, if the transversality condition does not hold, the exchange rate may be subject to an explosive rational bubble. Assuming that the bubble follows an AR(1) process, it can be written as

$$b_t = \frac{1}{1-\gamma} b_{t-1} + \varepsilon_t, \tag{2}$$

where the first-order autoregressive coefficient $\frac{1}{1-\gamma}$ is greater than 1, as the bubble is an explosive process. Errors are captured by $\varepsilon_t \sim NID(0, \sigma^2)$. Therefore, we can write the exchange rate as

$$s_t = s_t^f + b_t, \tag{3}$$

where s_t^f denotes the fundamentals component of exchange rate and b_t represents the bubble component. We employ the purchasing power parity (PPP) fundamental

$$s_t^f = p_t - p_t^*, \tag{4}$$

where p_t the log level of the domestic price index. Asterisks are used to denote foreign counterparts. Engel (1999) points out that the relative prices of

non-traded goods hardly account for the movements of the U.S. real exchange rates. Consider a price index for a country as a weighted average of traded- and nontraded- goods prices $p_t = (1 - \alpha)p_t^T + \alpha p_t^N$. p_t^T stands for the log of the traded goods price index, and p_t^N stands for the log of the nontraded goods price index. For the foreign country, one can also write $p_t = (1 - \beta)p_t^{T*} + \beta p_t^{N*}$. Thus it follows:

$$p_t - p_t^* = p_t^T - p_t^{T*} + \alpha(p_t^N - p_t^T) - \beta(p_t^{N*} - p_t^{T*}) \tag{5}$$

Equation (5) shows that the relative price differential can be decomposed into tow components, the traded goods component, and the non-traded goods component which is a weighted difference of the relative prices of nontraded-to traded-goods prices in each country $s_t^{f,N}$:

$$s_t^f = s_t^{f,T} + s_t^{f,N} \tag{6}$$

We construct the traded goods component using the aggregate producer price indexes (PPI) as the measure of traded goods prices following Engel (1999):

$$s_t^{f,T} = ln(PPI_t) - ln(PPI_t^*) \tag{7}$$

The relative nontraded goods component is constructed from the aggregate consumer price indexes (CPI) relative to aggregate PPI:

$$s_t^{f,N} = ln(CPI_t) - ln(PPI_t) - (ln(CPI_t^*) - ln(PPI_t^*)) \tag{8}$$

In the spirit of stationarity tests proposed by Diba and Grossman (1988), existence of explosive bubbles implies explosive behavior in the asset prices. In the following section, we demonstrate how explosiveness can be detected in the Sterling-dollar exchange rates using recursive right-tailed unit root tests by Phillips, Wu, and Yu (2011) and Phillips, Shi, and Yu (2012).

3   The Sequential ADF Tests

Phillips, Wu, and Yu (2011) provide a new framework to test and date bubble phenomena in asset prices. Homm and Breitung (2012) show that this sup ADF (SADF) test is capable of detecting periodically collapsing bubbles and is

robust against multiple breaks due to a possible burst of the bubble. The test procedure is based on the autoregressive process

$$x_t = \mu + \delta x_{t-1} + \sum_{j=1}^{J} \phi_j \Delta x_{t-j} + \varepsilon_t, \qquad (9)$$

where x_t is the time series of interest, $E(\varepsilon_t) = 0$ and $E(\varepsilon_t^2) = \sigma^2$. The unit root null hypothesis is $H_0 : \delta = 1$ and the right-tailed alternative hypothesis is $H_1 : \delta > 1$.

Given a fraction r_0 of the total sample as an initial window size, Equation (9) is estimated recursively fixing the first observation as the starting the point, and using the subsets of sample data increased by one observation stepwise.

For a subsample starting from the first observation and at a fractional size of the full sample r_2, where $r_0 < r_2 \leq 1$, the corresponding ADF test statistic can be denoted by ADF_{r2}. Hence ADF_1 corresponds to the ADF test statistic of the full sample. The SADF test statistic is thus the supremum value of ADF_{r2}, for $r_0 < r_2 \leq 1$.

$$SADF(r_0) = \sup_{r_2 \in [r_0, 1]} \{ADF_{r_2}\} \qquad (10)$$

Evidence of explosive behavior is obtained on certain time series if the SADF statistic is larger than the right-side critical values for a chosen nominal size.

One limitation of the SADF test is that the starting point is fixed as the first observation. The discriminatory power of the SADF test by Phillips, Wu, and Yu (2011) could be diminished especially in the presence of multiple bubbles with periodically collapsing behavior. Phillips, Shi, and Yu (2012) extend the SADF test by changing both the starting points (r_1) and the ending points (r_2) of the sample. The generalized SADF test (GSADF) is able to detect potentially multiple bubbles in the data and thus overcomes the weakness of the SADF test.

4   Explosive Behavior in the Sterling-dollar Exchange Rates?

Our study is focuses on the bilateral exchange rates between the United States and the Great Britain. We obtained time series of the British Pound/ US dollar

exchange rates from the OECD database. The time series of the consumer price index (US) and retailer price index (UK) as well as the producer price index (PPI) are obtained from the International Financial Statistics and used for constructing the fundamentals of the exchange rates. All times series are transformed into logarithm. The data sample ranges from 1972 M1 to 2012 M6 and covers 486 monthly observations. We set the lag order to zero for all time series, because Phillips, Shi, and Yu (2012) suggest that the power of the *sup* ADF test is reduced by significance testing as in Campbell and Perron (1991).

Table 1: Tests for Explosive Behavior in the Sterling-dollar Exchange Rate

	Sample: 1972 M1-2012 M6		
Variable	ADF	SADF	GSADF
s_t	-2.478	2.128	2.416
$s_t - s_t^{f,N}$	-1.934	2.630	2.794
$s_t - s_t^{f,T}$	-1.827	0.374	1.623
CV 1%	0.614	1.984	2.860
CV 5%	-0.091	1.490	2.340
CV 10%	-0.451	1.218	2.106

This table shows the various test statistics of the nominal exchange rates s_t, the real exchange rates of nontraded goods $s_t - s_t^{f,N}$, and the real exchange rates of traded goods $s_t - s_t^{f,T}$ (see Equation (7) and Equation (8)). The initial window size r_0 is set as three years (36 observations) for the SADF and GSADF tests. Critical Values are obtained from Monte-Carlo simulations with 5000 replications for the ADF, SADF and GSADF tests.

None of the exchange rates seem to behave explosively if we only look at the ADF test statistics shown at the second column of Table 1. All three ADF test statistics are smaller than the critical values at 10% significance level. According to the right-tailed ADF test, the null hypothesis of no explosive behavior cannot be rejected. However, this result could be misleading if periodically collapsing bubbles occurred during the given period (see Evans (1991)).

The SADF and GSADF tests overcome this shortcoming and provide evidence for explosive behavior in the nominal exchange rate s_t. The null hypothesis that there is no explosive behavior in the nominal Sterling-dollar exchange rate is rejected at the 1% significance level for the SADF test, and is also re-

jected at the 5% significance level for the GSADF test. Figure (1) shows that the ADF_t statistic of the log nominal exchange-rate increases significantly in 1979 and 1985. Around both years, the British pound depreciates heavily, which leads to the question whether the Sterling-dollar exchange-rate is subject to bubbles or not.

Figure 1: The Nominal Sterling-dollar Exchange Rate
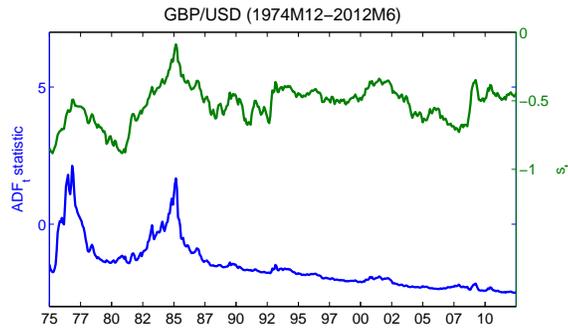
Note: This graph shows the series of the nominal Sterling dollar exchange rate s_t and its corresponding sequence of ADF statistics. The SADF critical values are reported in Table (1).

The relative prices of nontraded goods seem to play no role in the explosiveness in the nominal exchange rate, as the real exchange rate of nontraded goods $s_t - s_t^{f,N}$ remains explosive according to both the SADF and the GSADF test. Figure (2a) displays a behavior of the ADF_t statistics which is similar to the one of the nominal exchange rate.

In contrast, all the three test statistics of $s_t - s_t^{f,T}$ offer no evidence of explosiveness in the real exchange rates of traded goods. The null hypothesis that the series is nonexplosive can not be rejected at the 10% significance level for either the ADF, the SADF or the GSADF test. Figure (2b) shows this graphically. This implies that the relative prices of traded goods between the US and the Great Britain are the main driving force behind the explosive behavior in the nominal Sterling-dollar exchange rate. Consequently, we do not find evidence for bubbles in the exchange rate.

If bubbles are present, the asset prices and the fundamentals should be

Figure 2: The Real Sterling-dollar Exchange Rates

(a) The Real Exchange Rate of Non Traded Goods

GBP/USD (1974M12–2012M6)
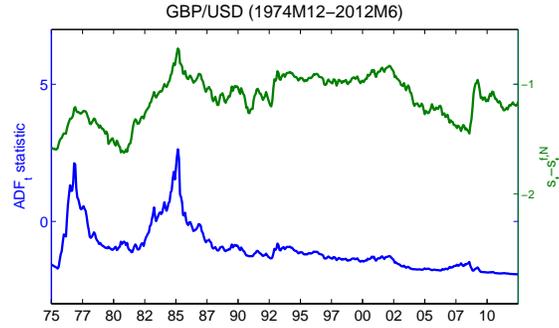
(b) The Real Exchange Rate of Traded Goods

GBP/USD (1974M12–2012M6)
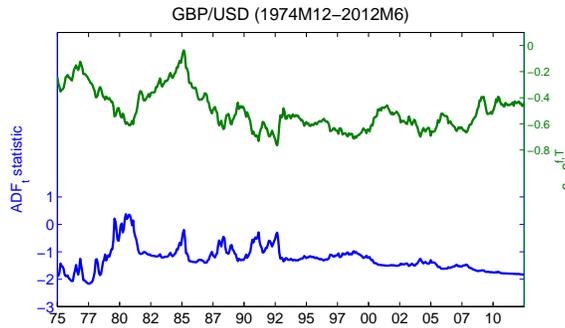
Note: The upper panel shows the series of the real exchange rate of non-traded goods $s_t - s_t^{f,N}$ and its corresponding sequence of ADF statistics. The lower panel shows the series of the real exchange rate of traded goods $s_t - s_t^{f,T}$ and its corresponding sequence of ADF statistics. The SADF critical values are reported in Table (1).

integrated of the same order according to Equation (3). The above results show that explosiveness in exchange rates disappears when the appropriate PPP fundamental is taken into account. This implies that speculative bubbles are not present in the nominal Sterling-dollar exchange rate. Our results are in line with the findings of Engel (1999) and Betts and Kehoe (2005) stating that the real exchange rate is mainly driven by the prices of traded goods.

5 Conclusion

In this paper we provide new evidence against the bubble hypothesis in the nominal Sterling-dollar exchange rates by employing recent sequential ADF tests developed by Phillips, Wu, and Yu (2011) and Phillips, Shi, and Yu (2012). Though we have found explosive behavior in the nominal exchange rates, the explosiveness is well explained by the explosive behavior in the relative prices of traded goods. In line with Engel (1999) and Betts and Kehoe (2005), our results demonstrate that the relative prices of nontraded goods play little role in the movements of exchange rates, while the relative prices of traded goods is the main driving factor behind the movements of exchange rates. Moreover, we highlighted the importance of the fundamental in this class of tests.

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