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Has the Link Between the Spot and Forward Exchange Rates Broken Down? Evidence From Rolling Cointegration Tests

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Has the link between the spot and forward exchange rates broken down?: Evidence from rolling cointegration tests

by

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and

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Abstract

In a recent survey, Engel (1996) reported conflicting results about the cointegration relationship between the spot and forward exchange rates. Applying rolling cointegration tests to the mark, yen, and Swiss franc with respect to the U.S. dollar for the post-80 period, we find that the relationship between the two rates broke down in the late 1980s. Although they became cointegrated again during the mid-90s, they no longer co-moved proportionally, however. It is argued that failure to account for such significant structural changes in the data generating process may explain the conflicting findings in the literature.

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I. Introduction

The relationship between spot and forward exchange rates has been studied from different angels. The literature has produced puzzling results over many related issues, however. One such conflicting finding has been about the cointegration relationship between the spot (s_t) and forward (f_t) exchange rates. In a recent survey, Engel (1996) summarized the accumulated evidence about the tests for stationarity and cointegration of s_t and f_t, and s_{t+1} and f_t as follows: "… Some have found $s_t - f_t$ is I(0); some have found it is I(1); some have found it is fractionally integrated. Some have found s_{t+1} and f_t are cointegrated with cointegrating vector [1,-1]; some have found they are cointegrating but not with cointegrating vector [1,-1]; some have found they are not cointegrated " (p. 141). Engel offered two reasons for the contrary findings: (1) different sample periods and/or (2) different properties of the various test statistics employed.

This paper focuses on the first explanation and tests the validity of Engle's proposition that different sample periods employed in previous studies may, in part, explain the inconsistent results. This is achieved by using rolling cointegration procedures to search for time periods during which the link between the spot and forward rates may be quite strong and those during which the relationship tends to break down. Indeed, an important shortcoming of previous empirical studies has been to utilize techniques that do not allow for potential changes in the data-generating process linking spot and forward rates over time. We argue that changes in such a process, due to a policy change, currency crises, and other exogenous factors, may cause persistent deviations from a long-run equilibrium and hence may explain the inconsistent findings. In such cases, an appropriate examination of the link requires using time-varying procedures, such as rolling or recursive techniques that capture the changes in the data-generating process (Rangvid and Sørenson, 2000).

This paper proposes to utilize the rolling cointegration procedures based on Hansen and Johansen (1999) and Rangvid and Sørensen (2000). For our purposes, these tests appear to be more appropriate than alternative recursive estimation procedures. In the rolling tests, the sample size is kept the same, but the sample period is allowed to change (Rangvid and Sørensen, 2000). When the sample period changes with each rolling-estimation, the observed test statistics at every stage reflects the variation in the degree of cointegration relationship due to new information. The recursive tests gradually add more observations into the sample and therefore do not allow us to differentiate whether the varying test statistics are due to a change in the extent of cointegration relationship or a result of increasing power of the tests along with the increasing number of observations.

This paper is organized as follows. The next section provides a discussion of the rolling approach employed. Section III describes the data employed and presents our empirical results. Section IV concludes.

II. Rolling Cointegration Tests

Cointegration analysis has been extensively applied to test the long-run equilibrium relationships among nonstationary economic variables. The time series of several variables, X_t, are cointegrated if these variables are individually nonstationary but there exists at least one linear combination of them, $Z_t = b'X_t$, that is stationary. The vector b is referred to as the cointegrating vector. Such cointegrated variables do not drift far apart. They tend to move together in the long run. However, the extent of cointegration may change over time as individual parameters in b or the stochastic properties of the underlying data-generating process (DGP) of X_t are changing. In this case, traditional tests for the presence of cointegration over the entire sample period would tend to reject the hypothesis that the series are cointegrated. To deal with this possibility of time-varying cointegration, we use rolling cointegration, a technique that explicitly allows for changes in the relationship among a system of variables.[1] Both the cointegration rank tests of Johansen (1994) as well as the augmented Dickey-Fuller (ADF) tests are employed to investigate the co-movements of s_t and f_t during different sub-sample periods of the full sample.[2]

The Johansen (1994) tests use the following vector autoregressive (VAR) system:

$$\Delta X_t = \sum_{j-1}^{k-1} \Gamma_i \, \Delta X_{t-j} + \Pi \, X_{t-1} + m_0 + m_1 t + \in_t , \tag{1}$$

where X_t is a vector of n variables, m_0 is a constant term, and $\in_t$ is a vector of independent Gaussian variables with mean zero and variance matrix Σ. The relevant hypotheses have to do with Π; if the rank of Π is r, where $r \leq n$-1, then r is called the cointegration rank. By including m_0 and $m_1 t$ in the model of ΔX_t, equation (1) allows a linear time trend and a quadratic trend to be present in the DGP of X_t. It is the least restrictive version of the Johansen tests for the specification of the deterministic components in the variables. Johansen (1994) has developed trace tests to examine the rank of cointegration of X_t and derived the asymptotic distributions of the trace test statistics with the critical values presented in Osterwald-Lenum (1992). For a system of two nonstationary variables, $X_t = [f_t, s_t]'$, the rejection of the null hypothesis of no cointegration indicates that there is a common stochastic trend driving the movements of the forward and spot rates.

If the forward and spot rates are cointegrated with a cointegrating vector $b' = [b_f, b_s] = [1, -1]$, the difference of the two rates is stationary. Imposing $X_t = [1, -1]\,[f_t, s_t]' = f_t - s_t$ and $\Pi X_{t-1} = a\,[1, -1]\,[f_{t-1}, s_{t-1}]'$ into equation (1), it becomes a typical equation for the well-known ADF tests with the t_a test statistic for the null hypothesis of nonstationarity and the lag length being k -1. Therefore, applying the ADF tests to the difference of f_t and s_t to directly examine the stationarity of the forward premium, $f_t - s_t$, allows us to test the joint hypotheses that not only are the spot and forward rates cointegrated, but also the two co-move proportionally over time.

The rolling cointegration tests are conducted by setting $k = 14$ for weekly data and rolling 5-year sub-samples, using $T + k$ observations with the effective number of observations $T = 260$, through the full sample.[3] The first test statistic was obtained by using a total of 260 + k observations from the beginning of the sample period through to the 274th observation, for example, the first week of 1980 - the 14th week of 1985. The next test statistic was obtained by using data from the second observation through to the 275th observation, and so on, until the last observation was used.

III. Data and Empirical Results

Weekly data of the spot and forward exchange rates of three industrial countries, namely, Germany, Japan, and Switzerland, against the U.S. dollar are constructed from daily data for the period January 1980 - June 1998. We use these currencies because they are heavily utilized in earlier studies (Engel, 1996). The end-of-week day is selected as the day of the week. s_t and f_t are the logarithms of the average of London bid/offer spot exchange rates and one-month forward rates, respectively, specified in terms of units of foreign currency with respect to the U.S. dollar.

Figure 1 reports the rolling Johansen tests and ADF tests with the 1980-85 period utilized for initial estimates.[4] Because the sample size is relatively small, the asymptotic critical values of the Johansen trace test are adjusted by a factor of $T/(T - nk)$, as suggested by Reinsel and Ahn (1992),[5] while the critical values of the ADF tests are adjusted based on MacKinnon (1991). The test statistics obtained from the rolling cointegration tests are scaled by the adjusted 5% critical values and plotted in Figure 1. Values greater than 1 in the plot indicate rejection of the null hypothesis of no cointegration for the Johansen tests or the null of nonstationarity for the ADF tests at the 5% significance level.

A. Rolling Johansen tests: Are s_t and f_t cointegrated?

The results indicate strong evidence for a time-varying link between the spot and forward rates. The strongest cointegration between f_t and s_t occurred in the early and mid-1980s periods across all currencies, indicating that the two series were driven by common shocks with permanent effects during this time period. The degree of co-movement of the spot and forward rates started declining around 1987-1988, however. The hypothesis of no cointegration between the spot and forward rates cannot be rejected for the late-1980s till early 1990s for all currencies, suggesting that the two series were not subject to common shocks anymore as they started drifting apart from each other. There are signs that f_t and s_t of Swiss franc tended to co-move again in the 1991-92 but quickly moved away in 1993 till 1995. The co-movement pattern of f_t and s_t seems to have been re-established in the mid-1990s for the dollar exchange rates of all three currencies.

B. Rolling ADF tests: Are s_t and f_t cointegrated with a cointegrating vector [1, -1]?

Here we offer tests for the proportionality of cointegration relationship to test whether the spot and forward rates are cointegrated with cointegrating vector [1,-1]. The test statistics of the rolling ADF test, applied to $f_t - s_t$, in Figure 1 show evidence of rejecting the null of nonstationarity for the early period for all three forward premia, indicating significant cointegration between the forward and spot rates with a [1, -1] cointegrating vector for this period. Following the period of late 1980s, there is almost no evidence that the spot and forward rates move together *proportionally*.

Comparing the results of the rolling Johansen tests with that of the rolling ADF tests, we infer that for all three currencies the spot and forward rates co-move proportionally during the earlier period from 1980 to 1987. Such proportional co-movements of the two rates disappeared since 1988, however. Even when the spot and forward rates tend to co-move again in the mid-1990s, they no longer move together proportionally over time.

Our results clearly demonstrate that the observed time-varying link between the spot and forward rates in Figure 1 has contributed to the reported conflicting findings in the literature regarding stationarity of f_t - s_t and cointegration of s_t and f_t. Our evidence coincides with the sensitivity of the findings in the earlier studies to the sample period employed, supporting Engel's proposition. The results of the earlier studies were dependent on whether their sample includes the data of the 1990s during which we find that the proportional link between s_t and f_t broke down. For example, when the sample period ends at the late 1980s, Horvath and Watson (1995) and Hai et al. (1997) either rejected the nonstationarity of the forward premium or found that the spot and forward rates are cointegrated with a [1, -1] cointegrating vector. On the other hand, when the sample period is extended to the 1990s, the studies often rejected the null of stationarity of the forward premium or cannot reject the null of nonstationarity of the forward premium (see Baillie and Bollerslev, 1994, and Newbold et al., 1998).

An important lesson for future studies is that they need to account for potential changes in the nature of the shocks driving the dynamic process of the spot and forward rates in order to produce more reliable results. Although the identification of the sources of such breaks is beyond the scope of this paper, we offer some suggestions. One is the change in the operating procedures of the Federal Reserve in the late 1980s. During that period, the Fed gradually moved away from reserves targeting back to the interest-rate targeting procedure (Urich and Wachtel, 2001).[6] Another source of break may come from large differences in the monetary policies of the Fed and Bundesbank and other former EMS central banks in the 1990s.[7] The former might account for the break we observed in Figure 1 in the relation between spot and forward rates in the late 1980s, and both may contribute to the broken-link between the two rates in the 1990s.

IV. Conclusions

This paper has used time-varying rolling cointegration tests to re-examine the dynamics of the spot and forward exchange rates for the mark, yen, and Swiss franc with respect to the U.S. dollar for the post-80 period. We have found that the cointegration relationship between the spot and forward exchange rates broke down starting in the late 1980s. Although the two rates tended to move together again during the mid-90s, they no longer co-moved proportionally over time. Researchers using different sample periods during the post-80 period have thus found contrary findings depending on what sample period they employed.

Our findings, which provide empirical support for Engel's proposition, show that changes in the data generating process can, at least partially, account for the sensitivity of results to using different sample periods. An important lesson for future studies is that researchers need to identify and account for potential changes in the process linking the spot and forward rates to produce more reliable and consistent results.

Endnotes

1. Specifically, we apply the techniques developed by Hansen and Johansen (1999) and Rangvid and Sørensen (2000). For applications of these techniques to other settings, see Rangvid (2001).

2. Note that cointegration between s_t and f_t implies cointegration between s_{t+1} and f_t, as shown in Zivot (2000, p. 785).

3. It is found that the residuals from the models with k = 14 are not significantly serially correlated.

4. We do not apply the unit root tests to examine the order of integration (nonstationarity) for individual variables, because there is overwhelming evidence that the logarithms of the dollar exchange rates of mark, yen, and Swiss franc are integrated of order one.

5. Using a bootstrapping technique, van Giersbergen (1996) shows that the asymptotic critical values of the Johansen tests adjusted by such a factor fit the finite-sample studies quite well.

6. We argue that under a reserves targeting procedure, U.S. interest rates and price level would respond relatively quickly to a change in U.S. monetary policy and thus adjust fast to restore equilibrium based on covered interest rate parity, generating mean-reversion (stationarity) in the forward premium. On the other hand, under an interest rate targeting procedure, the Fed may prevent the U.S. rate from reverting to its mean. The adjustment toward the new equilibrium takes place mainly through the changes in foreign interest rates. A sluggish or incomplete foreign reaction to the U.S. policy changes would cause lasting changes in the differentials between foreign and U.S. interest rates and in the forward premium, thus creating persistent deviations from the long run relationship between spot and forward rates.

7. Because of different economic conditions associated with German reunification in 1990 and the European currency crisis in 1992-94, and/or because of their focus upon meeting the criteria of the Maastricht Treaty to qualify for European Monetary Union, the interest rates of many European countries depart substantially from the U.S. rate in the first half of the 1990s. According to covered interest rate parity, such large and persistent interest rate differentials are consistent with the nonstationary behavior of the forward premia in the 1990s.

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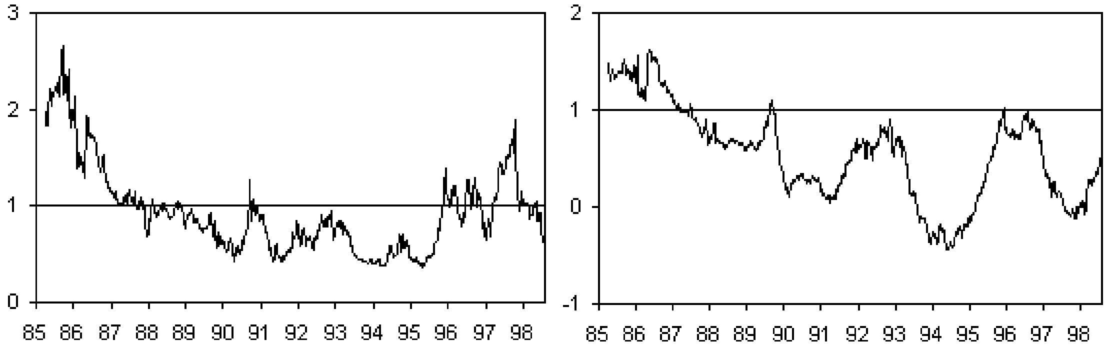
Figure 1. Rolling Johansen and ADF Tests with Weekly Data (Window size = 5 years)

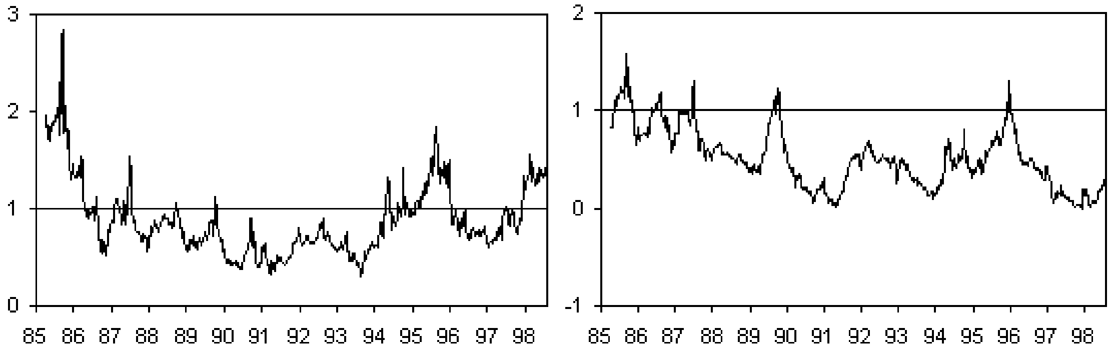
The figures show rolling Johansen and ADF test statistics, trace and t_{α}, respectively, scaled by their 5% critical values adjusted by the degrees of freedom. Values greater than 1 in the plot indicate rejection of the null hypothesis of no cointegration for the Johansen test or the null of nonstationarity for the ADF test at the 5% significance level.

Johansen test ADF

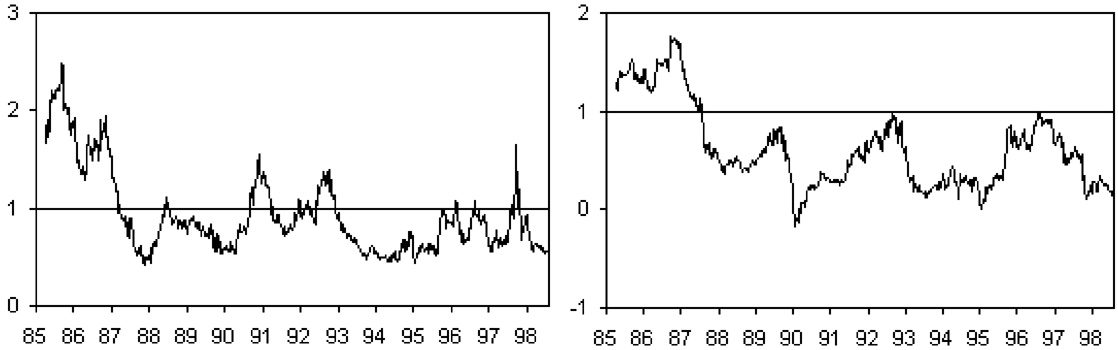
Germany



Japan



Switzerland



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