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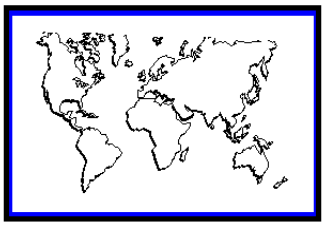
Simón Sosvilla-Rivero
María del Carmen Ramos Herrera



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Detection of Implicit Fluctuation Bands and their Credibility in Candidate Countries

SIMÓN SOSVILLA-RIVERO
Universidad Complutense de Madrid
Facultad de Ciencias Económicas y Empresariales
Campus de Somosaguas, 28223, Madrid, Spain.

MARÍA DEL CARMEN RAMOS-HERRERA
Universidad Complutense de Madrid
Facultad de Ciencias Económicas y Empresariales
Campus de Somosaguas, 28223, Madrid, Spain.
e-mail: madelram@ccee.ucm.es

Abstract:

This paper attempts to identify implicit exchange rate regimes for currencies of candidate countries *vis-à-vis* the euro. To that end, we apply three sequential procedures that consider the dynamics of exchange rates to data covering the period from 1999:01 to 2012:12. Our results would suggest that implicit bands have existed in many sub-periods for almost all currencies under study. Once we detect *de facto* discrepancies between *de facto* and *de iure* exchange rate regimes, we make use of different methods to study the credibility of the detected fluctuation bands. The detected lack of credibility in a high percentage of the sample is robust using the Drift Adjustment method and discrete choice models, suggesting that economic agents do not behave as if these bands actually were in force at time of making their financial plans. These countries do not improve the confidence on the fluctuation bands as time evolves.

Keywords: exchange-rate regimes; implicit fluctuation bands; credibility; exchange rates.

JEL classification: F31, F33.

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1. Introduction

In this paper we first investigate the existence of implicit fluctuation bands in candidate countries(Croatia[1], Iceland, the former Yugoslav Republic of Macedonia, Serbia and Turkey). To that end, we make use of three sequential procedures based on the exchange-rate behavior during the period 1999-2012.

Given that these countries aspire to become EU Member States, for in the future move to the next phase of the integration process (it means to belong to the Economic and Monetary Union, EMU), an improvement should be observed in the commitment of these economies, since once join EMU will involve the replacement of national currencies by a common one (the euro) and the simultaneous adoption of a single monetary policy set by the European Central Bank (ECB) for the whole Euro Zone.

Another fundamental requirement to join the Euro Zone is that the national authorities have to coordinate their economic policies according to the Stability and Growth Pact (SGP) to guarantee the EU benefit as a whole. For this reason, these countries are subjected to diverse controls in order to verify if these economies are meeting the Maastricht criteria or convergence criteria. These conditions were adopted in 1991 and their purposes to achieve four main objectives: price stability, the duration of convergence, obtaining sound and sustainable public finances and exchange rate stability. The motivation of this paper is based on the evaluation of this last requirement due to its important implications on the economy, since the absence of stages characterized by severe fluctuations in the exchange rate guarantee a context of macroeconomic stability and a favorable environment for investment.

On January 1, 1999 the Exchange Rate Mechanism II (ERM II)was established as a structure through which serves to help candidates economies to face a similar scenario to which they will find once join the Euro Zone. Before any disturbance, the country will not be able to respond devaluing its currency in order to boost its exports and reduce its imports. For this reason, the responsible authorities (the ECB and the European Commission) investigate whether at least during two years of participation in

[1] Although Croatia became the 29th Member State of the EU on July 1, 2013, we will consider it as a candidate country since it was its status during the examined sample.

ERM II the candidates countries do not have experienced severe fluctuations in their currencies *vis-à-vis* the euro, showing that they will be able to act appropriately to any disturbance once join the EU. This method reaches to avoid harming the economic stability of the EU as a whole. If the convergence report indicates the compliance of the Maastricht criteria, then the Economic and Financial Affairs Council (ECOFIN) decide the central parity between the national currency and the euro. Besides it establishes ± 15% fluctuation bands with respect to the central parity, providing to the economies the possibility of establishing narrower bands if they consider it appropriate.

Moreover, based on the strong empirical evidence that proves the monetary authorities trend to deviate with respect to the exchange rate agreement to which they have committed [see, for example, Ötker Bubula-Robe (2002), Shambaugh (2003) Reinhart and Rogoff (2004) and Levy-Yeyati and Sturzenegger (2003), among others], our main interest in this paper is the detection of *de facto* fluctuation bands in the five countries mentioned above.

This paper is organized as follows. In Section 2, we present the statistical procedures based on the evolution of the exchange rates *vis-à-vis* the euro used to detect implicit fluctuation bands and we offer the empirical results country by country for the five candidate countries covering the period 1999-2012. Section 3, in the first three sub-sections, we examine in detail three instruments as different measures of robustness to determine the credibility of the identified fluctuation bands in the previously section. The last sub-section in Section 3 detects the sub-periods characterized by absence of credibility in the exchange rate system for each particular case. Finally, in Section 4 some concluding remarks are provided.

2. Methodology and main results

2. 1. Implicitfluctuationbands

In this section we will explain in detail the three procedures based on the dynamics of the exchange rate for the detection of implicit fluctuation bands. First, the descriptive procedure used by Reinhart and Rogoff (2004) is based on the monthly percentage variation of the absolute value of exchange rate. This method is based on the probabilities that this variation is maintained within a certain band, it can be ±1, ±2 or

±5%, for two or five rolling years. According to this criteria, if the probability exceeds or equals 80%, we will conclude the existence of a *de facto* fixed monetary system during the time in which that percentage stays.

Nevertheless, one of the main limitation of this method, according to Ledesma-Rodríguez, Navarro-Ibáñez, Pérez-Rodríguez and Sosvilla-Rivero (2005a), is the absence of a statistical significance contrast to corroborate the achieved results. To rectify this weakness, they propose a contrast which the null hypothesis (H_0) says that the probability that the monthly exchange rate percentage variation is maintained a band of ±1 or ±2% for 24 consecutive months (including the current one) is less or equal than the same threshold established by the above procedure (0.8).

One of the necessary requirements to apply this procedure is to ensure firstly normality and the absence of serial correlation of the series to analyze. For this reason, we take advantage of the Jarque-Bera, Kolmogorov-Smirnov test and the test of von-Neumann. Having confirmed these two properties we are able to continue with the statistical constrast, which formally can be expressed in the following way:

$$H_0\colon\ p \leq p_0$$
$$H_1\colon\ p > p_0$$

where$p$ represents the proportion of the population and $p_0$is the established probability or threshold. Therefore this contrast serves to determine if the population proportion is less or equal than a frequency p_0, accepting the absence of bands. According to these authors, the region's acceptance of the null hypothesis happens when$\hat{p} \leq \varepsilon$, being $\hat{p}$the estimated sample proportion and $\varepsilon = p_0 + z_{1-\alpha}\frac{\sqrt{p_0 q_0}}{\sqrt{n}}$, where $z_{1-\alpha}$is the critical value of standard normal distribution at confidence level of 1-α. On the other hand,$\frac{\sqrt{p_0 q_0}}{\sqrt{n}}$ indicates the population deviation, $q_0 = 1 - p_0$ and n is the sample size.

Another variant that also allows us to filter results by their statistical significance for the identification of the implicit fluctuation bands is proposed in Ledesma-Rodríguez, Navarro-Ibáñez, Pérez-Rodríguez and Sosvilla-Rivero (2005b). Unlike the previous method, this approach does not offer a contrast on the probabilities, but directly on the

monthly exchange rate percentage variations. Based on the normality and independence assumptions, this criteria contrast if the average of such variations is significantly less or equal than ±1 or ±2% over a period of 24 consecutive months:

$$H_0\colon\ \mu \leq \mu_0$$
$$H_1\colon\ \mu > \mu_0$$

where μ represents the population mean of these variations and μ_0 is the given mean (±1 or ±2%). In this contrast, the acceptance region happens when $\bar{x} \leq \varepsilon$, being$\bar{x}$ the sample mean and $\varepsilon = \mu_0 + t_{1-\alpha}\frac{S}{\sqrt{n}}$where $t_{1-\alpha}$is the critical value of the t-Student distribution at a confidence level of $1-\alpha$, the S is the quasi-variance and n is the sample size.

2. 2. Detection of implicit fluctuation bands

In this sub-section we proceed to the detection of *de facto* fluctuation bands of the exchange rates for the five countries during the period 1999:01-2012:12 using the three sequential procedures. The monthly exchange rates are spot rates expressed as domestic monetary units per euro and have been downloaded from the ECB and the Eurostat websites. We exhibit the main conclusions about the implicit fluctuation bands, country-by-country, relying on Figures 1-5.

Croatia: The behaviour of the Croatian kuna/euro exchange rate(HRK/EUR) shows patterns consistent with a *de facto* fixed exchange-rate regime that is endorsed by our detection criteria, although in different degree. The contrast directly on average variations proposed by Ledesma-Rodríguez *et al.* (2005b) concluded the presence of ±2% and ±1% fluctuation bands in the 100% of the sample (Figure 1, Panels F and E, respectively), selecting the latter for being the narrowest. In the same line Reinhart and Rogoff (2004)'s method is positioned, who also identified bands of ±2% throughout the period reduced this percentage to the 74.85% of the sample after proceed to its relevant statistical contrast (1999:01-2001:07 and 2003:04-2012:12). Analyzing potential ±1% bands, the percentage is still quite significant, we are talking that the first procedure detects a 61.40% (1999:01-2001:07 and 2005:03-2012:12), keeping a 37.43%

(2001:2001-01:03, 2006:04-2008:11, 2010:11-2012:12) in the second (Figure 1, Panels A and C, respectively).

[Insert Figure 1]

Iceland: Beginning our analysis for the checking of the existence of ±2% fluctuation band in the exchange rate Icelandic krona/euro (ISK/EUR), the last procedure is capable of specifying the following sub-periods 1999:01-2008:03, 2008:05, 2008:07-2008:08, 2008:10-2008:12 and 2010:10-2012:12 as those in which the exchange rate does not experiment deviations with respect to the above mentioned bands (Figure 2, Panel F).This 72.51 % that it represents on the whole sample period moves away enough of the contributed ones for the remaining methods. The first one just determines a 14.04 % (1999:01, 2003:12-2005:05, 2011:05-2011:08 and 2012:01) whereas the second one accepts the hypothesis of absence of bands during the whole period (Figure 2, Panels B and D, respectively).We do not also find any evidence of which the probability of these percentage absolute monthly variations of the exchange rate Icelandic krona/euro is under ±1 % fluctuation bands in no sub-period, result that it reiterated after having been filtered through its statistical significance (Figures 2, Panels A and C, respectively).On the other hand, and taking into account that the critical region of Figure 2 (Panel E) is above the average of percentage variations, this means the acceptance of the presence of minor or equal to ±1 % bands for the following sub-periods: 2000:12, 2001:02-2001:03, 2003:10-2005:09, 2008:10-2008:11, 2012:01-2012:02 and 2012:04-2012:07, which would represent a 20.47 % of the sample.

[Insert Figure 2]

The former Yugoslav Republic of Macedonia: In spite of the fact that Macedonia is a candidate country to became part of EU, the exchange rate Denar (of the former Yugoslav Republic of Macedonia)/euro (MKD/EUR) presents a standard behaviour typical enough of an exchange system distinguished by the stability, which would

suppose an impulse on trade and investment[2]. This statement has its base in the achieved results across the three sequential procedures that consider the exchange rate's dynamic. All of them support the existence of ±1 % fluctuation bands (Figure 3, Panels A, C and E) and of ±2 % throughout the whole period (Figure 3, Panels B, D and F).

[Insert Figure 3]

Serbia: The disparity between previous methods becomes evident for the Serbian dinar/euro exchange rate (RSD/EUR). If we focus on the potential band of ±1 %, Reinhart and Rogoff (2004) and Ledesma-Rodríguez *et al*. (2005a)'s methods suggest the lack of ±1 % bands. In contrast, the last criterion proposes the following sub-periods: 2010:04-2012:02 and2012:05 as those in those the average of percentage variations does not turn aside of a minor or equal ±1 % band (representing 60.74 % of the sample). Major conformity seems to exist when ±2 % fluctuation band is considered, though not so much in magnitude. The first mechanism is capable of detecting a 49.63 % (1999:01-2007:12 and 2010:07-2011:12), the second one diminishes its percentage up to 26.67 % (1999:01-2006:06 and 2010:12-2011:04), whereas the last one recognizes the totality of sample (in this case given the available information: 2002:01-2012:12).

[Insert Figure 4]

Turkey: We do not find evidence that allows us to confirm the presence of ±1 % not of ±2 % implicit fluctuation bands for the Turkish lira /euro exchange rate (TRY/EUR) using the first two approaches. On the one hand, if we analyze Panels A and B of Figure 5, as its Panels C and D, we can verify that the proportion of monthly TRY/EUR exchange rate variation does not exceed threshold nor the critical region, respectively. On the other hand, the last procedure does not identify the presence of narrow bands of ±1 % (see Figure 5, Panel E). Nevertheless, it is capable of detecting the following

[2]Given that under fixed exchange rates the monetary authority is committed to defend its exchange rate maintaining its central parity or ensuring that its path is within the fluctuation band, this provokes a favorable context for investment and trade as a result of the reduction in the degree of uncertainty and reduced transaction costs.

substages (1999:01-2001:02, 2004:06-2008:10 and 2010:02-2012:12), in which the exchange rate does not turn aside of ±2 % bands of representing 54.97 % of the sample.

[Insert Figure 5]

3. Credibility test of fluctuation bands

The entrance to the ERM II for many countries means an increase in the level of credibility about the monetary and exchange commitments made by monetary authorities, especially for those who have experienced inflationary periods, since it allows them to act as a real anchor on exchange rate policy.

In this section we present three alternative indicators as measures of credibility that have been widely used in the empirical literature. First, we discuss the methodology of the simple Svensson (1991)test and its results, then we provide the improvements with respect to the limitations of the Svensson test that the drift adjustment method (*drift adjustment*) offered. Finally, based on the latter approach we proceed to develop a new dichotomous variable that allows us to calculate the probability of realignment of the exchange rates through discrete choice models. These methods facilitate the comparison between the three alternative procedures contributing to the identification of the sub-periods associated with lack of credibility in the exchange system.

3. 1. Svensson simple test

The simple and robust Svensson (1991)'s method is an indicator that is commonly used to verify the credibility of the exchange rate regime of a target zone exchange rate regime with fluctuation bands. A target zone delimits explicitly what are the bands of appreciation and depreciation of the exchange rate.

To understand the logic of this contrast, imagine a context in which an economic agent has to respond to the following question at time t: what is the optimum amount that I should maintain of financial assets in domestic currency with respect to the amount of financial assets in foreign currency? To be able to clear this question it will need to

compare what is the associated profitability with each alternative, knowing that, by one of the fundamental principles of the financial economy, profitability should compensate for the supported risk. On the one hand, the asset expressed in domestic currency gives a return of i_t^{τ}between t and the maturity date, while the bond expressed in foreign currency means a performance of $i_t^{*\tau}$. If we assume some similarity between national and foreign bonds not only in the maturity period and risk but also in the elimination of the market imperfections, the investor's decision is only conditioned to exchange risk. The reason is simple, this economic agent will need of the exchange rate tool to perform the comparison of yields in the same currency. Therefore, the more flexible the exchange rate greater uncertainty associated with the evolution of the exchange rate. However, within a target zone with a credible fluctuation bands, the exchange rate margins are delimited as explained above.

Under the assumption of perfect capital mobility (which is the lack of opportunities for arbitrage between different currencies), the annualized rate of return in terms of the domestic currency, *ex post*, associated with the purchase of a financial asset at time t in foreign currency with a maturity period τ can be obtained from the following expression:

$$R_t^{\tau} = (1 + i_t^{*\tau}) \left(\frac{S_{t+\tau}}{S_t} \right)^{\frac{12}{\tau}} - 1$$

where the maturity period of the asset (τ) it is measured in months. According to Svensson (1991), if an investor invests a national currency unit is equivalent to say that is investing $\frac{1}{S_t}$units of foreign currency, which means that, after the maturity period τ, acquires a yield of $\frac{(1+i_t^{*\tau})^{\frac{\tau}{12}}}{S_t}$units of foreign currency. Once again, to express this performance in units of national currency must be multiplied by the exchange rate ($S_{t+\tau}$) being equal to $(1 + R_t^{\tau})^{\frac{\tau}{12}}$.

Thus as at time t has to predict the behavior of $S_{t+\tau}$and in a context of a target zone is expected that the exchange rate is between minimum ($\underline{S}$) and maximum ($\overline{S}$) limits:

$$\underline{S} \leq S_t \leq \overline{S}$$

And therefore, these limits in the national currency appreciation and depreciation involve a delimitation of the rate of return, which is to be found between the lower limit ($\underline{R}_t^{\tau}$) and the upper limit ($\overline{R}_t^{\tau}$):

$$\underline{R}_t^{\tau} \leq R_t^{\tau} \leq \overline{R}_t^{\tau}$$

where the lower (upper) limit of return is the result of the replacement of the exchange rate for $t + \tau$ periods ahead ($S_{t+\tau}$)by the lower (upper) limit established by the target zone:

$$\underline{R}_t^{\tau} = (1 + i_t^{*\tau}) \left(\frac{\underline{S}}{S_t}\right)^{\frac{12}{\tau}} - 1$$

$$\overline{R}_t^{\tau} = (1 + i_t^{*\tau}) \left(\frac{\overline{S}}{S_t}\right)^{\frac{12}{\tau}} - 1$$

It is necessary to clarify that even if the national interest rate is within these bands cannot be guaranteed with firmness that the target zone is credible. On the other hand, if the domestic interest rate falls significantly outside of the return bands, we are able to confirm that this exchange rate system during the period under study is not credible.

In the context of non-credibility, we can find two possibilities: on the one hand, that the national interest rate is higher than the upper limit of return band ($\overline{R}_t^{\tau}$), in which case the economic agent has incentives to get foreign financing and then invest in the purchase of financial assets expressed in national currency. On the other hand, the other scenario that neither presents the equilibrium condition in the international capital market is the situation in which the national interest rate is lower than the lower limit of profitability ($\underline{R}_t^{\tau}$). In this particular case, the asset expressed in foreign currency becomes the most attractive in the market for investors by their guaranteed benefit.

3. 2. DriftAdjustmenttest

The Svensson (1991)´s test has been criticized because it cares only about the possibility of a realignment (change in the established central parity level) when the exchange rate is close to the fluctuation bands limits. For this reason, we have selected another alternative procedure, known as the method of *Drift Adjustment* (DA).

This method, originally proposed by Bertola and Svensson (1993), consists of estimating, through a linear regression model, the realignment expectations of economic agents conditioned to have experienced one of these events before. This indicator, reverse the measure of credibility, is obtained by taking the uncovered interest parity hypothesis:

$$i_t - i_t^* = \frac{E_t[\Delta s_{t+\tau}]}{\tau}$$

wherei_t and i_t^* are the domestic and the Euro Area interest rate, respectively and τ reflects the maturity period (in our case are 3 months, therefore its value is 3/12).

Given that the exchange rate can be decomposed into two components: the central parity and the exchange rate within the band, the expression of the uncovered interest parity can be expressed as:

$$i_t - i_t^* = \frac{E_t[\Delta s_{t+\tau}]}{\tau} + \frac{E_t[\Delta c_{t+\tau}]}{\tau}$$

In addition:

$$E_t[\Delta x_{t+\tau}] = (1 - p_t^\tau) E_t[\Delta x_{t+\tau} / nr] + p_t^\tau E_t[\Delta x_{t+\tau} / r]$$

where$p_t^\tau$is the probability determined at time *t* of experiencing a realignment during the period between *t* and *t* + *τ*. The right side of the expression indicates if the expectation is conditioned to having submitted a realignment (r) or not having it experienced (nr).

Moreover, taking into account the definition of devaluation, the following expression contains in its first term on the right side the expected realignment and in the second one its own expected depreciation within the band:

$$g_t^\tau = \frac{E_t[\Delta c_{t+\tau}]}{\tau} + \frac{p_t^\tau}{\tau}\{E_t[x_{t+\tau}/r] - E_t[x_{t+\tau}/nr]\}$$

Finally, combining the above expressions we obtain that:

$$g_t^\tau = i_t - i_t^* - \frac{E_t[\Delta x_{t+\tau}/nr]}{\tau}$$

To obtain the expected devaluation we proceed in the following way: first, we estimate the expected depreciation within the band conditioned on not having suffered any realignment (last term in the right side of this equation) and subsequently applying the interest rate differential we achieve g_t^τ.

Then, instead of working with the point estimation, we calculate confidence intervals with a 0.10 significance level for our interest variable. Thus, we ensure that with 90% of confidence, the real population parameter of devaluation is within that interval.

In order to estimate the expected depreciation within the band according to the DA method, we use the linear regression model proposed by Svensson (1993) in which the explanatory variables to consider are: the logarithm of the distance of the exchange rate with respect to the central parity(x_t)and 3-months interbank interest rates, both national and Euro Zone($i_t$andi_t^*, respectively):

$$\frac{x_{t+\tau} - x_t}{\tau} = \sum_j \alpha_j d_j + \beta_1 x_t + \beta_2 i_t + \beta_3 i_t^* + \epsilon_{t+\tau}$$

The dummy variables d_j take value one during the sub-period between realignments and fluctuation bands enlargement[3], shown by a vertical line in Figure 8 (Panels A-E).

[3] As Ledesma *et al.* (2005), we implement the fluctuation bands expansion, given the importance within ERM II.

Since the expected depreciation with the band needs to be predicted taking into account that is conditioned on not having experienced any episode of realignment, Svensson (1993) removes the observations associated with the three months preceding the realignments occurred. However, to avoid reducing the number of observations significantly, we follow the Ledesma-Rodríguez *et al.* (2000, 2005a and 2009)'s procedure estimating with the whole sample. This means that, instead of obtaining the expected devaluationg_t^τ, we get the expected realignment.

3. 3. Discrete choice models

Unlike traditional econometrics, the usefulness of these models is the possibility of working with qualitative dependent variables. To summarize, in this perspective there is a wide variety of modelling depending on the number of alternatives of the endogenous variable, which can be encompassed into: dichotomous response models (two possible alternatives for the interest variable, as in our case) or multiple choice models (more than two options).Since our interest is to be able to calculate the probability of realignment for these five countries, we consider non-linear probabilistic models that allow us reliable estimates for the dichotomous variables. The most common models focus on the function of logistic distribution (known as Logit model) or the standard normal distribution (Probit model). This paper presents the results related to the Logit model, since the Logit and Probit estimated coefficients are very similar (see Ameniya, 1981, in which it is stated that:$\hat{\beta}_{LOGIT} = 1.6 * \hat{\beta}_{PROBIT}$[4]).

Before estimating the model is necessary to explain that our dependent variable will be built based on the result obtained by the DA method in order to get estimated probabilities time series. In particular, when both confidence interval limits of the expected depreciation within the band are greater or less than zero, we say that there is no credibility, assigning value 0 to the interest variable ($y_t = 0$)and when this condition is not fulfilled the dependent variable takes value 1 ($y_t = 1$), indicating credibility in the exchange system.

[4]The similarity of the coefficients is due to own distribution functions. To be symmetric around zero it is reasonable that the estimated coefficients are practically equal and differ closed to the tails. Both models are very similar respect to the predicted probabilities (Cameron and Trivedi, 2010).

Therefore if we focus on the Logit model, the probability that agents assign the value 1 in a given moment, that is, that on that date the exchange rate is credible, can be calculated from the following expression:

$$P(y_t = 1) = \Lambda\left(z_t' \beta\right) = \frac{e^{z_t' \beta}}{1 + e^{z_t' \beta}}$$

where $z_t'\beta = \beta_1 + \beta_2 z_{1t}$, Λ (.) is the cumulative logistic distribution function, $z_{1t}$is the explanatory variable and $P(y_t = 0) = 1 - P(y_t = 1)$(in our case the probability of realignment). As explanatory variables, this model includes the exchange rate, the distance from the central parity, the distance from the upper limit of the band and finally the interest rates differential.

3. 4. Empirical results of the fluctuation bands credibility tests

In this section, different methods to test the credibility explained in the previous sections (3. 1-3. 3)are applied in the five countries analyzed in this study from 1999 to 2012 as a measure of robustness. However, it is necessary to know the limitations of these methods before explaining the results. First, the results of the simple Svensson (1991)´s test are determined largely by the lower and upper bands limits range. Second, there is no theoretical justification for the explanatory variables that uses the DA method to explain the expected depreciation within bands. Finally, Ledesma-Rodríguez *et al*. (2005a) also mention the impact of the non-stationarity of the exchange rate on the outcome of this procedure. Nevertheless, despite these limitations, though uneven degree of accuracy, the three procedures are able to identify some credibility crises that the exchange rates investigated in this paper have experienced.

Figure 6 (Panels A-E) reflects the evolution of the five countries exchange rates *vis-à-vis* the euro, besides their central parities and their fluctuation bands. Moreover, Figure 7 (Panels A-E) indicates, for each of the investigated countries, at what time the domestic interest rate[5] is outside the return bands since this is evidence of the lack of

[5]Both the national and the Euro Zone interest rate corresponds to the 3-month interbank extracted from Eurostat and the ECB.

credibility in these sub-periods. Each of these figures is explained in detail when we focus on a particular interpretation of each country making a comparison between the three considered approaches.

[Insert Figure 6 and 7]

The results on how the explanatory variables of the method DA influence on the expected depreciation within the band are provided in Table 1. These coefficients have been estimated by OLS, correcting their standard errors for possible heteroskedasticity or serial correlation using the Newey-West (1987) covariance estimator. Among the main conclusions, note that the coefficient associated with the logarithm of the distance from the central parity (x) is highly significant and affects inversely on the expected depreciation within the band, corroborating the average of exchange rate reversion hypothesis for all currencies under study. This negative sign means that if economic agents observe at time *t* a deviation from its central parity they form stabilizing expectations, that is, expect that the exchange rate is close to the central parity in the following period stabilizing their behavior towards equilibrium. However, in our study there is no consensus on how affects the profitability of holding financial assets in domestic currency (i) and foreign currency (i^*) on the expected depreciation. Starting with the domestic interest rate, the only currency that matches with the results of Svensson (1993), Rose and Svensson (1994) and Ledesma-Rodríguez *et al*. (2000, 2005a) is the Icelandic krona reflecting the expected negative sign, being significant at 10%. Other currencies shown both positive and negative signs varying the level of significance.

With respect to the reference interest rate relative to the Euro Area, this variable can not be considered as explanatory of the expected depreciation behavior since it does not display significant in any country. Finally, taking into account the high *p*-values that show the dichotomous variables, it is able to conclude the limited relevance of the different exchange rate regimes.

[Insert Table 1]

Moreover, Table 2 shows the results of estimating the Logit model for the different explanatory variables explained in Section 3. 3, in order to assess the probability of realignment. In this procedure, and given our interest, we focus on the signs

interpretation of the estimated coefficients[6].As in Ledesma-Rodríguez *et al.* (2005a), we find that in most of the sample, there is enough empirical evidence to say that as a result of a depreciation of the domestic currency, increase (decrease) in the probability of realignment (credibility) occurs.

As in Ledesma-Rodríguez *et al.*(2005a), we find that in most of the sample, there is enough empirical evidence to confirm that a domestic currency depreciation provokes an increase (decrease) in the probability of realignment (credibility).However and contrary to expectations, for the Turkish lira, it can be seen that a depreciation *vis-à-vis* the euro would trigger a significant increase in the credibility of the exchange rate system. In general, with the exception of the Serbian dinar, Croatian kuna and Icelandic krona, it shows, with high significance, how the fact of turning aside respect of the central parity affects negatively on the probability of exchange regime credibility. Another indicator that has been used in this paper as a robustness measure is the distance with respect to the upper fluctuation band.

As expected, the domestic interest rate differential with respect to the Euro Zone triggers a negative and highly significant impact on the probability of credibility, thereby increasing the probability of a realignment in the exchange rate.

[Insert Table 2]

Table 3 provides a statistical summary of the estimated probability of realignment for all exchange rates analyzed in this paper according to the four explanatory variables.

[Insert Table 3]

Then we analyze, country by country, the results of the three credibility indicators making a comparison between them, trying to figure out which one is the most accurate identifying stages of credibility crisis.

Croatia: In Figure 6 (Panel A) it can be seen two sharp declines in the exchange rate HRK / EUR; the first, in July 2001 and the second episode is associated with the global

[6]Recall that these estimated coefficients have no the interpretation to which we are accustomed to work in traditional econometrics, for this reason it is necessary the calculation of the marginal effects but since the objective of this paper, we are concerned about their sign to see how these variables influence on the probability of realignment.

financial crisis, which eventually lead to the appreciation of the local currency in September and November 2008.Based on the Svensson (1991)`s test, both events have coincided with a lack of credibility in the fluctuation band by economic agents (Figure 7, Panel A).This figure shows high volatility in the credibility throughout the whole period, identifying both stages in which the evolution of the interest rate is above the return bands and where the opposite happens, it means in which is more profitable to borrow in the domestic market and then lend abroad.

In addition to the phase associated with not much credibility after the realignment occurred in 2004:05, that the DA method detects from 2004:10 to 2005:02, other previous stages are identified (1999:12-2000:04, 2001: 07 and 2004:01) and subsequent phases coinciding with the financial crisis (2009:02-2009:03).The last criterion using all the explanatory variables reinforces the previously identified stages: 1999-2001, along with the stage at the end of 2008 and at the beginning of 2009.

Iceland: The sharp depreciation of the exchange rate at the end of 2008 which can be perceived as quite remarkable from Figure 6 (Panel B) is due to the financial crisis that took place in this economy. Even though the interest rate is within the return bands during only three months, this fact does not guarantee, according to Svensson (1991), a period of credibility on the fluctuation bands. However, we can affirm that from October 2008 onwards there is evidence of a lack of credibility by the economic agents. In addition, the exchange rate ISK / EUR also shows evidence of deviations from the minimum limit, both 2000:03-2000:05, 2005:10-2006:03 and 2010:08-2010:12, this situation is a consequence of the high lack of credibility associated with the fluctuation bands (see Figure 7, Panel B). This argument is also applicable to stages in which the exchange rate has experienced deviations from the upper limits of the fluctuation bands (2009:08-2010:01).

The absence of credibility detected in 2001:03 by the DA mechanism (Figure 8, Panel B) confirms the ability by the economic agents to anticipate correctly that later (in 2001:04) would lead to a realignment of the exchange rate. This situation is reiterated in the third and fourth realignment, which takes place as a result of the economic crisis and the difficulties to refinance its short-term debt, leading to the collapse of three major commercial banks in its country.

Unlike prior procedures, in which a larger number of confidence crisis is detected, the binary choice method only identifies, by unanimity, the stage at the end of 2008 and at the beginning of 2009 (see Panel B in Figures 9, 10, 11 and 12).

The former Yugoslav Republic of Macedonia: Although the exchange rate remains stable without deviating at any time of its fluctuation bands (Figure 6, Panel C), both the Svensson test and DA method confirm the lack of confidence in the exchange rate during this period. In Figure 7 (Panel C) the profitability associated with borrowing in foreign market to finally lend on the national one stays significantly away from the return bands. On the other hand, the expectation of depreciation within the band for this candidate country holds throughout the whole period, since both confidence interval limits are greater than zero (see Figure 8, Panel C).

Serbia: Examining the behavior of the Serbian dinar *vis-à-vis* the euro exchange rate, it can confirm how barely trading around the central parity, in fact it is often close to the upper and lower fluctuation bands (Figure 6, Panel D).

At the beginning of the period, the lack of credibility was clearly significant, but in spite of this scenario, a gradually reduction to its minimum in 2007:08 is achieved (Figure 7, Panel D). From this date, since the return bands delimit the evolution of the exchange rate, the absence of credibility disappears, increasing again in 2009:01, time in which time the interest rate stands at 18.61%.Given the availability of data from the interbank rate for this economy, we are unable to confirm whether the positive deviation from the upper limit of the fluctuation band has been due to the lack of credibility of the agents to these bands.

According to the DA procedure (Figure 8, Panel D), the expected depreciation within the band becomes more important in 2004:02-2005:11, just at the moment in which realignments occur (2006:07 and 2008:10) and, like Svensson test, from January to May 2009 and again in July 2010.

Figure 9 (Panel C) shows a clear trend of increase in the probability of realignment as time evolves, presenting values around 0.61 in the two realignments upcoming dates.

Around more than 50% is the probability for the first realignment when we analyze the distance from the central parity as an explanatory variable, a completely opposite situation for the second realignment, where barely reach 10% (Figure 10, Panel C).Considering the distance from the upper limit of the fluctuation band, we can also observe a high volatility in the estimated probability of exchange system collapse since at least this probability is around 30% at any time during the whole period (Figure 11, Panel C).

Turkey: This other candidate country for EU membership does no present a clear trend of currency depreciation or appreciation; nevertheless, it identifies significant fluctuations during the thirteen years examined (Figure 6, Panel E).As a consequence of speculative attacks, it has generated an uncertain environment supported by the three methods used as tools for robustness. First, Svensson test shows no credibility from the beginning to the end of the period analyzed, although it shows a downward trend, reducing significantly from mid-2005 (Figure 7, Panel E).The DA method also offers a multitude of accurate dates for which the expected depreciation within the fluctuation band acquires more importance; among them, at the end of 1999, during 2001 and 2002 (coinciding with the realignment of 2001:03 and 2002:07) and subsequently to the extension of bands in 2004:05-2004:11, 2006:06 and 2011:08.

Finally, the discrete choice method shows an average probability of the expected realignment over than 20%. With the exception of Panel D of Figures 9 and 12, where an increase in agents' confidence is detected as we move away along the time horizon, the Panel D of Figures 10 and 11 shows short periods but high distrust in the exchange rate over the whole sample period.

[Insert Figure 8-12]

4. Conclusions

Having applied three sequential procedures based on the evolution of the exchange rate vis-à-vis the euro on five candidates countries to join the EU, our results suggest the presence of ± 2% and ± 1% implicit fluctuation band in high percentages of the sample period. These percentages vary depending on the methodology used, even reach 100%

in countries such as Croatia, the former Yugoslav Republic of Macedonia and Serbia. Therefore, this paper provide new empirical evidence that strengthens the hypothesis of that the implemented policies differ from those announced by the monetary authorities, identifying the existence of *de facto* fixed monetary systems along large number of sub-periods for different currencies. In other words, it has been detected that many of these countries act as if they were already *de facto* (but not *de iure*) in the ERM-II, showing an evolution of their currencies consistent with the existence of fluctuation bands vis-à-vis the euro.

Nevertheless, the simple Svensson test, the drift adjustment method and discrete choice models indicate lack of credibility for a high percentage of the sample in which the evolution of the exchange rate exceeds the detected minimum and/or maximum fluctuation bands limits, suggesting that economic agents do not behave as if these bands actually were in force at time of making their financial plans. Furthermore, these countries do not show signs of improvement in the confidence on the fluctuation bands as time evolves. In fact, in countries such as Croatia, the former Yugoslav Republic of Macedonia and Turkey it can be observed an important volatility in the credibility throughout the period analyzed, a conclusion that is reinforced by the implementation of the three different methods. The other candidate countries reveal extended stages of absence of credibility accompanied by an upward trend in the probability of realignment.

It should be emphasized that the three alternative procedures have been able to capture accurately those stages of absence of credibility prior to those realignments that really occurred subsequently. In some cases, the three methods coincide identifying the sub-periods of lack of credibility, while in others they complement each other improving the results. On the other hand, the figures associated to the simple Svensson test reveal us a pattern of behavior that can be seen in most of the analyzed currencies: the domestic interest rate deviates quite often above the upper limit of return band indicating the ease of borrowing abroad to subsequently lend in the domestic market.

Thus, it seems that the results offer a wide variety of strategies in the countries under study when they link *de facto* to the ERM-II to try on the one hand to capture the benefits of their participation (helping actively to stabilize their economies-especially on

prices and consolidation of public accounts- and the increase in the governments reputation), moderating somewhat the potential problems arising from formal participation (*de iure*) in the ERM-II (primarily the possibility of currency appreciation episodes due to capital inflows, especially by foreign direct investment).

Acknowledgements

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Table 1: Expected depreciation of the exchange rates within band

	HRK/EUR	ISK/EUR	MKD/EUR	RSD/EUR	TRY/EUR
D1	-0.003522 (0.8439)	0.007063 (0.9641)	-0.003524 (0.5700)	0.127450 (0.2098)	-0.089752 (0.5724)
D2	-0.021324 (0.1915)	0.049520 (0.7122)	-0.002490 (0.5714)	0.017072 (0.8727)	-0.057929 (0.8004)
D3		0.139833 (0.4083)	0.000177 (0.9704)	0.135736 (0.0760)	-0.005681 (0.9427)
D4		-0.222335 (0.3939)			
D5		0.086730 (0.3249)			
X	-2.707117 (0.0000)	-5.215865 (0.0000)	-2.316721 (0.0000)	-2.313829 (0.0000)	-2.854239 (0.0000)
i	0.528323 (0.0052)	-1.488618 (0.2540)	0.001239 (0.9047)	-0.774275 (0.0582)	0.330268 (0.0667)
i^*	-0.658828 (0.2462)	2.771364 (0.4985)	0.067919 (0.3009)	0.470247 (0.8338)	-2.693158 (0.3155)

Note: In parentheses are the *p*-values.

Table 2: Estimation results of the Logit model

	HRK/EUR	ISK/EUR	RSD/EUR	TRY/EUR
Exchange rates				
δ_1	64.61155 (0.0003)	6.590385 (0.0000)	2.052755 (0.3674)	-1.72627 (0.0244)
δ_2	-8.32492 (0.0004)	-0.0296 (0.0002)	-0.00934 (0.7332)	1.951479 (0.0000)
Distance from the central parity				
δ_1	4.803055 (0.0000)	5.049467 (0.0000)	1.222223 (0.0258)	1.506624 (0.0000)
δ_2	-21.4428 (0.0001)	-0.23217 (0.0001)	0.037742 (0.8979)	-0.11528 (0.9699)
Distance from upper fluctuation band				
δ_1	-1.24819 (0.0627)	3.515918 (0.0000)	-0.53628 (0.3791)	-1.46351 (0.0039)
δ_2	19.70216 (0.0000)	-0.06973 (0.0005)	0.566905 (0.0031)	22.76037 (0.0000)
Interest rate differential with respect the Euro Zone				
δ_1	2.940181 (0.0000)	6.242408 (0.0000)	-0.27128 (0.6175)	4.009783 (0.0000)
δ_2	-0.25454 (0.0007)	-0.44553 (0.0001)	0.228895 (0.0140)	-0.07444 (0.0000)

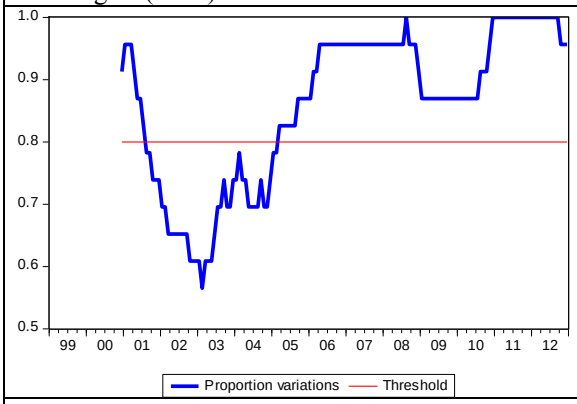
Note: In parentheses are the *p*-values.

Table 3: Statistical summary of the estimated probability

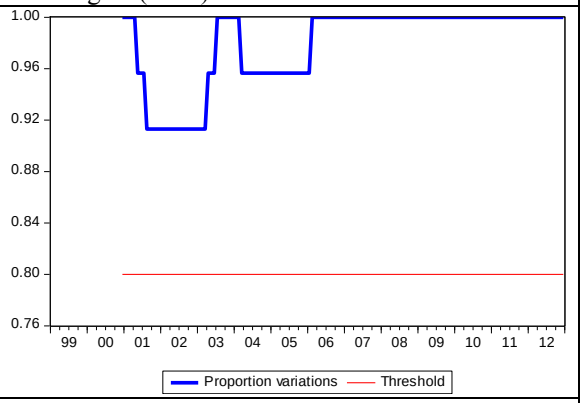
	HRK/EUR	ISK/EUR	RSD/EUR	TRY/EUR
Exchange rates				
Mean	0.902163	0.928571	0.615218	0.770263
Median	0.950657	0.981321	0.614669	0.848384
Maximum	0.995126	0.989358	0.622672	0.960117
Minimum	0.520204	0.117648	0.609374	0.270607
Stand. Dev.	0.10372	0.117855	0.003625	0.205216
Skewness	-1.730178	-4.363421	0.163113	-1.426692
Kurtosis	5.634162	27.38254	2.114819	3.564148
Distance from the central parity				
Mean	0.898459	0.928571	0.568754	0.816979
Median	0.959187	0.986932	0.616324	0.817231
Maximum	0.991489	0.993503	0.771734	0.818549
Minimum	0.066238	1.50E-06	0.081096	0.813317
Stand. Dev.	0.136508	0.200674	0.159309	0.001256
Skewness	-2.615899	-3.928106	-1.098939	-0.664928
Kurtosis	12.23315	17.31814	3.502515	2.458355
Distance from upper fluctuation band				
Mean	0.870379	0.928571	0.634303	0.776896
Median	0.964233	0.955976	0.631359	0.935811
Maximum	0.999957	0.971103	0.981583	0.999894
Minimum	0.270139	0.013745	0.315457	0.194498
Stand. Dev.	0.189686	0.123361	0.177598	0.275081
Skewness	-1.692494	-5.600464	0.217066	-0.906864
Kurtosis	4.664335	36.01787	2.121604	2.177548
Interest rate differential with respect the Euro Zone				
Mean	0.899281	0.928571	0.634246	0.816901
Median	0.946029	0.96123	0.844243	0.950689
Maximum	0.972258	0.994657	0.996195	0.973296
Minimum	0.212803	0.271191	0.093296	0.01992
Stand. Dev.	0.107486	0.116833	0.35239	0.274191
Skewness	-3.107716	-3.836332	-0.442684	-1.850246
Kurtosis	16.38224	19.25068	1.485846	4.980048

Figure 1: Detection of *de facto* fluctuation bands of Croatian kuna

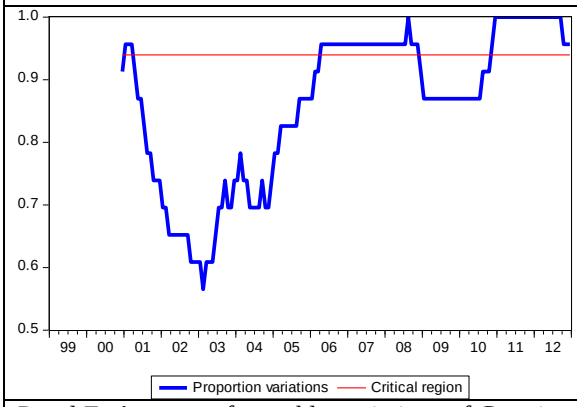
Panel A: Probability of monthly variations of Croatian kuna within bands of 1% using Reinhart and Rogoff (2004)'s method.



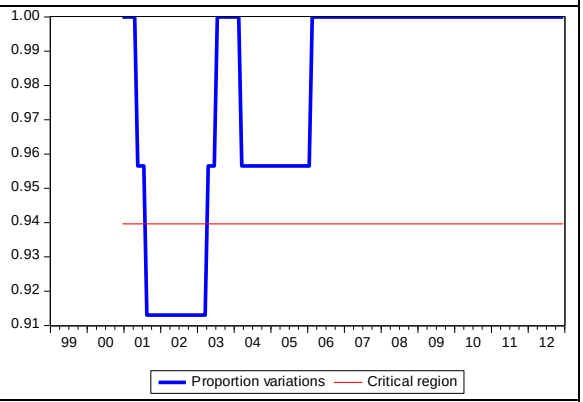
Panel B: Probability of monthly variations of Croatian kuna within bands of 2% using Reinhart and Rogoff (2004)'s method.



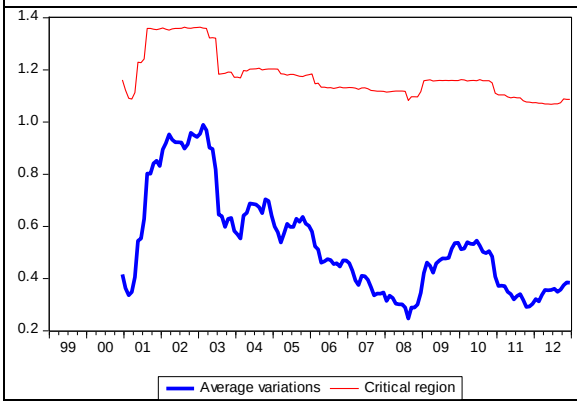
Panel C: Probability of monthly variations of Croatian kuna within bands of 1% using statistical test in the Reinhart and Rogoff (2004)'s method.



Panel D: Probability of monthly variations of Croatian kuna within bands of 2% using statistical test in the Reinhart and Rogoff (2004)'s method.



Panel E: Average of monthly variations of Croatian kuna within bands of 1% using Ledesma-Rodríguez *et al.* (2005b)'s method.



Panel F: Average of monthly variations of Croatian kuna within bands of 2% using Ledesma-Rodríguez *et al.* (2005b)'s method.

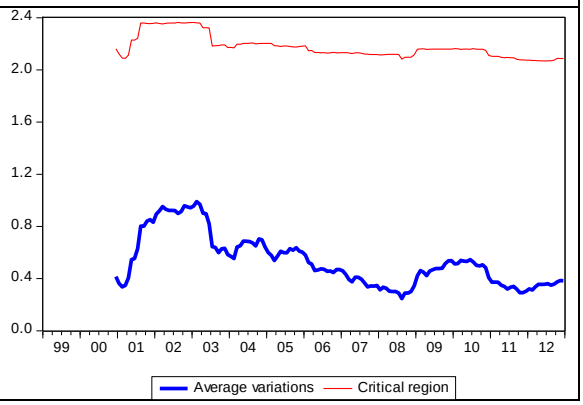
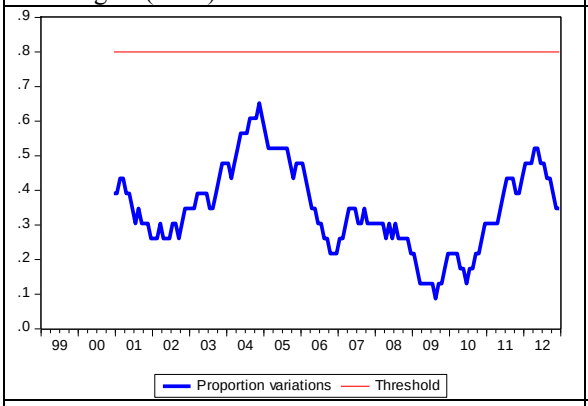
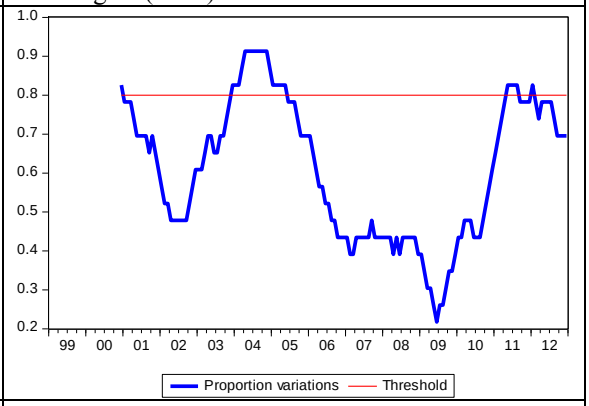


Figure 2: Detection of *de facto* fluctuation bands of Icelandic krona

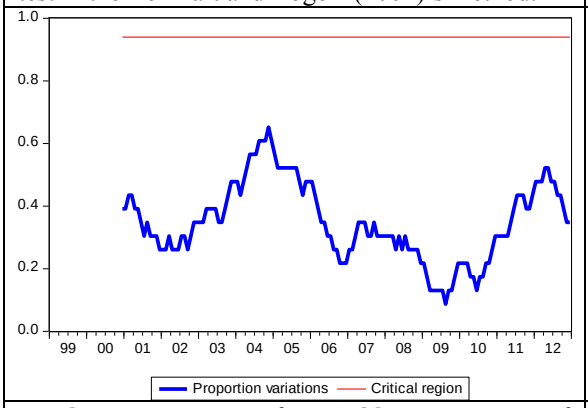
Panel A: Probability of monthly variations of Icelandic krona within bands of 1% using Reinhart and Rogoff (2004)'s method.



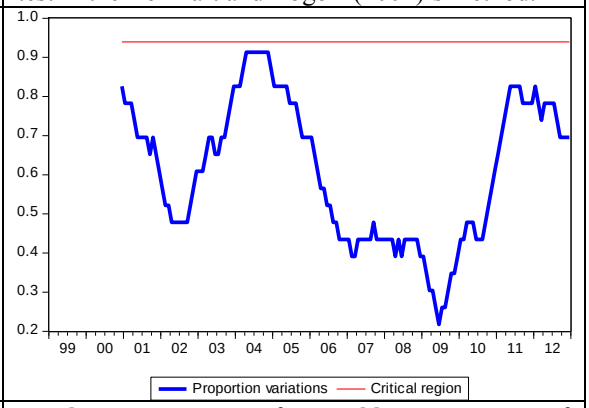
Panel B: Probability of monthly variations of Icelandic krona within bands of 2% using Reinhart and Rogoff (2004)'s method.



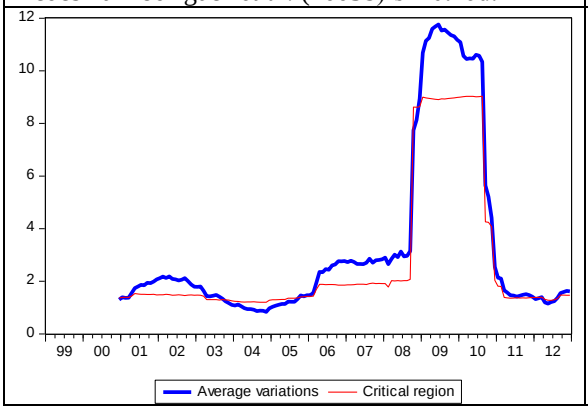
Panel C: Probability of monthly variations of Icelandic krona within bands of 1% using statistical test in the Reinhart and Rogoff (2004)'s method.



Panel D: Probability of monthly variations of Icelandic krona within bands of 2% using statistical test in the Reinhart and Rogoff (2004)'s method.



Panel E: Average of monthly variations of Icelandic krona within bands of 1% using Ledesma-Rodríguez *et al.* (2005b)'s method.



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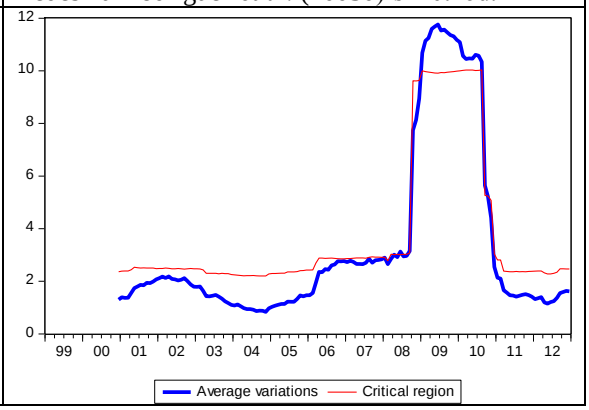
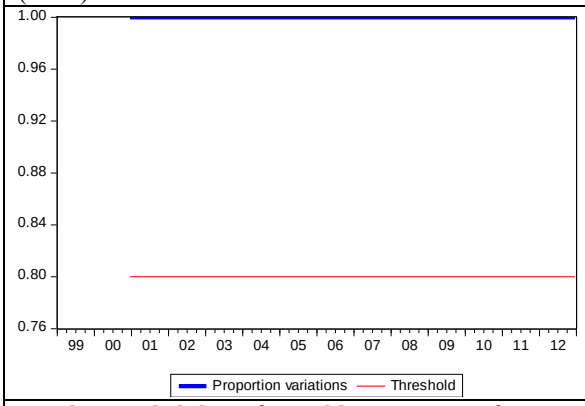
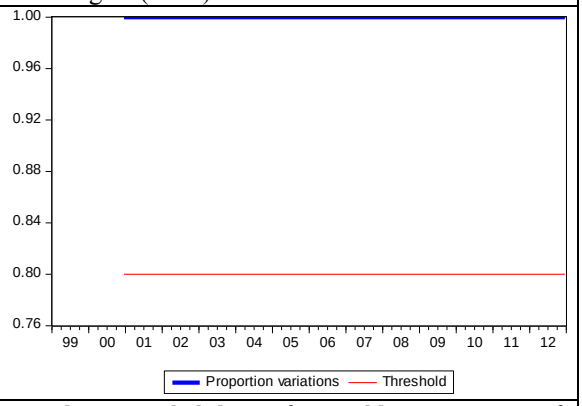


Figure 3: Detection of *de facto* fluctuation bands of Denar (of the former Yugoslav Republic of Macedonia)

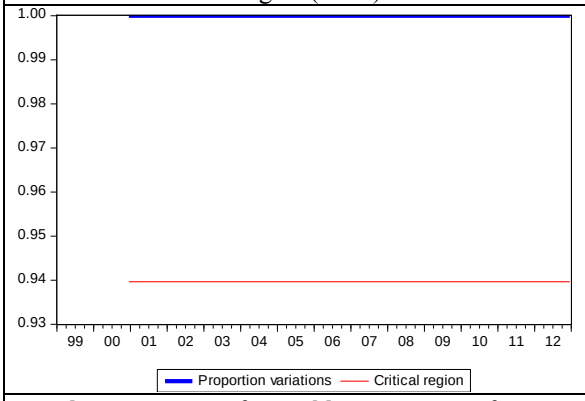
Panel A: Probability of monthly variations of Denar (of the former Yugoslav Republic of Macedonia) within bands of 1% using Reinhart and Rogoff (2004)'s method.



Panel B: Probability of monthly variations of Denar (of the former Yugoslav Republic of Macedonia) within bands of 2% using Reinhart and Rogoff (2004)'s method.



Panel C: Probability of monthly variations of Denar (of the former Yugoslav Republic of Macedonia)within bands of 1% using statistical test in the Reinhart and Rogoff (2004)'s method.



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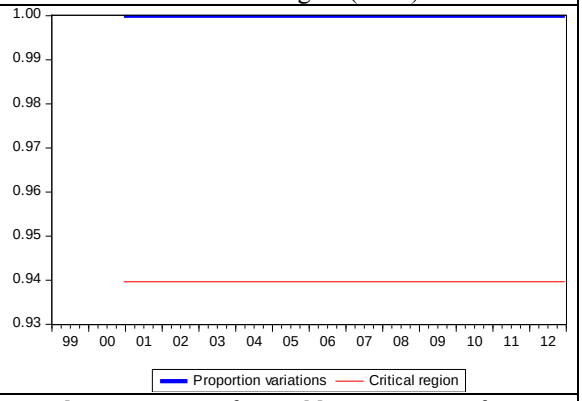
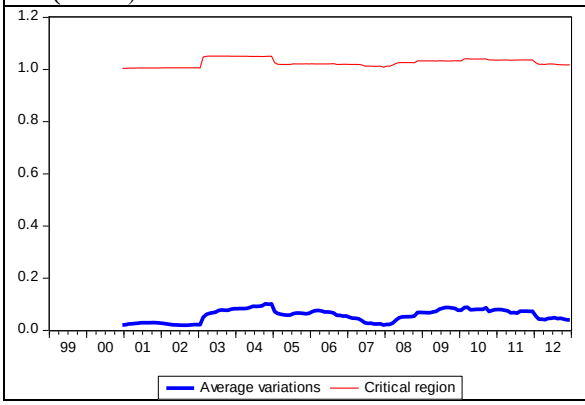


Panel E: Average of monthly variations of Denar (of the former Yugoslav Republic of Macedonia) within bands of 1% using Ledesma-Rodríguez *et al.* (2005b)'s method.



Panel F: Average of monthly variations of Denar (of the former Yugoslav Republic of Macedonia) within bands of 2% using Ledesma-Rodríguez *et al.* (2005b)'s method.

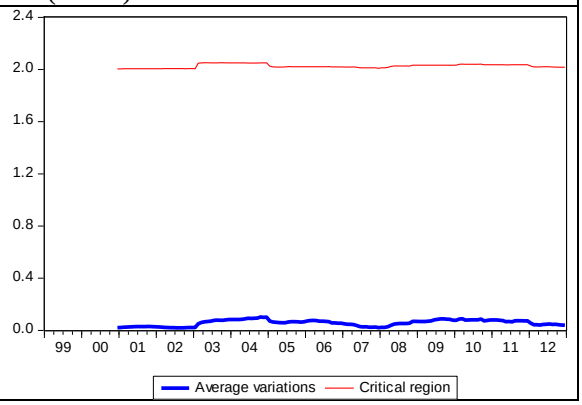
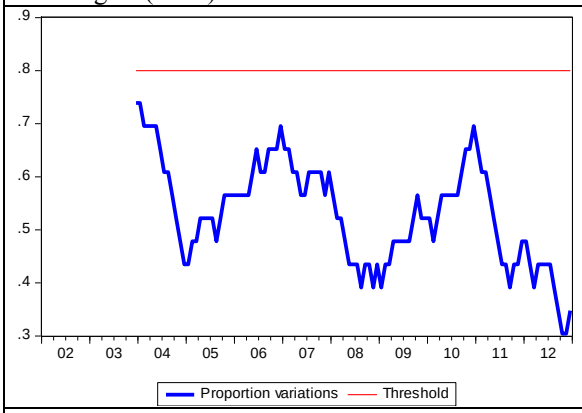
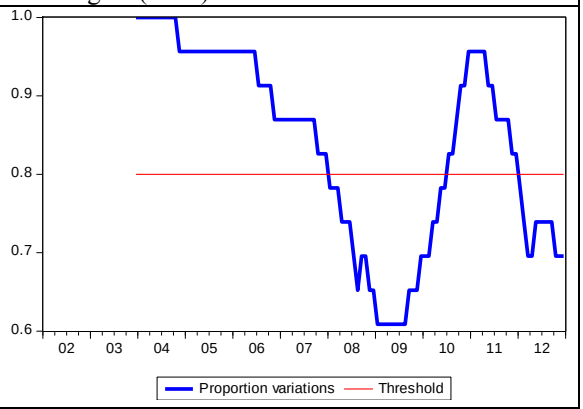


Figure 4: Detection of *de facto* fluctuation bands of Serbian dinar

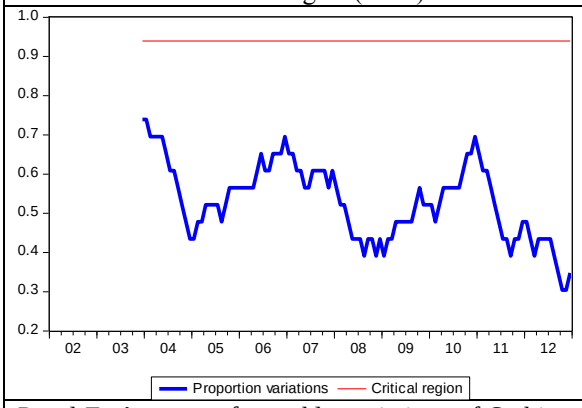
Panel A: Probability of monthly variations of Serbian dinar within bands of 1% using Reinhart and Rogoff (2004)'s method.



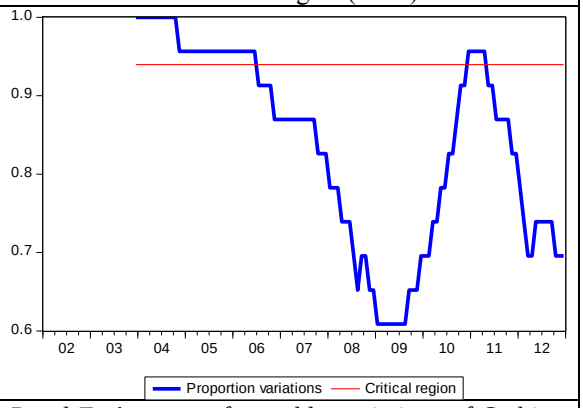
Panel B: Probability of monthly variations of Serbian dinar within bands of 2% using Reinhart and Rogoff (2004)'s method.



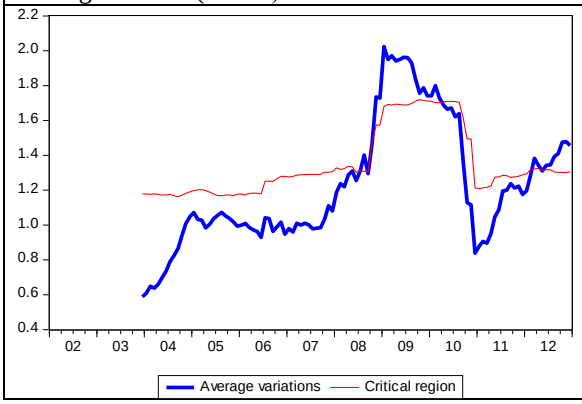
Panel C: Probability of monthly variations of Serbian dinar within bands of 1% using statistical test in the Reinhart and Rogoff (2004)'s method.



Panel D: Probability of monthly variations of Serbian dinar within bands of 2% using statistical test in the Reinhart and Rogoff (2004)'s method.



Panel E: Average of monthly variations of Serbian dinar within bands of 1% using Ledesma-Rodríguez *et al.* (2005b)'s method.



Panel F: Average of monthly variations of Serbian dinar within bands of 2% using Ledesma-Rodríguez *et al.* (2005b)'s method.

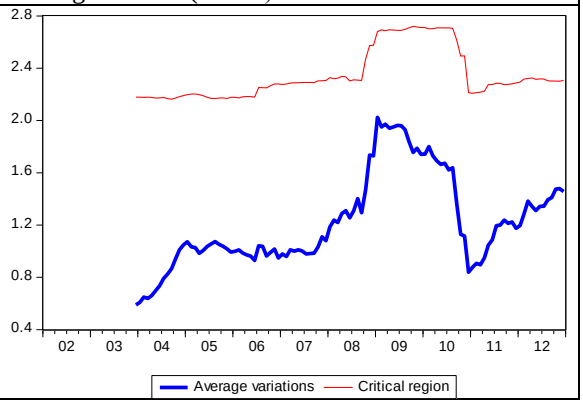
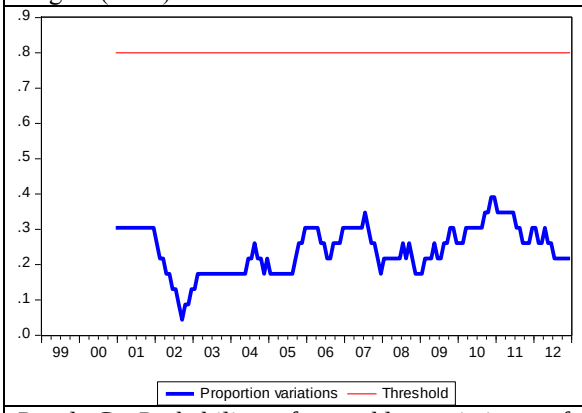
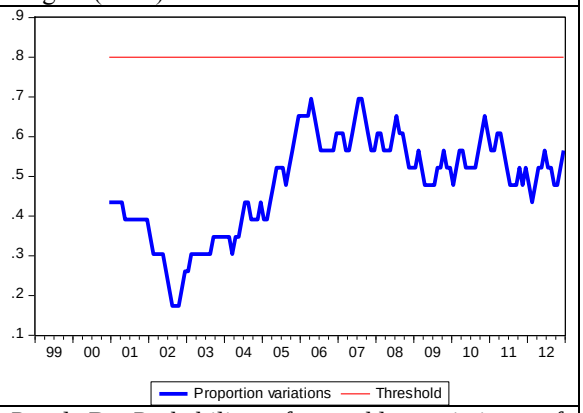


Figure 5: Detection of *de facto* fluctuation bands of Turkish lira

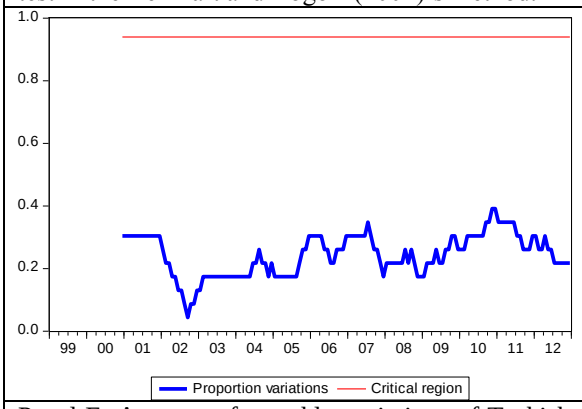
Panel A: Probability of monthly variations of Turkish lira within bands of 1% using Reinhart and Rogoff (2004)'s method.



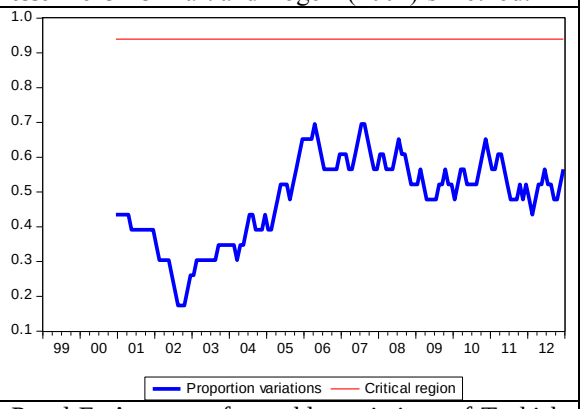
Panel B: Probability of monthly variations of Turkish lira within bands of 2% using Reinhart and Rogoff (2004)'s method.



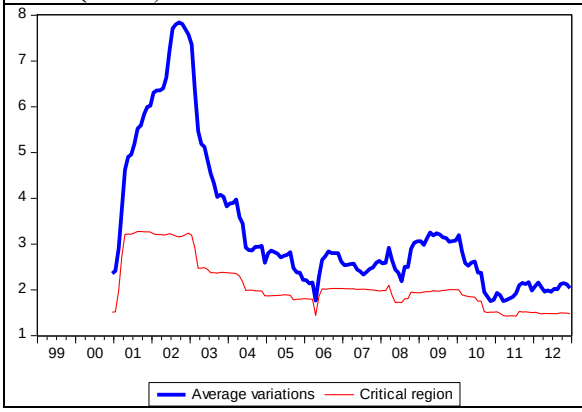
Panel C: Probability of monthly variations of Turkish lira within bands of 1% using statistical test in the Reinhart and Rogoff (2004)'s method.



Panel D: Probability of monthly variations of Turkish lira within bands of 2% using statistical test in the Reinhart and Rogoff (2004)'s method.



Panel E: Average of monthly variations of Turkish lira within bands of 1% using Ledesma-Rodríguez *et al.* (2005b)'s method.



Panel F: Average of monthly variations of Turkish lira within bands of 2% using Ledesma-Rodríguez *et al.* (2005b)'s method.

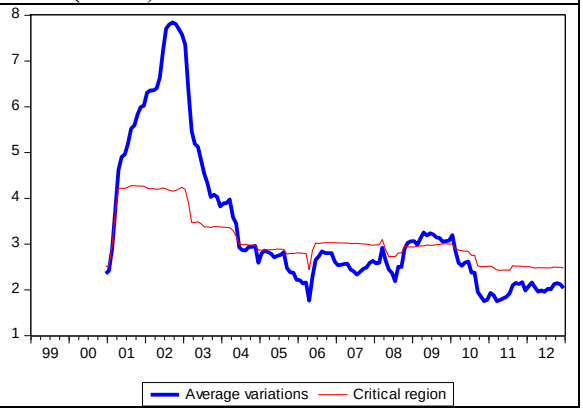
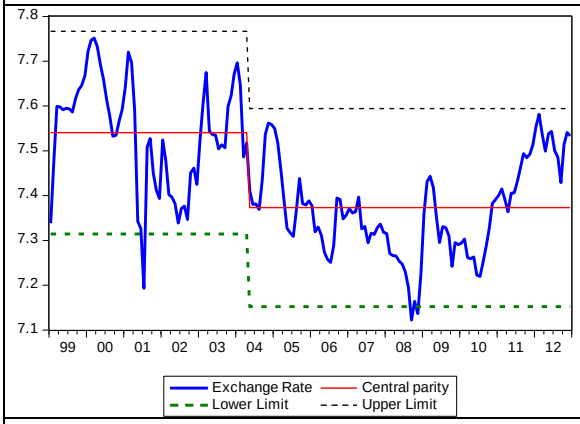
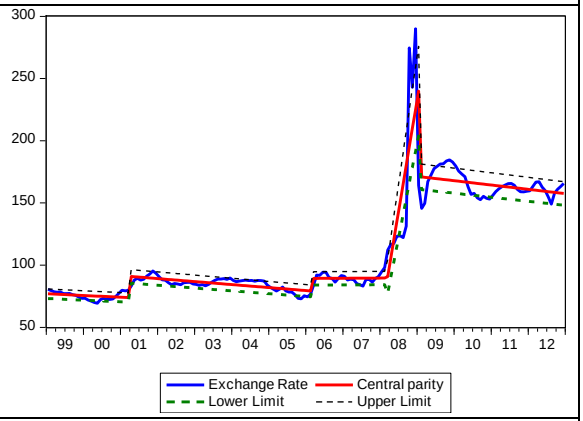


Figure 6: Evolution of the exchange rates *vis-à-vis* the euro, their central parities and their fluctuation bands

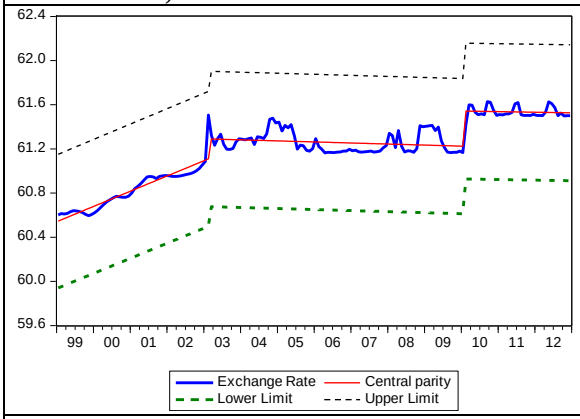
Panel A: Croatian kuna



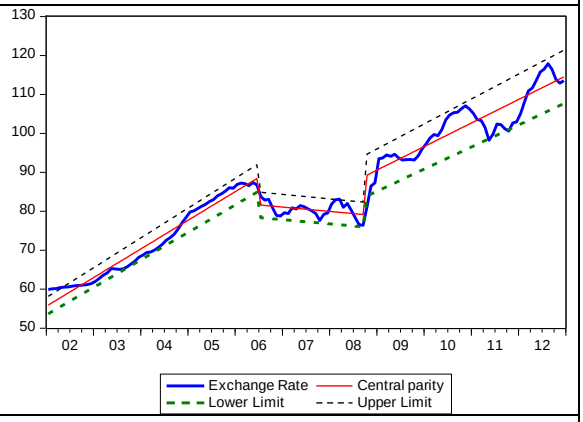
Panel B: Icelandic krona



Panel C: Denar (of the former Yugoslav Republic of Macedonia)



Panel D: Serbian dinar



Panel E: Turkish lira

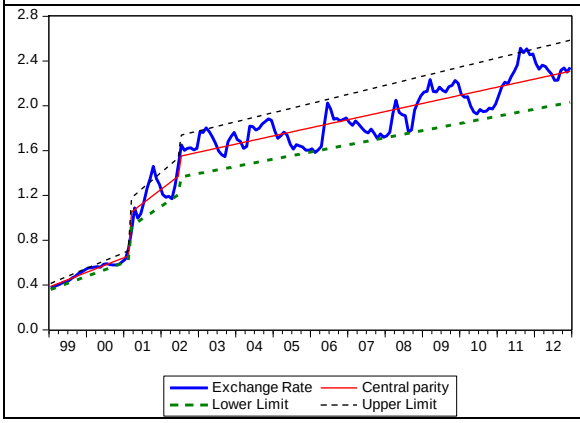
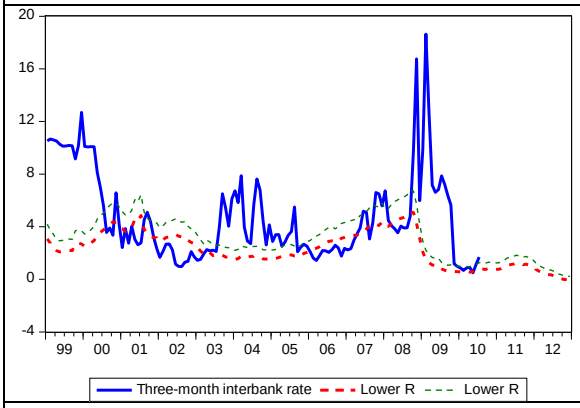
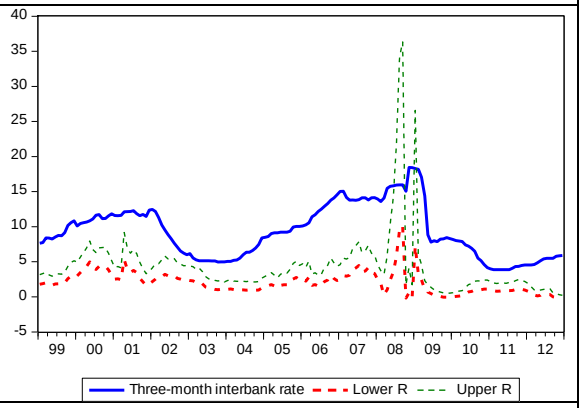


Figure 7: Svensson (1991)´s credibility test of the exchange rate fluctuation bands *vis-à-vis* the euro

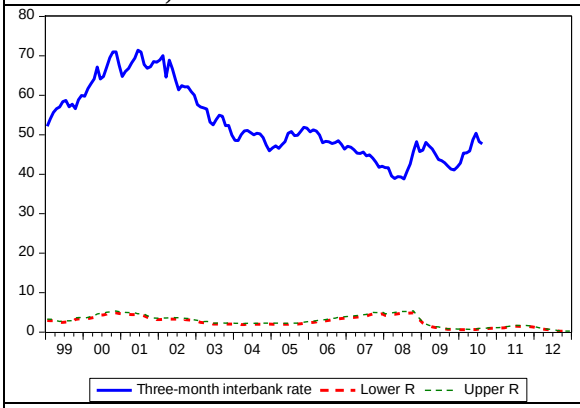
Panel A: Croatian kuna



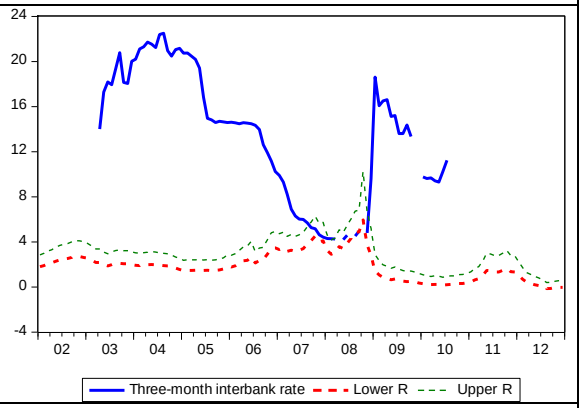
Panel B: Icelandic krona



Panel C: Denar (of the former Yugoslav Republic of Macedonia)



Panel D: Serbian dinar



Panel E: Turkish lira

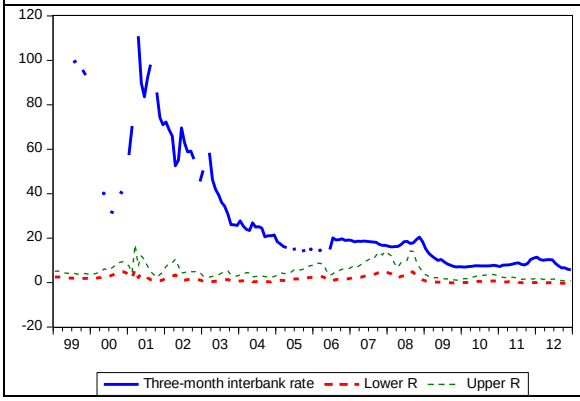
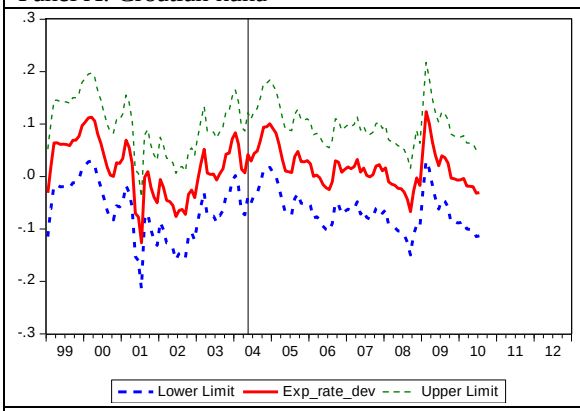
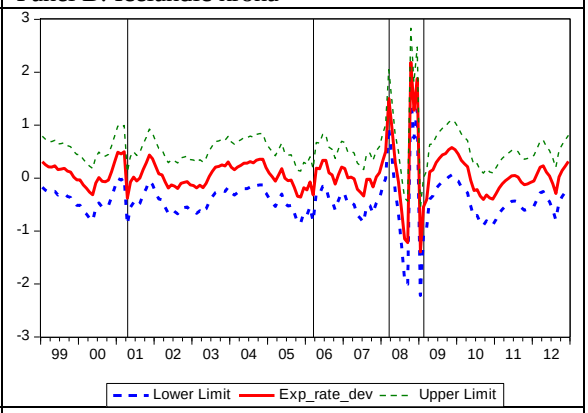


Figure 8: Expected realignment rate of the exchange rates *vis-à-vis* the euro and its confidence interval at 90%

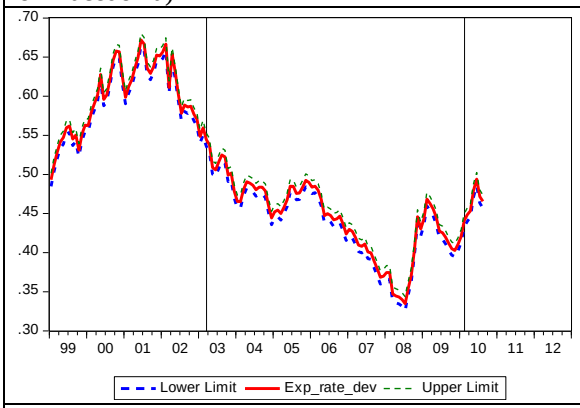
Panel A: Croatian kuna



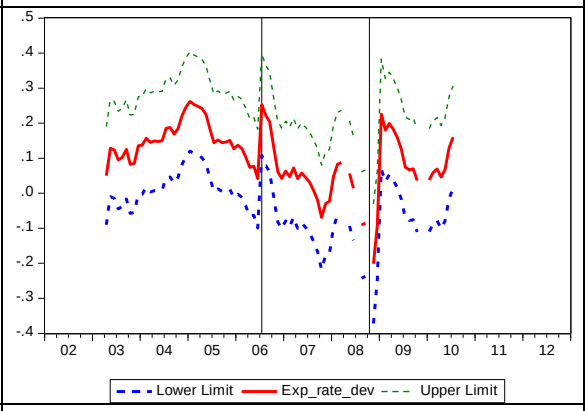
Panel B: Icelandic krona



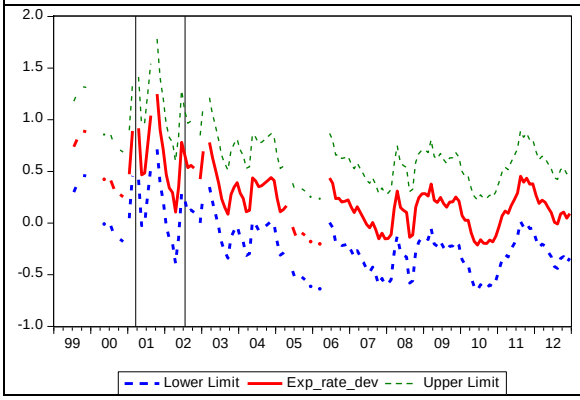
Panel C: Denar (of the former Yugoslav Republic of Macedonia)



Panel D: Serbian dinar

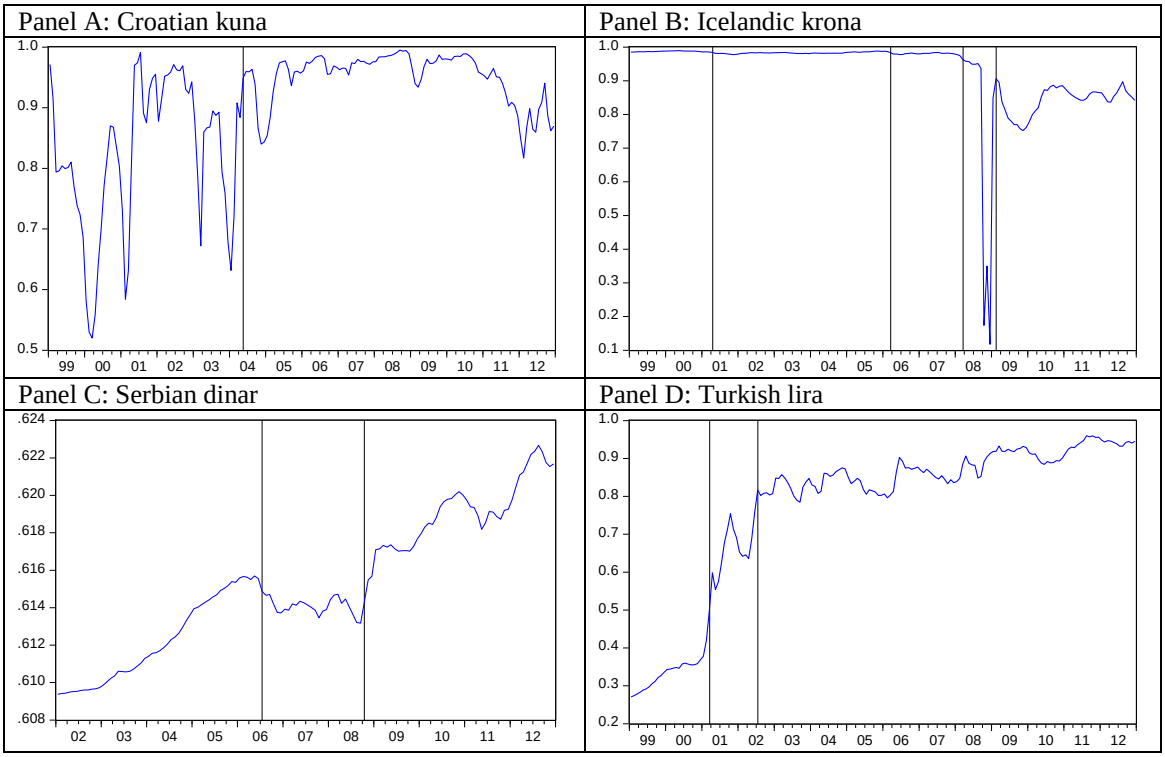


Panel E: Turkish lira



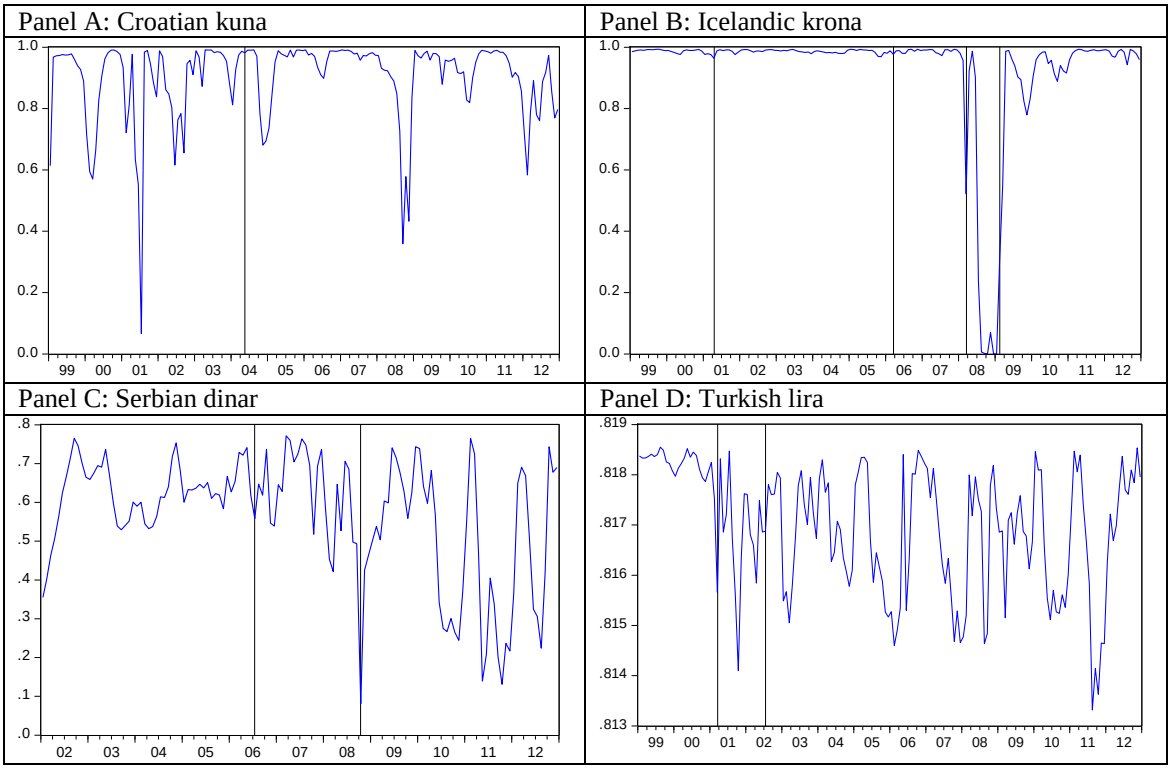
Notes: The vertical lines correspond to realignments and bands extensions.

Figure 9: Estimated realignment probability of the exchange rates *vis-à-vis* the euro based on its exchange rates *vis-à-vis* the euro



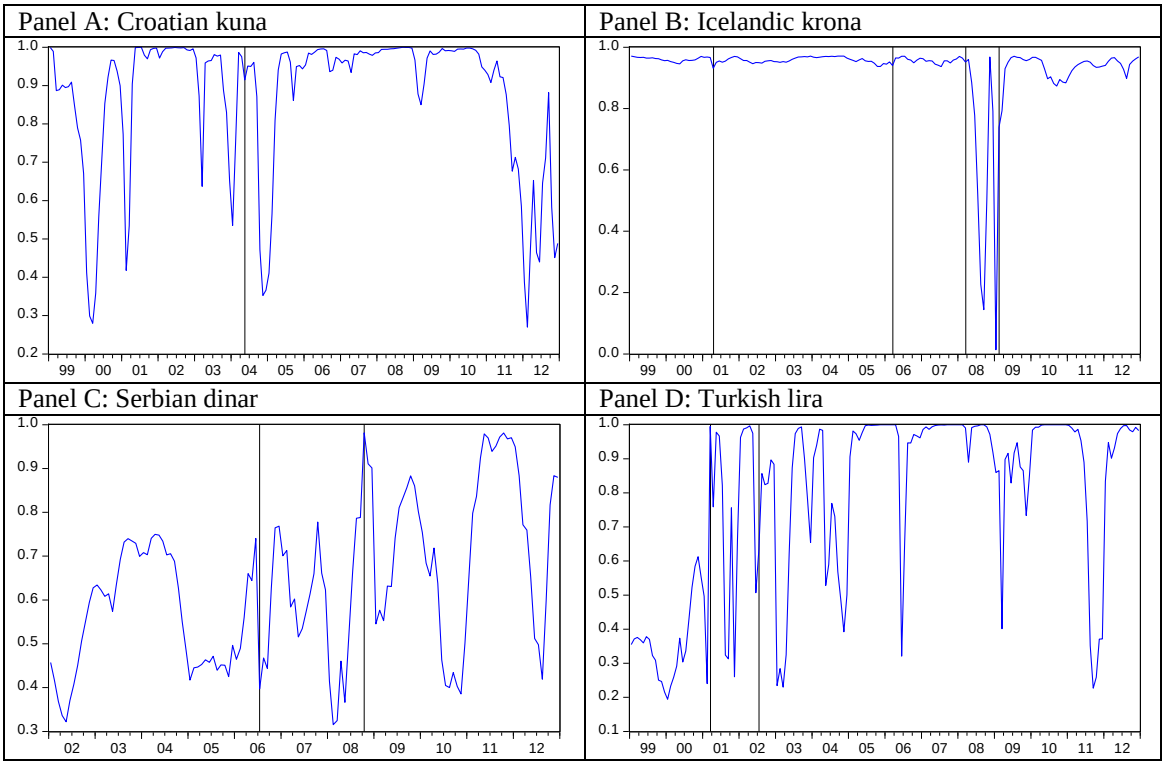
Notes: The vertical lines correspond to realignments and bands extensions.The exchange rates whose dependent variable always takes the same value (either one or zero) is not possible to represent them graphically since this procedure is not able to be applied.

Figure 10: Estimated realignment probability of the exchange rates *vis-à-vis* the euro based on the distance from the central parity



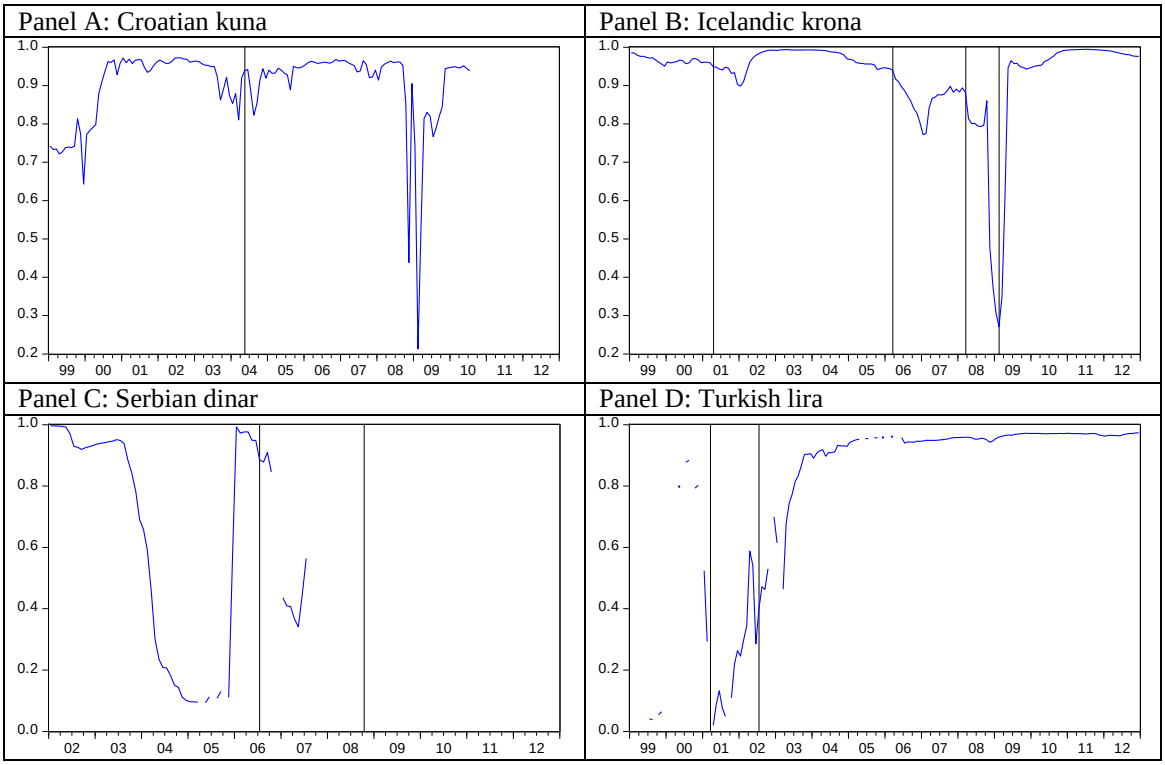
Notes: The vertical lines correspond to realignments and bands extensions. The exchange rates whose dependent variable always takes the same value (either one or zero) is not possible to represent them graphically since this procedure is not able to be applied.

Figure 11: Estimated realignment probability of the exchange rates *vis-à-vis* the euro based on the distance from the upper fluctuation band



Notes: The vertical lines correspond to realignments and bands extensions. The exchange rates whose dependent variable always takes the same value (either one or zero) is not possible to represent them graphically since this procedure is not able to be applied.

Figure 12: Estimated realignment probability of the exchange rates *vis-à-vis* the euro based on the interest rate differential with respect to the Euro Zone



Notes: The vertical lines correspond to realignments and bands extensions. The exchange rates whose dependent variable always takes the same value (either one or zero) is not possible to represent them graphically since this procedure is not able to be applied.