FURTHER EVIDENCE ON IMPLICIT BANDS IN THE YEN/DOLLAR EXCHANGE RATE*

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Abstract

This paper attempts to identify implicit exchange rate regimes for the Yen/Dollar exchange rate. To that end, we apply a sequential procedure that considers both the dynamics of exchange rates and central bank interventions to data covering the period from 1971 to 2003. Our results would suggest that implicit bands existed in two subperiods: April-December 1980 and March-December 1987, the latter coinciding with the Louvre Accord. Furthermore, the study of the credibility of such implicit bands indicates the high degree of confidence attributed by economic agents to the evolution of the Yen/Dollar exchange rate within the detected implicit band rate, thus lending further support to the relevance of such implicit bands.

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1. Introduction

The *de facto* exchange rate policy adopted by monetary authorities has tended to differ from the announced *de jure* exchange rate regime, which is why IMF classifications are not always a good guide to the true exchange rate intentions of said authorities.

The new literature in this area seeks to achieve two linked objectives, namely, to detect divergences between *de jure* and *de facto* regimes and to assess the consequences of these differences on the relevance of exchange rates for macroeconomic performance[1]. Recognition of the divergences opens up a number of key questions regarding the analysis and recommendations of international economic organizations as well as for academic work: which is the correct classification and which variables and methods should be considered for this purpose?

Recently, Reinhart and Rogoff (2004) have presented a comprehensive classification of the exchange rate regimes of 153 countries over the last half-century. Their research suggests the importance of *de facto* bands in the international economy. Other approaches focus on the variation of central bank reserves and acknowledge the relevance of intervention in detecting implicit pegs and bands (see, for instance, Poirson, 2001).

The main objective of this paper is to use a sequential procedure that considers both the dynamics of exchange rates and central bank interventions to detect implicit bands for the Yen/Dollar exchange rate.

We analyse the Yen/Dollar exchange rate as a interesting case study since it has traditionally been considered a paradigmatic example of a flexible exchange rate (see e.g. Cooper, 1999). Notwithstanding the customary consideration of the Yen/Dollar exchange rate as free-floating, a number of studies have examined the behaviour of the US Federal Reserve (Fed) and the Japanese monetary authorities in exchange rate markets and the effectiveness of such intervention in driving the Yen/Dollar exchange rate[2].

This paper is organized as follows. To place the study in its proper context, Section 2 presents a brief history of exchange rate regimes. In Section 3, we apply the statistical procedure suggested by Reinhart and Rogoff (2004) to detect implicit bands and analyse its sensitivity; moreover, we propose a test to assess the statistical significance of the outcome of the Reinhart-Rogoff classifying algorithm. In addition, we apply two tests to interventions and to exchange rate data to assess both the intention and the efficacy of foreign exchange market interventions. Section 4 examines the credibility of the implicit bands suggested in Section 3. Finally, Section 5 provides some concluding remarks.

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[1] See Coudert and Dubert (2004) for a survey of studies on implicit exchange rate regimes. Reinhart and Rogoff (2004) examine the relevance of the exchange rate regime classifications for empirical macroeconomics.

[2] For example, Ito and Yabu (2004) and Frenkel *et al.* (2004) estimate the Japanese monetary authorities' reaction function.

2. Exchange rate regimes

The relationship between a country's exchange rate regime and its macroeconomic performance has been discussed extensively ever since the collapse of the Bretton Woods system. After the prolonged period of fixed exchange rates which characterized the system, many anticipated a generalisation of more flexible regimes in the belief that these were better equipped to protect the economy from real and monetary shocks. Instead, however, in several countries the monetary authorities pegged the external value of their currencies to the Dollar, the Yen, the Pound Sterling, or to a basket of currencies[3], believing that greater exchange rate flexibility led to excessive fluctuations. Such volatility was considered to originate economic instability, having a negative impact on productive investment, international trade and growth.

During the 1980s, monetary authorities adopted their exchange rate regimes with the clear intention of seeking a sound stabilisation instrument to protect against real and monetary shocks. In particular, they expected that fixing the exchange rate would prevent excessive monetary growth, thus conferring greater discipline on public spending (Levy-Yeyati and Sturzenegger, 2001). The widespread monetary instability experienced during the period called for disinflation and budget consolidation policies and it was no surprise that monetary considerations attracted more attention.

The series of crises in the 1990s led many to once again question the appropriateness of pegged exchange rates. More flexible systems were now considered more adequate than their fixed counterparts as a means of protection against speculative pressures. This change in perspective stemmed from the growing importance of movements of private capital between countries, a circumstance which had a profound impact on the international financial system. The crises experienced during these years centred on the evolution of the capital account, in contrast to the previous decades, when more traditional causes –high fiscal deficits and the ensuing monetisation, distortions in goods and services markets, as well as production market factors, among others- were paramount (Summers, 2000).

In this context, this paper aims to study the exchange rate regimes followed by the Yen/Dollar exchange rate. The monetary and trade relationships between Japan and US have been difficult in different periods of their recent history. The monetary policy pursued by the Federal Reserve seems to have been quite independent while the Japanese monetary policy appears instead to have been conditioned by the appreciating trend of the Yen with respect to the Dollar (Glick and Hutchinson, 1994). This trend may explain the differences between Japan and US since 1971 in trade policy and the financial pressures due to the accumulation of external surpluses. The observed appreciation of the Yen and the expectations of further appreciations might be reasons for the deflationary monetary policy of Japan at the end of the seventies.

Before the fall of Bretton-Woods, the sensible appreciation of the Yen implied a better competitiveness of US industrial goods. As a response, the Bank of Japan reduced the short-term interest rates in order to switch this trend. The Japanese economy entered in an unstable period due to both the depreciation and expectations of depreciation of

[3] Yoshino *el al.* (2004) note that a basket–peg with trade weights will generally not be the optimum choice for a small, open economy.

the Yen and the increasing risk derived from the accumulation of assets denominated in dollars by the Japanese financial institutions.

In the 1990s the Japanese economy seemed to be in a liquidity trap externally imposed. Economists and practitioners alike were unable to identify the true origins of the crisis, in which consumption and investment were weakened; in fact, this is one of the most important failures of modern macroeconomics (McKinnon, 2000). In this period, Japan suffered high rates of unemployment and deflation, low growth, and it has been considered "a lost decade" by Hiyashi and Prescott (2002).

The choice of exchange rate regime every country has to make has also centred empirical discussion on the appropriate estimation of the economic costs and benefits of the different systems. A difficulty that often arises concerns the wide range of possibilities, since there are more than two extremes (in contrast to the approach taken in the numerous studies which naturally employed the official IMF classification). Rather, countries use a range of regimes, such as currency boards, narrow bands, moving or crawling bands and managed floats.

To all these should be added another difficulty which has come to light more recently: many countries do not declare the true system used. The exchange rate policy followed *de facto* by numerous countries has been found to be vastly different to what was officially notified to the IMF by the economic authorities. Many countries experience what Calvo and Reinhart (2002) and Reinhart (2000) have called the "fear of floating", namely, they do not really allow their exchange rates to move freely, regardless of the *de jure* exchange rate system reported by the authorities to the IMF.

One of the consequences of this divergence between "deeds" and "words" (Levy-Yeyati and Sturzeneger, 2000; 2001) has been to call into question the results of various empirical studies based on the IMF classification. For this reason, before proceeding any further with an evaluation of the different exchange rate regimes, a classification of the *de facto* systems is needed to replace the *de jure* systems used until recently by researchers in the field of International Economics.

One of the aims of this paper is to identify implicit band or peg regimes. Specifically, we examine the possible existence of fluctuation bands, "agreed" by the monetary authorities in order to intervene in the Yen/Dollar market during the period 1971-2003. In this regard, Fischer (2001), for example, has pointed to the possibility that a commitment to maintain a desired exchange rate target zone between the US Dollar, the Euro (the Deutsche Mark previously) and the Yen may have existed, albeit informally and loosely.

According to the literature on optimum exchange rate regime, the most appropriate regime may vary in each circumstance, attending to the nature of the kind of disequilibria suffered by an economy, the capacity to transmit or isolate from internal or external shocks, and the ability of economic authorities to use different instruments of economic policy (see, for instance, Horvath, 2003). The observed exchange rate system might be related to concrete episodes and the economic policy used as a response. This literature may provide a good guide to interpret the *de facto* deviations from the *de jure* exchange rate regime. In this sense, flexible exchange rates could be preferable when real shocks, both domestic and external, occur while fixed regimes seems to perform better when shocks are merely nominal (Buiter, 1995). A smaller degree of trade openness reduces the possible damage done to price stability and to the external balance of a country due to exchange rate variability (McKinnon, 1963). Also a small product diversification increases the likelihood of asymmetric shocks and so the need for exchange rate flexibility (Kenen, 1969), and it is more difficult to fix the exchange rate if both inflation rates are quite dissimilar and prices and wages are sticky (Fleming, 1971). Lastly, pegging the exchange rate can provide a reasonably credible commitment to a non-inflationary policy but, as indicated by Stockman (1999), there are alternative institutional arrangements that have shown a better performance.

3. Implicit bands

3.1. Detection of implicit bands

Reinhart and Rogoff (2004) proposed a "natural" classification of exchange rate regimes, as opposed to the "artificial" one followed by the IMF. In their extensive research they collected monthly data on the exchange rates of 153 countries from 1946 to 2001, highlighting the existence of dual, multiple, or even parallel (legally or otherwise) rates. In the event of the absence of a dual market to adequately classify the *de facto* regimes, their approach based the search for peg or band regimes on the proportional variation of the absolute value of the exchange rate, as well as on the probability that it would remain within a given fluctuation band (±1%, ±2% or ±5%) over a rolling 2 or 5-year period. Reinhart and Rogoff (2004), somewhat surprisingly, focus on the evolution of exchange rates, without taking into account variations in official foreign currency reserves.

They accept the existence of a *de facto* pegged system if, during at least four consecutive months, no variation is seen in the exchange rate. They then calculate the probability that the monthly variation remained within ±1% over a rolling 5-year period. If the probability is at least 80%, the regime is labelled a *de facto* peg or crawling peg during said years. If the exchange rate does not show drift, it is classified as a fixed parity. If a positive drift is observed, it is identified as a crawling peg while if the rate undergoes periods of both appreciation and depreciation it is deemed to be a moving peg.

In the case of pre-announced and *de facto* bands, Reinhart and Rogoff (2004) follow a similar two-step process also, although here the limit for the monthly variation is ±2% as opposed to ±1%. If a band was announced by the authorities and a dual or parallel market did not exist, the authors accept the existence of bands, except where it was found previously to be a *de facto* peg. They also verify whether the *de jure* (announced) and the *de facto* bands coincide, since the former tend to be conisderably wider. The authors then calculate the probability that the monthly exchange rate variation remains within a ±2% band over a rolling 5-year period. If the probability is 80% or above, the system is labelled a *de facto* narrow band, narrow crawling or moving band for the period during which it remains continuously above 80%. Where the limits to the announced fluctuation are wide, they also test ±5% bands.

Among the most interesting results obtained by Reinhart and Rogoff (2004), pegs are found to account for 33% of observations during the period 1970-2001, while crawling pegs or narrow crawling bands account for over 26% of the sample.

We have applied this same procedure to the Yen/Dollar exchange rate. Figure 1 gives the results obtained by calculating the monthly proportion of the 24 previous months during which the percentage monthly variation in the exchange rate is less than ±1%. The proportion is close to 80% in the early phases of the sample period (i.e. the final Bretton Woods years and just after the system was abandoned).

[Figure 1, here]

The same procedure is followed in Figure 2, although here a fluctuation band of ±2% is considered. Taking again a threshold of 80%, the procedure more clearly suggests the existence of bands in 1971 and 1972, as well as during the period from the second quarter of 1974 to the first quarter of 1978. Our results coincide with those obtained by Reinhart and Rogoff (2004).

[Figure 2, here]

3.2. Taking into account the statistical significance

One of the weaknesses of the approach taken by Reinhart and Rogoff (2004) is that the results are not filtered by their statistical significance. For this reason we perform a test in which the null hypothesis is that the probability of the exchange rate variation remaining within a ±1 or ±2% fluctuation band during a rolling period of two years will be less than or equal to the above-mentioned threshold of 0.8.

Formally, we test if the population proportion is less than or equal to a given frequency, p_0, and we can thus establish whether bands are absent, as follows:

$$\begin{matrix} H_0 : p \leq p_0 \\ H_1 : p > p_0 \end{matrix}$$, where p_0 is the determined probability.

The acceptance region of the null hypothesis is: $\hat{p} \leq \varepsilon$, where $\hat{p}$ is the estimated sample proportion and $\varepsilon = p_0 + t_{1-\alpha,n-1} \frac{\sqrt{p_0 q_0}}{\sqrt{n}}$, where $t_{1-\alpha,n-1}$ is the critical value of the t-Student distribution at a confidence level of $1-\alpha$, q_0 is $1-p_0$, $\frac{\sqrt{p_0 q_0}}{\sqrt{n}}$ is the population deviation and n the sample size.

The results of this test do not allow us to reject the null hypothesis of absence of bands over the entire sample period, when a ±1% width is considered, although Reinhart and Rogoff suggest they are present following the end of the Bretton Woods system. Using ±2%, the null hypothesis is rejected only in the second quarters of 1974 and 1976, which would suggest that bands are present. Thus, a considerably shorter period is detected by a strict application of the procedure used by the aforementioned authors.

3.3. A variant of the Reinhart and Rogoff approach

An alternative approach to detect implicit pegs or bands involves direct testing to see whether the average of the proportional absolute monthly variations for each rolling 24-month period is significantly less than ±1% or ±2%. To test if the population mean (of the monthly variations during 24-month periods) is less than or equal to a given mean μ_0 (±1% or ±2%) the following expression may be used:

$$\begin{matrix} H_0 : \mu \le \mu_0 \\ H_1 : \mu > \mu_0 \end{matrix}, \text{ where } \mu_0 \text{ is the given mean.}$$

The acceptance region of the null hypothesis is $\bar{x} \le \varepsilon$, where $\bar{x}$ is the sample mean of the Yen/Dollar exchange rate and $\varepsilon = \mu + t_{1-\alpha,n-1} \frac{\sigma}{\sqrt{n}}$, where $t_{1-\alpha,n-1}$ is the critical value of the t-Student distribution at a confidence level of $1-\alpha$, σ is the serial population deviation and n is the sample size. At a 5% confidence level we choose a critical value of 1.71.

The results of the application of this statistical procedure, which avoids the need to count the periods previously, as Reinhart and Rogoff do, are given in Figures 3 and 4.

[Figure 3, here]

Figure 3 shows the results when ±1% fluctuation bands are considered. The average value (24 months rolling) of absolute proportional variations of the exchange rate of each month with respect to the previous month is given in blue, while the critical region appears in red. Thus, when the red series is above the blue one the null hypothesis cannot be rejected, which would suggest the presence of fluctuation bands. This occurs around the Bretton Woods period but extends until the end of 1977. With respect to the first years of the 1970s, any observer could argue that the Japanese economy was suffering a real shock due to the increase of the crude oil prices, and therefore the convenience of a flexible exchange rate. However such shock only had a temporary impact due to the rapid response of the Bank of Japan (Meltzer, 1986) --- quite different from the more permanent character of the monetary shock produced at the end of the Bretton Woods system (Hetzel, 2004); in this sense its temporary character would have made more appropriate a *de facto* exchange rate. Furthermore, the small size of the Japanese economy compared to the US, its lesser diversification of production, and its continuous external surplus could explain why the Japanese monetary authorities optimally chose less flexibility for their exchange rate, as suggested by Aghion *et al.* (1999) and Bachetta (2000).

Likewise, between 1983 and 1985, between 1995 and 1997, and at the end of the sample period the results indicate that the regime was in the band neighbourhood. In 2003, the Japanese economy was in a deep deflationary process, aggravated by a zero interest rate policy (Ito and Mishkin, 2004). Svensson (2003) pointed out that the Bank of Japan felt the need to make a commitment of maintaining a level of the exchange rate compatible with the objective of affecting agent expectations. This non-conventional monetary policy and the fact that the deflation had an origin in a domestic monetary shock (Metzler, 2002) could explain the smaller *de facto* flexibility of the exchange rate in 2003.

[Figure 4, here]

As can be seen in Figure 4, the average of the monthly variations generally lies below the critical region when a ±2% fluctuation band is used, suggesting (given the rolling quality of the 24-month test) that in practical terms there were monthly limits of ±2% during the entire period. Combining this result with that observed with the ±1% bands, we can be confident that fluctuation bands between ±1% and ±2% existed throughout the sample period, except during the three subperiods detected with the ±1% test, when the bands were narrower.

3.4. Incorporating interventions

In this section we incorporate interventions into the search for bands in the Yen/Dollar exchange rate. In the previous section different periods of *de facto* bands or pegs were identified from different approaches based on exchange rate data, which suggests that the results obtained using the Reinhart and Rogoff approach are not robust. Most of the literature that classifies exchange rate regimes also uses exchange rate data or a combination of foreign reserve and exchange rate data. Such analysis either has not taken into account central bank interventions or has used an imperfect proxy for these to detect periods with exchange rate regimes other than a free floating regime[4]. An ideal method should, however, consider interventions in foreign markets to screen both for the intentions of central banks and their efficacy with regard to peg or band regimes[5].

In spite of its relevance, the availability of intervention data limits its consideration. Here we use Federal Reserve intervention data from 1 January 1980 to 31 December 2003, and data from the Japanese Ministry of Finance between 13 May 1991 and 31 March 2001. We consider that the intervention has a positive sign when the monetary authority buys US dollars, and negative otherwise.

The Pesaran and Timmermann (1992) test is used as a directional prediction test of change. In the test the sign of central bank intervention and the exchange rate trend are related, particularly when lagged interventions (to measure efficacy) and leads (to detect the monetary authorities' intention to maintain bands or pegs) are considered relative to the exchange rate trend. In the first case one would expect the *ex ante* intervention consisting of the purchase of Yens to be followed by an appreciation of the Yen. In the second case the *ex post* intervention is considered once the trend has been observed, assuming that the intervention is of the *leaning against the wind* type: a depreciation of the Yen should normally be followed by Yen purchases[6].

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4 Neely (2000) has shown that central bank interventions and reserve changes may be loosely related. Therefore, the use of reserves instead of interventions may lead to inadequate classifications.

5 We study the incidence of interventions at the exchange rate level. For a survey of the literature analyzing the effect of interventions on the volatility of exchange rates, see Domínguez (1993, 2003).

6 We adopt this approach because standard time-series techniques may not be appropriate when dealing with the study of interventions and the associated behaviour of exchange rates. Exchange rates are highly volatile and interventions are usually sporadic (Fatum and Hutchison, 2003, 2005). In contrast, Frenkel *et al.* (2004) estimate a reaction function for sterilised interventions by the Japanese monetary authorities and find major interventions after 1995 in reaction to the previous exchange rate trend.

The test is applied to daily exchange rate and intervention data and calculated for monthly periods (i. e., the frequencies needed to construct the statistic is obtained for each month of the sample period)[7]. The sign of the exchange rate trend is measured by the difference between the current value s_t and the previous value s_{t-k}, where k=1,5,10,20,30,40,60[8].

The Pesaran and Timmermann (*DA*, 1992) test is a directional prediction test of changes under the null hypothesis that the actual and predicted values are independent.

The distribution of the *DA* statistic is *N*(0,1), which has the following structure: $DA = [\text{var}(SR) - \text{var}(SRI)]^{-0.5}(SR - SRI)$, where $SR = H^{-1}\sum_{h=1}^{H} I_h[y_h . \hat{y}_h > 0]$ and $SRI = p_1\hat{p}_1 + (1-p_1)(1-\hat{p}_1)$, *SRI* being the success ratio in the case of independence between actual and predicted values under the null hypothesis. The other elements are: $p_1 = H^{-1}\sum_{h=1}^{H} I_h[y_h > 0]$, $\hat{p}_1 = H^{-1}\sum_{h=1}^{H} I_h[\hat{y}_h > 0]$, $\text{var}(SR) = H^{-1}[SRI(1-SRI)]$ and $\text{var}(SRI) = H^{-2}\left[H(2\hat{p}_1 - 1)^2 p_1(1-p_1) + (2p_1 - 1)^2 \hat{p}_1(1-\hat{p}_1) + 4p_1\hat{p}_1(1-p_1)(1-\hat{p}_1)\right]$.

In the case of *ex post* interventions, the actual values are the exchange rate trends and the predicted values are the signs of the interventions. The contrary is true when *ex ante* interventions are considered. The description of this application is presented in Table 1.

[Table 1, here]

For the analysis of the intention of the monetary authorities (ex-ante interventions) the description of each variable and function of the test is presented in the second and third column. The analysis of the efficacy is explained in the forth and the fifth column.

[Table 2, here]

The results for the interventions by the Federal Reserve are reported in Table 2. Panel A suggests that the Fed showed willingness to maintain the exchange rate only in specific subperiods. In particular, the Pesaran-Timmermann test indicates the years 1980 (coinciding with explicit commitments by the US and Japanese economic authorities) and 1987 (when the Louvre Accord was signed to stabilize exchange rates) for most of the values of *k*. In the rest of the sample period the null hypothesis of independence is not rejected.

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[7] To calculate these frequencies we only consider the number of days during a given month in which the monetary authority intervened.

[8] In order to assess the robustness of results, we additionally apply the Fisher's Exact Test. This test of independence (for 2x2 tables) is used when the members of two independent groups can fall into one of two mutually-exclusive categories. In our case, each day in a given month can fall into one of two categorical variables: the sign of the exchange rate trend and the sign of the intervention. The former may give two levels (appreciation or depreciation of the Yen) while the latter indicates the purchase or sale of Yens. The results confirm those obtained from the Pesaran-Timmermann test. Again, the results for Japanese interventions are less informative and the independence hypothesis could not be rejected for the whole sample period.

These conclusions can be confirmed in Panel B, where the efficacy of the interventions is analysed. For several months in 1980, as well as August 1987, the interventions appear to have been effective[9].

Although Japan is by far the largest participant government in the foreign exchange market (see Fatum and Hutchison, 2005), the analysis of Japanese interventions was restricted by the availability of data (from March 1991 only). Though quite weak in April and August 1992, which might signal dependence, in general the results do not seem to reject the hypothesis of independence[10]. With respect to the results for 1987 and Federal Reserve, from 1987 up to 1992, the Japanese monetary policy was conditioned by the Louvre Accord. In this sense, it is interesting to recall that large-scale, coordinated interventions, as those implied by the Louvre Accord, have seemed to be very successful, as documented in Fatum and Hutchinson (2005) and Huang and Neum (2006). Indeed, the Bank of Japan recognized the relevance of the stabilisation of the exchange rate, as its monetary policy was based in the reduction of short-run interest rates as a response to the external surplus and the appreciation of the Yen. This policy accelerated the increase of the asset prices until the collapse of the bubble. In fact, Hetzel (2004) pointed out that the initial shock had a monetary character. In addition, Leigh (2004) detected several negative monetary shocks in that period, something that could have justified the desire of the Japanese monetary authorities for a *de facto* smaller flexibility of the exchange rate.

4. Credibility and speculative pressures

In this section we study the degree of credibility for the implicit band regimes suggested by the analysis developed in the previous section and we check the degree of *exchange market pressure* for the Yen/Dollar exchange rate. Recall that we have obtained signs of the presence of a target zone in 1987, coinciding with the time of the Louvre Accord among the leading industrial nations. This commitment involved the coordination of macroeconomic policies in order to stabilize exchange rates.

Furthermore, our analysis indicates the presence of bands for the Yen/Dollar exchange rate in 1980. In 1979, as inflationary pressures at the wholesale level built up drastically and the current account was pushed deep into deficit, the Yen caved heavily on offer and depreciated sharply the exchange market. On 2 March the Bank of Japan announced that the Fed, the German Bundesbank and the Swiss National Bank would cooperate to prevent the Yen from declining excessively. By mid-April, with United States' interest rates falling, the Yen began to recover along with other major currencies [see, e. g., OECD (1980, 1981) and Pardee (1980, 1981)]. The Fed interventions suggest the presence of a crawling band.

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[9] Based on an event study methodology, Fatum and Hutchison (2005) analyse the Yen/Dollar exchange rate and find evidence that intervention affects the rate in the short term. Taylor (2004) also obtains evidence supporting the view that interventions increase the probability of stability (only when the exchange rate is misaligned) in a Markov-switching model.

[10] Schwartz (2000) argues that a strong Yen has not weakened as a result of interventions and sterilisation of Dollar purchasing. However, Pinto de Andrade and Divino (forthcoming) attribute a major role to exchange rates in accounting for cyclical patterns of the interest rate. In this sense, the Bank of Japan appears to have attempted to stabilize the exchange rate via interest rates.

In the study of the credibility for the period covering 30 April to 31 December 1980, implicit central parity is estimated by a least squares regression in which only a trend and a constant are included. The estimated central parity is shown in Figure 5. A band of ±6% is considered to include all observations falling within it during the aforementioned period[11]. From the analysis carried out in the previous section and from OECD reports, we assume a constant depreciation of the Yen/Dollar exchange rate within bands. Figures 5 and 6 illustrate the evolution of the Yen/Dollar exchange rate, adding the central parities and the band for the two periods studied.

[Figures 5 and 6, here]

Credibility is analysed using three indicators: the Svensson simple test, the drift adjustment method and an inverse measure of the probability of realignment. Svensson (1991) provides a simple test to study the credibility of a target zone exchange rate regime with fluctuation bands. We calculated a 100% confidence interval for the expected rate of realignment of the Yen/Dollar exchange rate using the three-month interbank rate. Taking into account the uncovered interest parity hypothesis, the expected rate of realignment is bounded according to:

$$i_t - i_t^* - (\bar{x}_t - x_t)/\tau \leq E_t\left[\Delta c_{t+\tau}\right]/\tau \leq i_t - i_t^* - (\underline{x}_t - x_t)/\tau \qquad (1)$$

where x_t is the deviation of the log exchange rate s_t from the log central parity c_t, $\underline{x}_t$ and $\bar{x}_t$ are the lower and upper bounds of the exchange rate bands, τ is the maturity (valued at 3/12 for a 3-month maturity), i-i^* is the interest rate differential and $E[\cdot]$ is the expectation operator.

The results of this test for 1980 and 1987 are shown in Figures 7 and 8 respectively. As can be seen in both cases, the hypothesis of a realignment expectation equalling zero cannot be rejected. Nonetheless, in 1980 the expected rate of revaluation grows as of the early part of the period, reaching its highest values around June. This behaviour was likely related to trader caution due to the upcoming parliamentary election on 22 June, particularly given that the sudden death of Prime Minister Ohira had added further uncertainty to the campaign. The lowest values of the expectation of revaluation occur in August, most likely due to the outbreak of hostilities between Iran and Iraq [see, e. g., (Pardee, 1980, 1981) and (OECD, 1980,1981)]. Furthermore, in the case of 1987 this measure could reflect both the existence of revaluation expectations at the end of March, before the supposed change in central parity from 153.5 to 146 Yen/Dollar, and expectations of devaluation at the end of July.

[Figures 7 and 8, here]

The second indicator to gauge credibility is the drift adjustment method. This method, originally proposed by Bertola and Svensson (1993), computes an econometric estimate of the expectations of economic agents regarding the realignment. These realignment expectations constitute an inverse measure of credibility. The procedure

[11] This band has been chosen as an exploratory proposal and hence the results must be interpreted in relative terms (i.e. through comparison of the different subperiods in the period studied, in this case 1980).

involves estimating the expected rate of variation of the exchange rate within the band in the absence of realignment, and then computing the expected rate of realignment g^{τ}_{t}. Once g^{τ}_{t} has been estimated, the corresponding 90% confidence intervals can be calculated.

In this paper we have estimated the expected rate of depreciation within the bands using a linear regression model where the exchange rate and the domestic and foreign interest rates are taken as explanatory variables:

$$\frac{x_{t+\tau} - x_t}{\tau} = \sum_j \alpha_j d_j + \beta_1 x_t + \beta_2 i_t^* + \beta_3 i_t + \varepsilon_{t+\tau} \qquad (2)$$

where $x_{t+\tau}$ and x_t are the exchange rate (log) deviation from the central parity at times $t+\tau$ and t, respectively. In the case of the 1987 bands, the variables d_j denote the dummies for the subperiods defined by the realignment on 7 April suggested by Esaka (2000).

Figures 9 and 10 show the expected rate of realignment and the 90% confidence intervals for the periods in 1980 and 1987, respectively. For 1980, expectations of revaluation are confirmed as increasing in May and June, as well as in December, following the announcement early that month by the Ministry of Finance that it would increase the quotas available to Japanese and foreign banks for swapping Dollar borrowing into Yen. This announcement gave more scope for capital inflows and improved market sentiment for the Yen. For their part, the expected rates of realignment greater than zero are obtained in August. For 1987, the method enables us to reject the hypothesis of null expectations of a realignment during the more critical stages of the period studied. Thus, it clearly reflects both the expectations of revaluation in March, May-June and August-September, and the expectations of devaluation in July and October. These results are very similar to those obtained by Esaka (2000, p. 123).

[Figures 9 and 10, here]

Lastly, the probability of non-realignment is obtained using a logit estimation. Here we have introduced the exchange rate, the distance to central parity and the interest rate differential as the explanatory variables. The selection of these variables stems from our interest in estimating credibility with high frequency data.

Assuming there is no credibility when y_t=0 and that when y_t=1 there is credibility, we use the drift-adjustment method to design the logit model. As explained above, the method estimates the 90% confidence interval. If both limits of the interval were simultaneously greater than, or less than, zero, the agents would have expected realignments with 90% confidence and y_t =0, otherwise y_t =1.

[Figures 11 to 16, here]

The probabilities estimated from the exchange rate, distance to central parity and the interest rate differential are illustrated in Figures 11, 12, and 13 for the 1980 period, and Figures 14, 15, and 16 for the 1987 period. As can be seen in Figure 11, when the exchange rate is used as the explanatory variable in estimating the probability of non-realignment, May 1980 could be classified as a low-credibility month. When distance to central parity is used (Figure 12) credibility is reduced in August and at the beginning of December 1980. Figure 13 indicates an increase in credibility from August until December, with some marginal credibility losses in October and December.

Figure 14 shows that, when the exchange rate is used, the probability of non-realignment would have been lower at the end of February and in March 1987, as well as at the end of July and the early days of August of that year. Figure 15, constructed using the distance of the exchange rate to the central parity, suggests that the probability of realignment is higher during May and in the latter part of July. The use of the interest rate differential confirms the lower credibility in March, as can be seen in Figure 16, as well as suggesting marginal credibility losses in July.

In recent years a number of researchers have claimed success in predicting currency crises. To that end, a definition of crisis has been necessary. Therefore, as a complementary analysis of the credibility measures, we calculate two *exchange market pressure* indices in order to know how robust the bands were. Both indices are weighted average of monthly percentage depreciations and monthly percentage reductions in reserves[12]. Both indices increase just before the beginning of the subperiod of 1980 (Figures 17 to 20). In fact, they exceed the critical level in one case, and decrease all during 1980. This suggests that the implicit band could have mitigated the speculative behaviour in the exchange market. The implications for the 1987 subperiod are less clear.

5. Concluding remarks

In this paper we have attempted to identify implicit exchange rate regimes for the Yen/Dollar. This particular rate was chosen because it is generally viewed as being the most flexible of all the exchange rates in the world economy and hence confirmation of the existence of such regimes has major empirical implications, given the widespread comparative use made of the rate.

To that end, we have applied different statistical approaches proposed in the literature to data covering the period 1971-2003. Our results indicate that implicit regimes other than a flexible one would have appeared to exist. An approach based on the use of exchange rate data to find *de facto* bands suggests that such regimes are present, but shows sensitivity to small variations in the methods used. A more realistic method considers central bank interventions in the exchange markets in order to study the intention (and efficacy) in maintaining the bands within certain limits.

Two statistical tests only using exchange rate data have been applied to complement the results obtained from the Reinhart and Rogoff approach. These tests analysed the empirical relationship between the exchange rate and interventions and found that standard time-series techniques may not be well suited to the study of

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[12] The weights used by Edison (2003) incorporate the standard deviations of the exchange rate and the reserves while Kaminsky *et al* (1998) introduce the standard deviations of the variations of the exchange rate and the reserves. Furthermore, in the first paper the critical level to consider a currency crises is the mean plus 1.5 times the standard deviation of the index while in the second one is the mean plus 3 times the standard deviation of the index

interventions and of exchange rate behaviour. A test of independence and a directional prediction test considerably restrict the implicit band regimes for the Yen/Dollar exchange rate. In the case of the Fed, the intention and efficacy of interventions are suggested for two subperiods: April-December 1980 and March-December 1987, the latter coinciding with the Louvre Accord.

To the extent that the market learns about the intentions behind central bank stabilizing interventions, an announcing hypothesis can also be considered. A study of the credibility of implicit bands was therefore undertaken for both subperiods mentioned above, detecting several critical events for the Yen/Dollar exchange. For the episode of implicit bands detected for the year 1980, all the indicators reflect a lack of credibility in June, August and December, while for the period identified around the Louvre Accord in 1987 there is evidence of credibility losses in May and June. For the remaining subperiods, the credibility indicators suggest a high degree of confidence by agents as regards the rate's evolution within the implicit bands. This, in turn, could be taken as further evidence supporting the existence of implicit bands that compromised the behaviour of the Fed and the Bank of Japan in exchange rate markets.

This paper has demonstrated the potential usefulness of a sequential procedure to detect implicit bands, taking into account both the dynamics of the exchange rate and the interventions of central banks. In our opinion, the results obtained suggest that further consideration of this procedure for other exchange rates could prove a fruitful exercise.

From the empirical point of view, central banks should be more transparent when communicating their interventions in foreign exchange markets, even providing researchers with the actual data involved in these operations. Where this is not possible, extensive literature exists to suggest alternative, more realistic measures of interventions other than changes in foreign reserves [see, e. g., Quirk (1977), Dornbusch (1980), Gärner (1987) and Hodgman and Resek (1987)].

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Figure 1

Proportion of monthly variations. Bands of ±1%

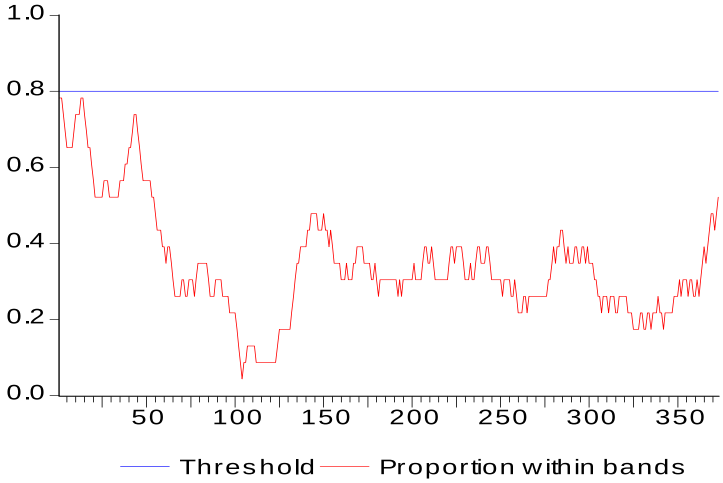

Figure 2

Proportion of monthly variations. Bands of ±2%

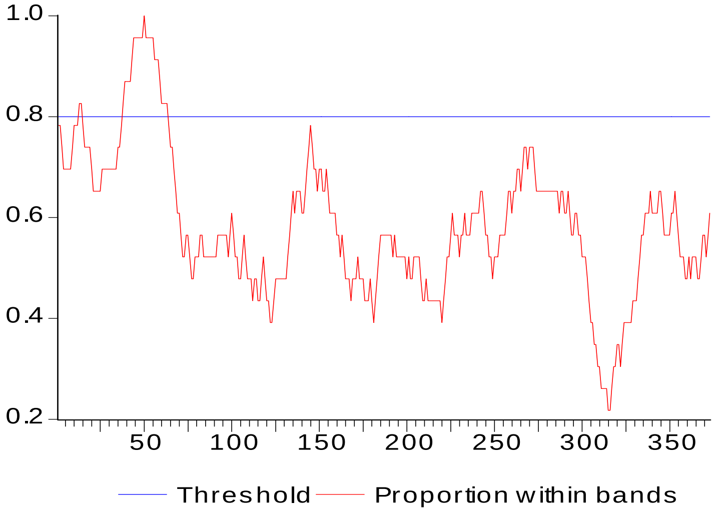

Figure 3

Test of the average monthly variations. Bands of ±1%

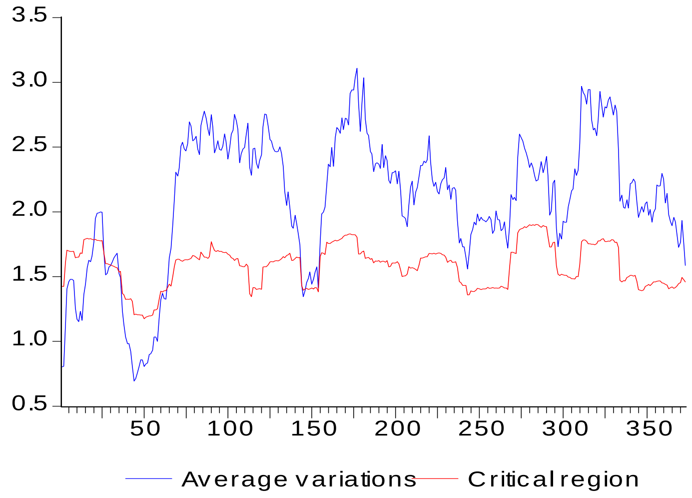

Figure 4

Test of the average monthly variations. Bands of ±2%

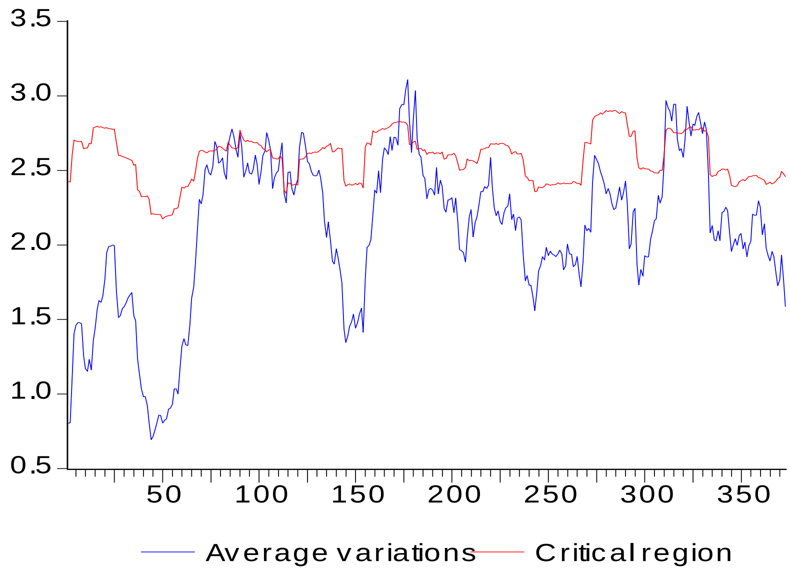

Figure 5

Yen/Dollar exchange rate, implicit central parity and bands (30 April 1980 to 31 December 1980)

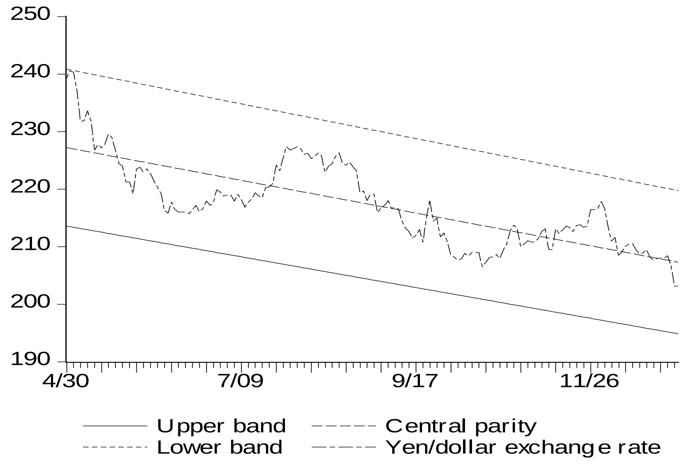

Figure 6

Yen/Dollar exchange rate, implicit central parity and bands (23 February 1987 to 18 October 1987)

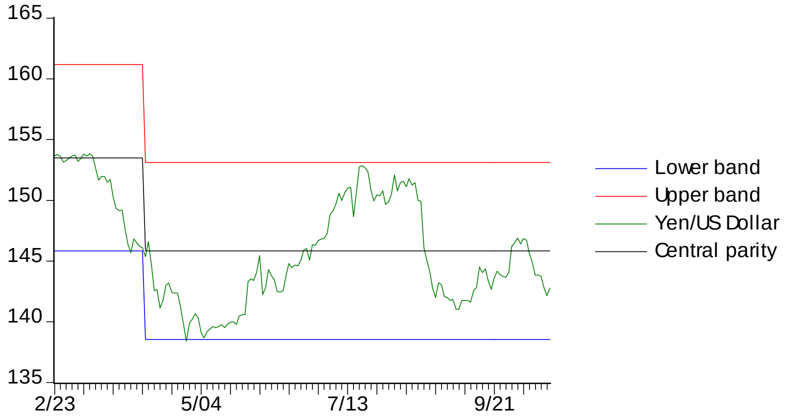

Figure 7

Svensson' test. 100% confidence interval (30 April 1980 to 31 December 1980)

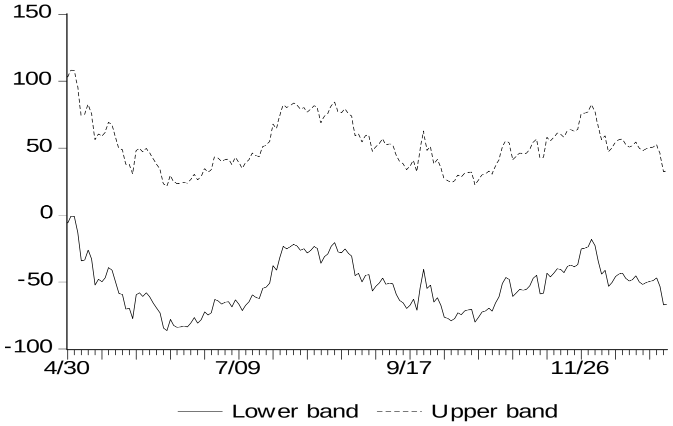

Figure 8

Svensson' test. 100% confidence interval (23 February 1987 to 18 October 1987)

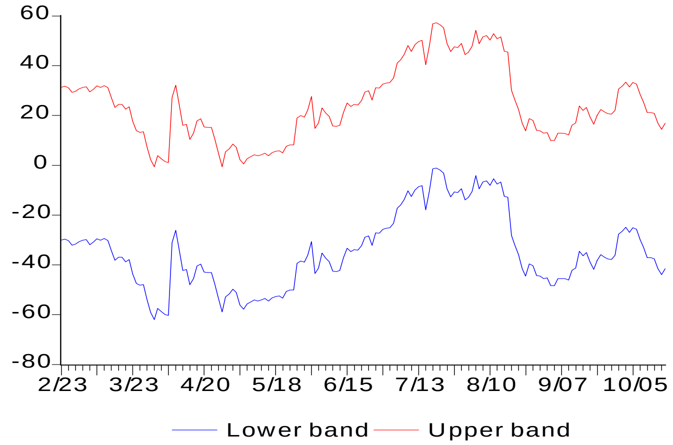

Figure 9

Drift adjustment method. 90% confidence interval (30 April 1980 to 31 December 1980)

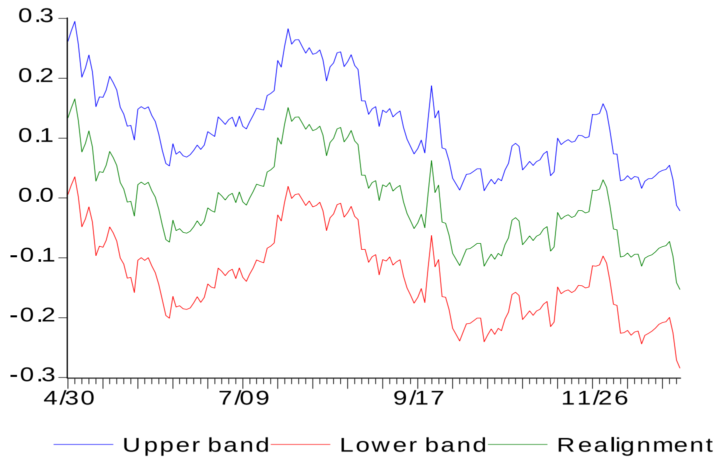

Figure 10

Drift adjustment method. 90% confidence interval (23 February 1987 to 18 October 1987)

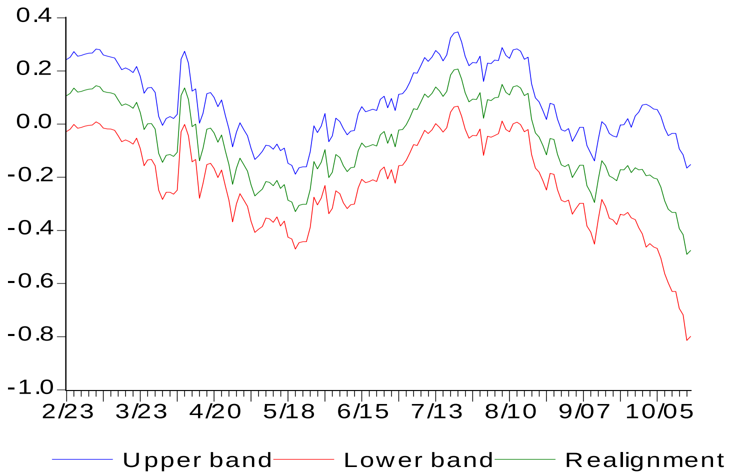

Figure 11

Probability of non-realignment. Exchange rate variable (30 April 1980 to 31 December 1980)

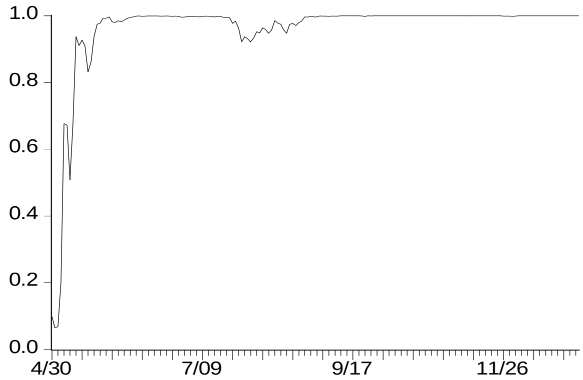

Figure 12

Probability of non-realignment. Central parity variable (30 April 1980 to 31 December 1980)

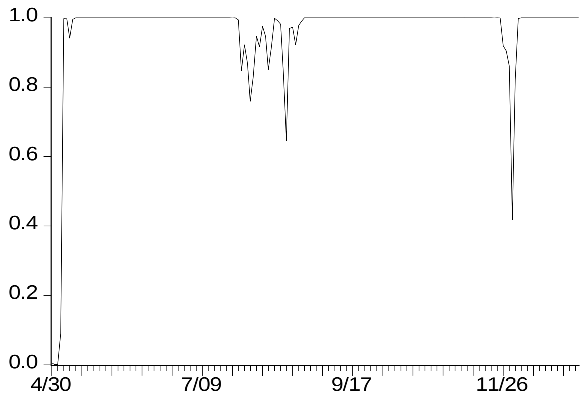

Figure 13

Probability of non-realignment. Interest rate differential (30 April 1980 to 31 December 1980)

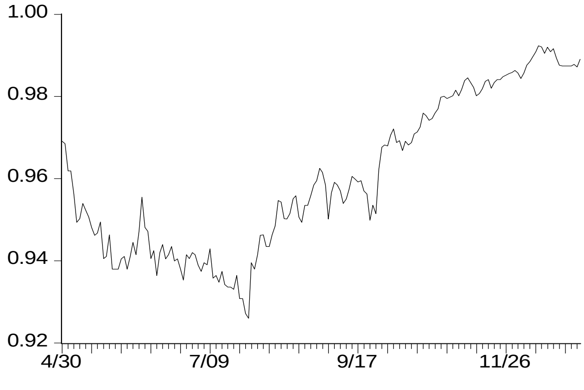

Figure 14

Probability of non-realignment. Exchange rate variable (23 February 1987 to 18 October 1987)

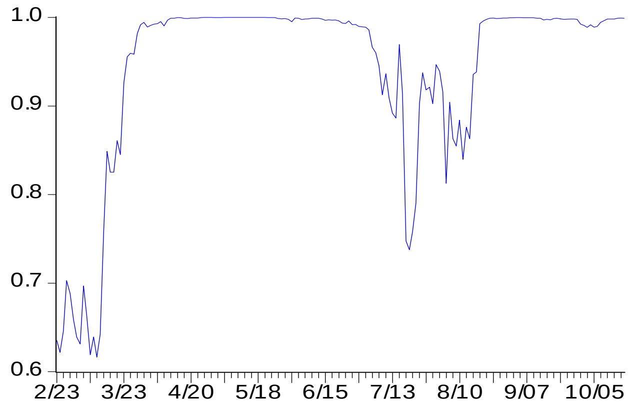

Figure 15

Probability of non-realignment. Central parity variable (23 February 1987 to 18 October 1987)

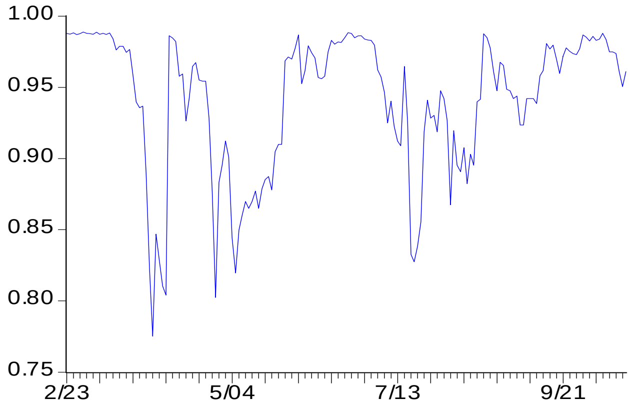

Figure 16

Probability of non-realignment. Interest rate differential (23 February 1987 to 18 October 1987)

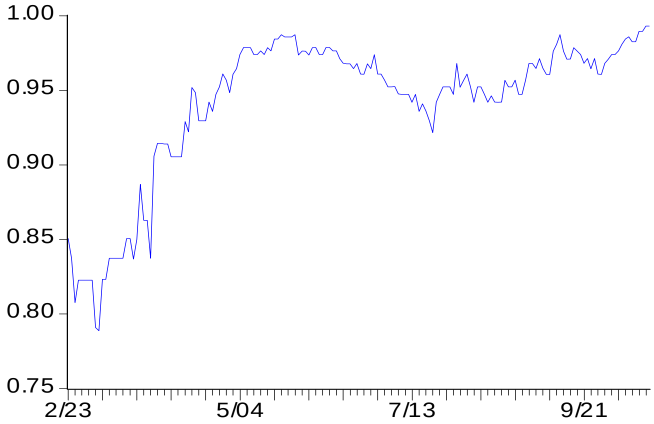

Figure 17

Japan. Exchange Market Pressure Index Based on Edison (2003)

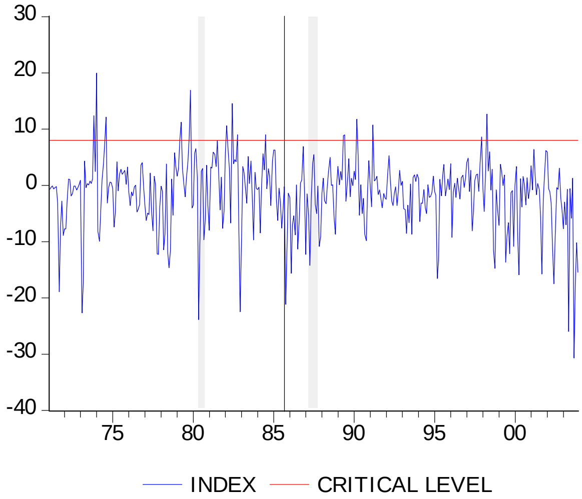

Figure 18

Japan. Exchange Market Pressure Index Based on Kaminsky et al (1998)

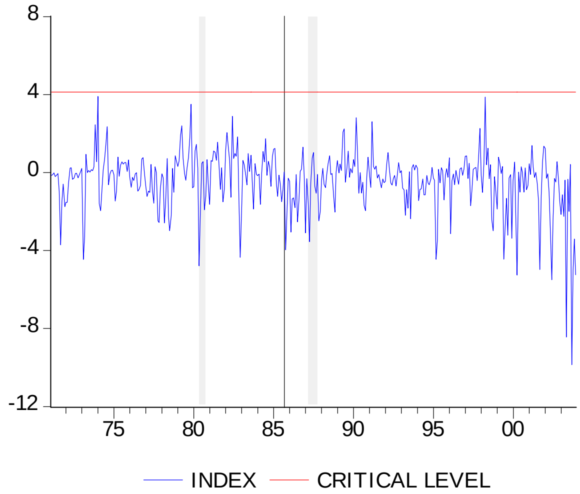

Figure 19

US Exchange Market Pressure Index Based on Edison (2003)

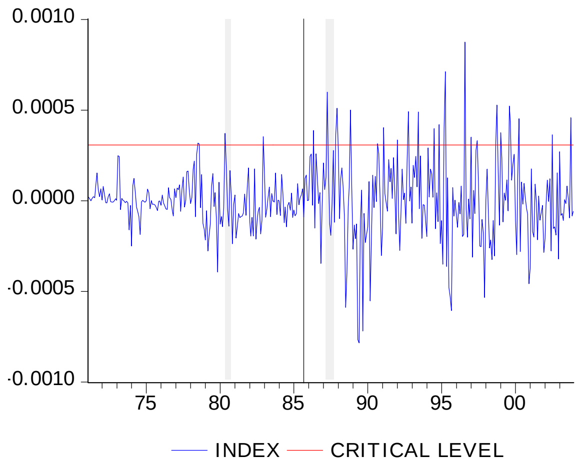

Figure 20

US Exchange Market Pressure Index
Based on Kaminsky et al (1998)

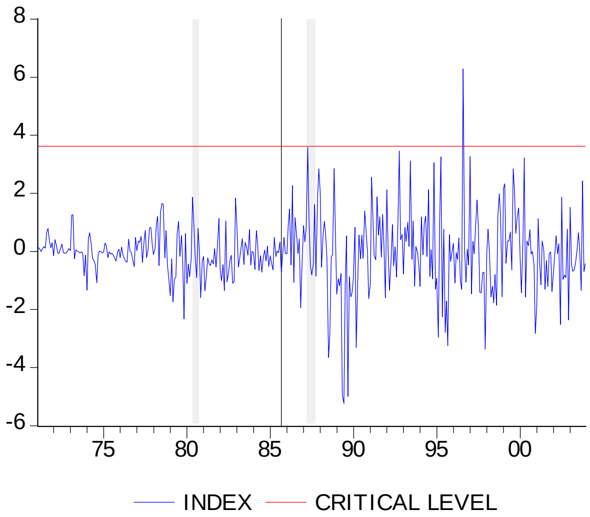

Table 1. Description of variables incorporated to the Pesaran-Timmermann test for the analysis of intention and efficacy

Variables	Intention		Efficacy	
	Formulation	**Description**	**Formulation**	**Description**
y_h	$y_h = \log s_h - \log s_{h-k}$	% depreciation of yen	$y_h = -(\log s_{h+k} - \log s_h)$	% appreciation of yen
$y_h > 0$	$I_h[y_h > 0]$	1 if depreciation of yen, 0 otherwise	$I_h[y_h > 0]$	1 if appreciation of yen, 0 otherwise
$\hat{y}_h$	-intervenjap	Sales of $	-intervenjap	Sales of $
$\hat{y}_h > 0$	$I_h[\hat{y}_h > 0]$	1 if sale of $, 0 otherwise	$I_h[\hat{y}_h > 0]$	1 if sale of $, 0 otherwise
$y_h \cdot \hat{y}_h > 0$	$I_h[y_h \cdot \hat{y}_h > 0]$	1 if purchase of $ after appreciation of yen or sale of $ after depreciation of yen; 0 otherwise	$I_h[y_h \cdot \hat{y}_h > 0]$	1 if depreciation of yen after purchase of $ or appreciation of yen after sale of $; 0 otherwise
p_1	$p_1 = H^{-1}\sum_{h=1}^{H} I_h[y_h > 0]$	Probability of yen depreciation	$p_1 = H^{-1}\sum_{h=1}^{H} I_h[y_h > 0]$	Probability of yen appreciation
$\hat{p}_1$	$\hat{p}_1 = H^{-1}\sum_{h=1}^{H} I_h[\hat{y}_h > 0]$	Probability of sale of $ intervention	$\hat{p}_1 = H^{-1}\sum_{h=1}^{H} I_h[\hat{y}_h > 0]$	Probability of sale of $ intervention
SR	$SR = H^{-1}\sum_{h=1}^{H} I_h[y_h.\hat{y}_h > 0]$	Probability of success under dependence	$SR = H^{-1}\sum_{h=1}^{H} I_h[y_h.\hat{y}_h > 0]$	Probability of success under dependence
SRI	$SRI = p_1\hat{p}_1 + (1 - p_1)(1 - \hat{p}_1$	Probability of success under independence	$SRI = p_1\hat{p}_1 + (1 - p_1)(1 - \hat{p}_1)$	Probability of success under independence

<u>Table 2</u>

Pesaran-Timmermann Test

Months	**k-values (days)**						
	1	**5**	**10**	**20**	**30**	**40**	**60**
Panel A: ex-post							
1980-Jan	1.35	0.89	-0.78	1.41	0.45		
1980-Mar					2.00	2.00	2.00
1980-Apr	3.03	2.27	1.73	1.13	1.48	1.48	1.48
1980-May	1.59						
1980-Jul	1.11	0.50	-0.13	1.01	1.75	2.52	2.52
1980-Aug	0.88	0.76	0.76	1.78	4.01	4.01	4.01
1980-Nov	2.44	1.89	3.62	-0.33	1.89	1.09	1.01
1980-Dec	-0.80				0.60	2.11	2.11
1981-Jan	1.20	2.25	-1.52	0.95			
1982-Oct	0.71	0.71	0.71	0.71	0.71	0.71	0.71
1987-Mar	1.98	3.02	3.02	3.02	3.02	3.02	3.02
1987-Aug	2.14	2.86	2.14	2.86	2.86	2.86	2.86
1988-Sep	0.71	0.71		0.71	0.71	0.71	0.71
1989-Apr	0.71	0.71		0.71	0.71	0.71	0.71
1989-May	1.50						
1989-Jun					2.00	2.00	2.00
1989-Jul	1.00						1.00
1990-Mar		1.41	1.41	1.41	1.41	1.41	1.41
Panel B: ex-ante							
1980-Jan	0.78	-1.81	0.45				
1980-Mar						2.00	2.00
1980-Apr	-0.43	-1.54					
1980-May	-1.26	1.59				-0.60	
1980-Jul	-1.26	1.75	1.75	2.52	1.75	-0.19	
1980-Aug	1.14	-0.54	-0.29				
1980-Nov	-0.63	0.92	1.09	-0.33			
1980-Dec	0.60	-0.40					-0.40
1981-Jan	-1.20	0.92	1.34	0.51			
1982-Oct		0.71	0.71		0.71	0.71	0.71
1987-Mar	0.66						0.43
1987-Aug	0.48	-0.65	2.09	2.86	2.86	2.09	
1988-Sep	0.71	0.71		0.71	0.71	0.71	0.71
1989-May	0.85	0.47	0.37	0.47	0.75	0.66	0.47
1989-Jun					2.00		

Note: the results for periods with Student-t close to 0.00 are omitted.