Detection of implicit fluctuation bands in the European Union countries

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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 for twelve European countries. Our results would suggest that implicit bands have existed in many sub-periods for almost all currencies under study. This paper provides 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.

Keywords: Exchange-rate regimes, Implicit fluctuation bands, Exchange rates.

JEL classification: F31, F33.

I. Introduction

In this paper we investigate the presence of implicit fluctuation bands through three alternative sequential procedures based on the dynamics of monthly exchange rate during the period 1999-2012. We examine economies that already belongs to the European Union (EU), both which joined on 1 May 2004 (Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia), as which they did on January 1, 2007 (Bulgaria and Romania).

Given that the purpose of the EU Member States is to move to the next phase of the integration process (it means to join the Economic and Monetary Union, EMU), an improvement should be observed in the commitment of these economies, since once became part of EMU 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 will occur.

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 purpose is 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 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 twelve countries mentioned above.

This paper is organized as follows. In Section II, we present three different statistical procedures based on the evolution of the exchange rates *vis-à-vis* the euro used to detect implicit fluctuation bands. Section III offers the empirical results country by country for the twelve candidate countries covering the period 1999-2012. Finally, in Section IV some concluding remarks are provided.

II. Methodology

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 *et al.* (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 *et al*. (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.

III. Detection of implicit fluctuation bands

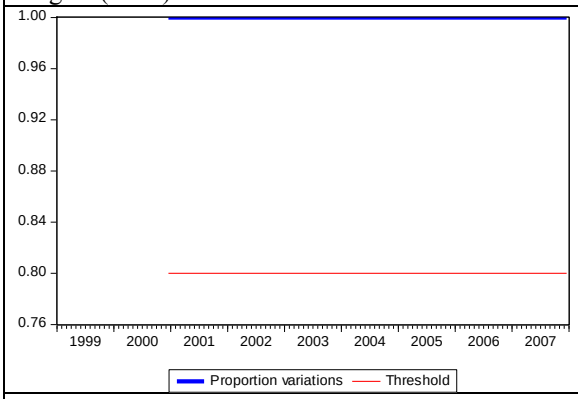
In this sub-section we proceed to the detection of *de facto* fluctuation bands of the exchange rates for the five countries during the period 1999:01-2012:12 using the three sequential procedures. The monthly exchange rates are spot rates expressed as domestic monetary units per euro and have been downloaded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

Cyprus: Following Reinhart and Rogoff (2004) criteria, it can be detected that the probability that the monthly percentage variation of the absolute value of the exchange rate Cyprus pound/Euro (CYP/EUR) is clearly higher than the established threshold, both in the case ± 1% and ± 2% bands [Fig. 1 (a) and (b), respectively]. This result indicates the existence of such implicit fluctuation bands during the whole period, therefore satisfying the requirement of exchange-rate stability that allowed Cyprus to

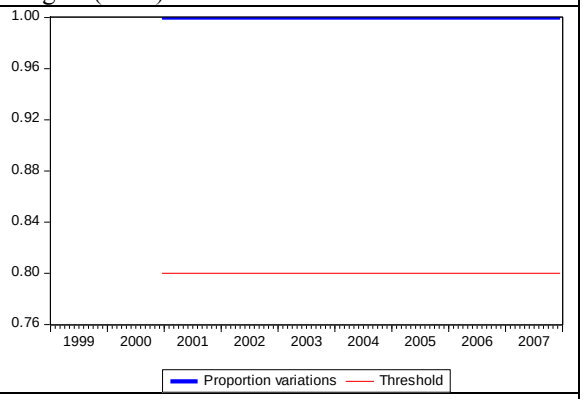
join EMU on January, 1st 2008. This result is further reinforced by the statistical test on such probability [see Fig. 1 (c) and (d), where the proportion of monthly percentage variation exceeds both critical region]. Finally, the last indicator based directly upon the statistical test over the absolute percentage variation of the Cyprus pound/Euro exchange rate also suggests the presence of implicit ±1% and ±2% fluctuation bands in all the sample period [Fig. 1 (e) and (f), respectively].

Fig. 1: Detection of *de facto* fluctuation bands of Cyprus pound

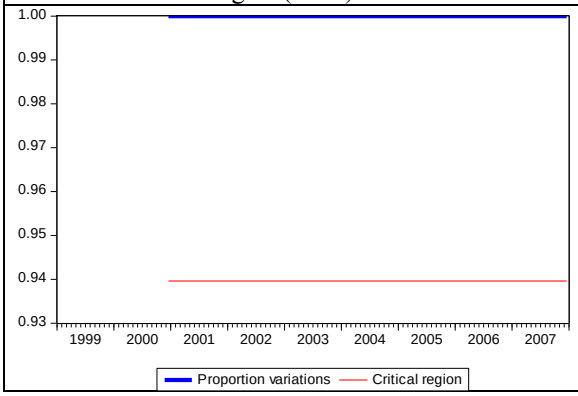
(a): Probability of monthly variations of Cyprus pound within bands of 1% using Reinhart and Rogoff (2004)'s method.



(b): Probability of monthly variations of Cyprus pound within bands of 2% using Reinhart and Rogoff (2004)'s method.



(c): Probability of monthly variations of Cyprus pound within bands of 1% using statistical test in the Reinhart and Rogoff (2004)'s method.



(d): Probability of monthly variations of Cyprus pound within bands of 2% using statistical test in the Reinhart and Rogoff (2004)'s method.

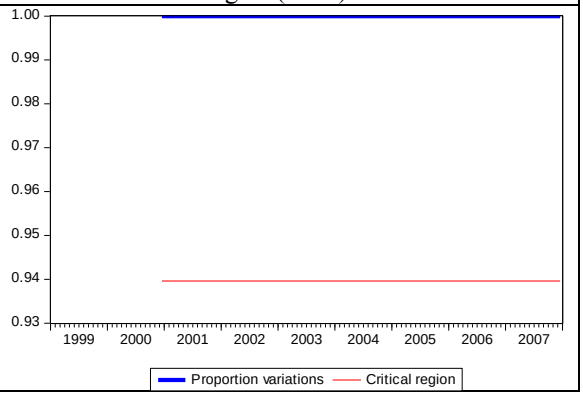
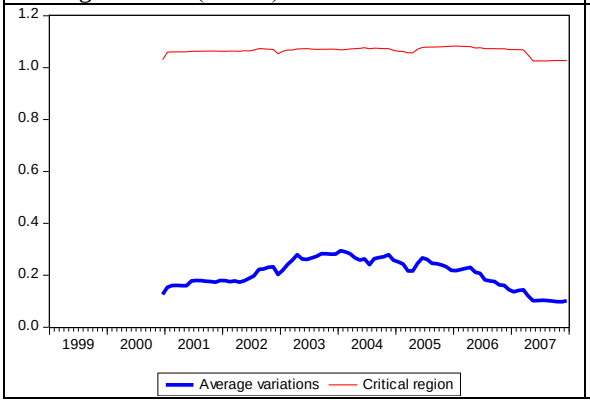
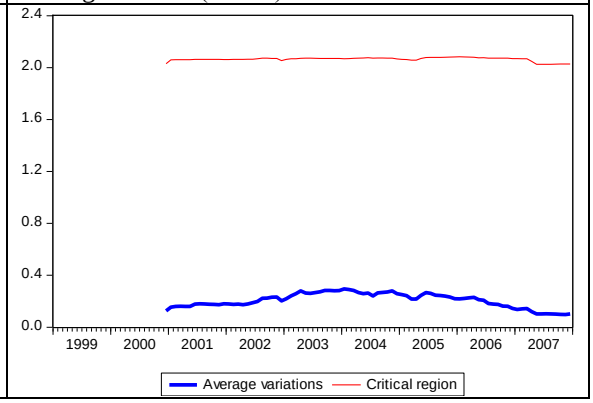


Fig. 1: Detection of *de facto* fluctuation bands of Cyprus pound (continuation)

(e): Average of monthly variations of Cyprus pound within bands of 1% using Ledesma-Rodríguez *et al.* (2005b)'s method.



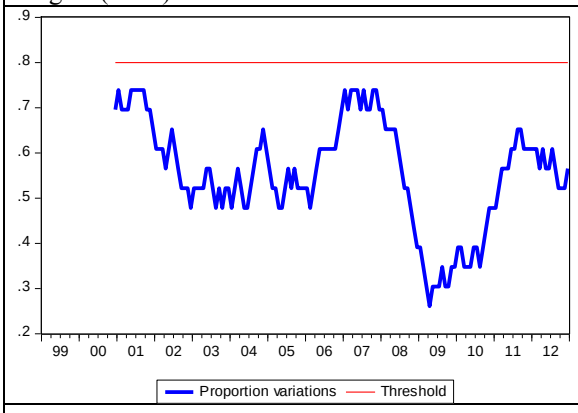
(f): Average of monthly variations of Cyprus pound within bands of 2% using Ledesma-Rodríguez *et al.* (2005b)'s method.



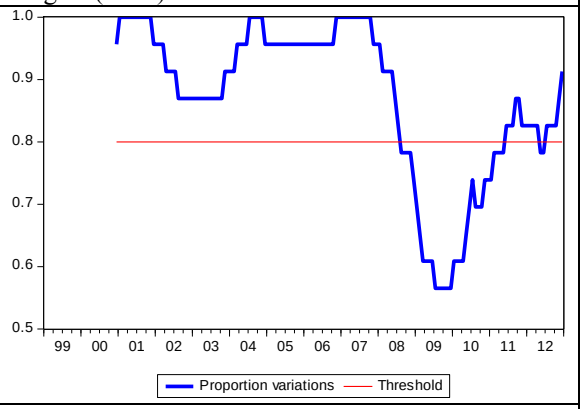
Czech Republic: Even we do not find evidence of existence of implicit ±1% fluctuation bands in the Czech koruna/Euro exchange rate (CZK/EUR) for any sub-period [Fig. 2 (a)] also empirically tested in Fig. 2 (c), the probability that its percentage variations exceeds the threshold for ±2% fluctuation bands occurs in a 65.50% of the sample period (1999:01-2008:07, 2011:06-2012:04 and 2012:07-2012:12). The test proposed by Ledesma-Rodríguez *et al*. (2005a) is even more selective, detecting that only in 36.84% of the sample the probability of being within a ±2% fluctuation bands is higher than 80%. As can be seen in Fig. 2 (d), the following sub-periods are identified: 1999:01-2002:03 and 2004:03-2008:01. Finally, our last criteria to detect the possibility of *de facto* fixed exchange-rate regime indicate the presence of ±1% fluctuation bands in a 71.93% of the sample period [1999:01-2008:10 and 2010:12-2012:12, Fig. 2 (e) and ±2% fluctuation bands for the whole sample under study, Fig. 2 (f)].

Fig. 2: Detection of *de facto* fluctuation bands of Czech koruna

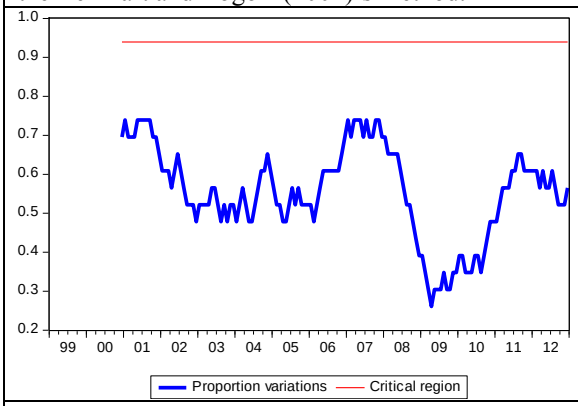
(a): Probability of monthly variations of Czech koruna within bands of 1% using Reinhart and Rogoff (2004)'s method.



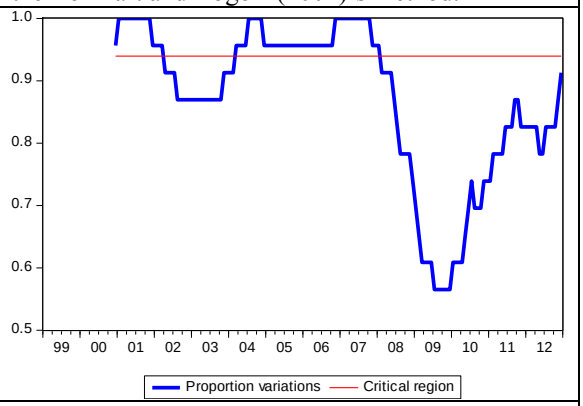
(b): Probability of monthly variations of Czech koruna within bands of 2% using Reinhart and Rogoff (2004)'s method.



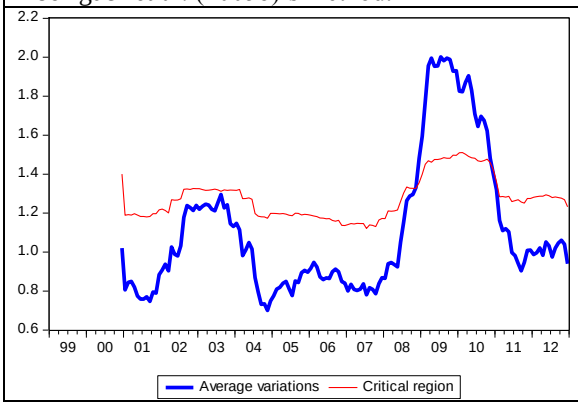
(c): Probability of monthly variations of Czech koruna within bands of 1% using statistical test in the Reinhart and Rogoff (2004)'s method.



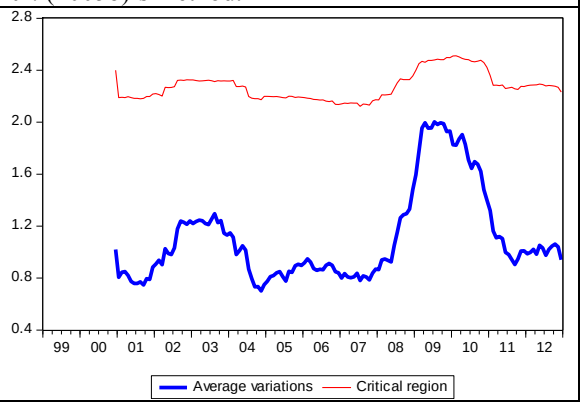
(d): Probability of monthly variations of Czech koruna within bands of 2% using statistical test in the Reinhart and Rogoff (2004)'s method.



(e): Average of monthly variations of Czech koruna within bands of 1% using Ledesma-Rodríguez *et al.* (2005b)'s method.



(f): Average of monthly variations of Czech koruna within bands of 2% using Ledesma-Rodríguez *et al.* (2005b)'s method.

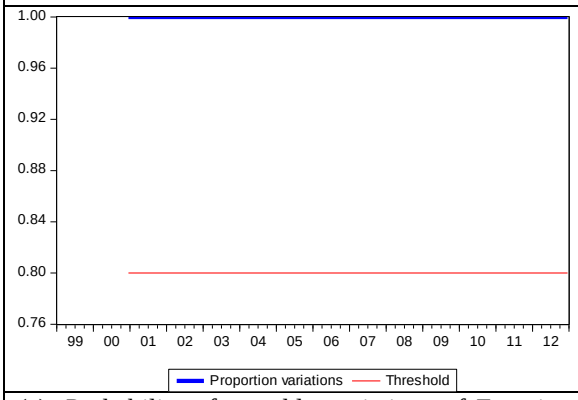


Estonia: The three sequential procedures used to detect the existence of *de facto* fluctuation bands identify a *currency board*, the exchange-rate regime established for

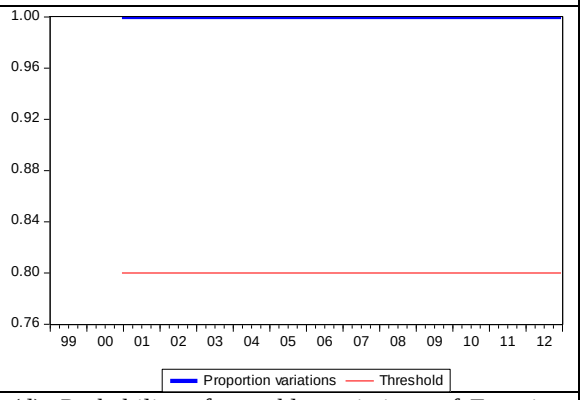
the Estonian kroon in 1992. This detection is based upon the identification of ±1% and ±2% fluctuation bands during the whole sample period [see Fig. 3 (b), (d), (f) and (a), (c), (e), respectively].

Fig. 3: Detection of *de facto* fluctuation bands of Estonian kroon

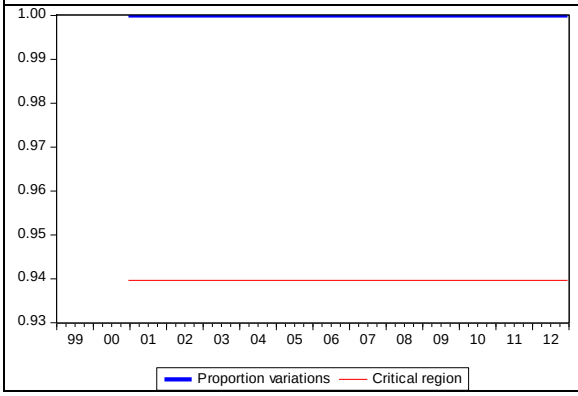
(a): Probability of monthly variations of Estonian kroon within bands of 1% using Reinhart and Rogoff (2004)'s method.



(b): Probability of monthly variations of Estonian kroon within bands of 2% using Reinhart and Rogoff (2004)'s method.



(c): Probability of monthly variations of Estonian kroon within bands of 1% using statistical test in the Reinhart and Rogoff (2004)'s method.



(d): Probability of monthly variations of Estonian kroon within bands of 2% using statistical test in the Reinhart and Rogoff (2004)'s method.

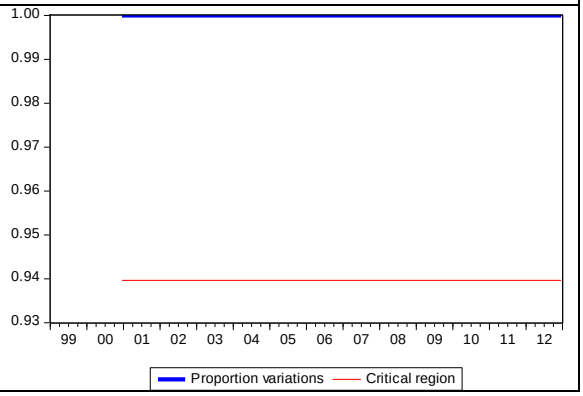
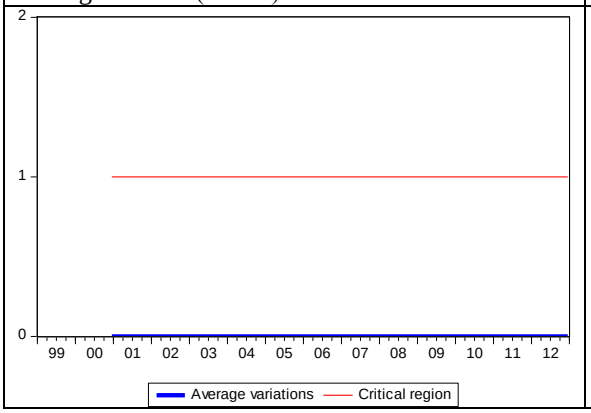
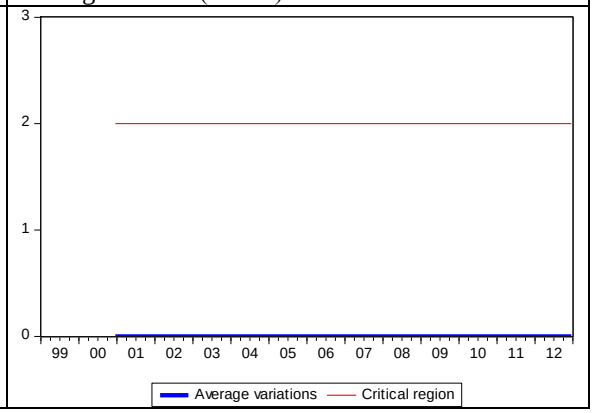


Fig. 3: Detection of *de facto* fluctuation bands of Estonian kroon (continuation)

(e): Average of monthly variations of Estonian kroon within bands of 1% using Ledesma-Rodríguez *et al.* (2005b)'s method.



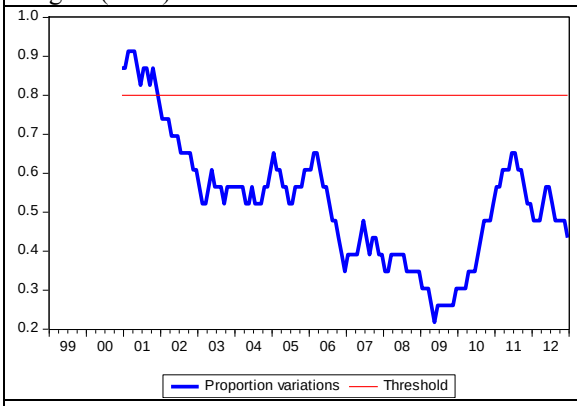
(f): Average of monthly variations of Estonian kroon within bands of 2% using Ledesma-Rodríguez *et al.* (2005b)'s method.



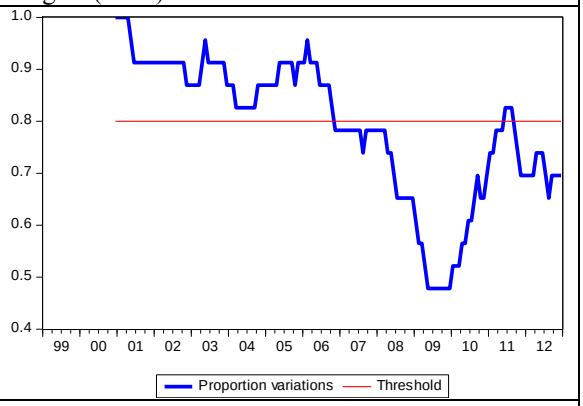
Hungary: When examining the presence of ±1% fluctuation bands, only for the 7.02% of the sample (1999:01-2001:11) we find that the probability that the percentage variation of the Hungarian forint/Euro exchange rate (HUF/EUR) exceeds the 80% threshold established by Reinhart and Rogoff (2004) [Fig. 4 (a)]. This result is rejected when we use the formal statistical test based on this probability, since we do not detect any sub-period where the percentage variation in the exchange rate is within such bands [Fig. 4 (c)]. On the contrary, applying the procedure suggested by Ledesma-Rodríguez *et al.* (2005b), nearly half of the sample (46.78%) is associated with ±1% fluctuation bands (1999:01-2006:10 and 2011:03-2011:10) as can be seen in Fig. 4 (e). The same contradictory picture emerges when we examine the possible existence of ±2% fluctuation bands: the sub-periods identified by the first method (1999:01-2006:10 and 2011:06-2011:08) represent a 43.27% of the sample period, while when using the second method only detects such bands in 4.68% of the sample period (1999:01-2001:05, 2003:05 and 2006:02). Finally, and in contrast with the two previous criteria, the method proposed by Ledesma-Rodríguez *et al.* (2005b) indicates the existence of implicit ±2% fluctuation bands in the whole sample under examination [Fig. 4 (f)].

Fig. 4: Detection of *de facto* fluctuation bands of Hungarian forint

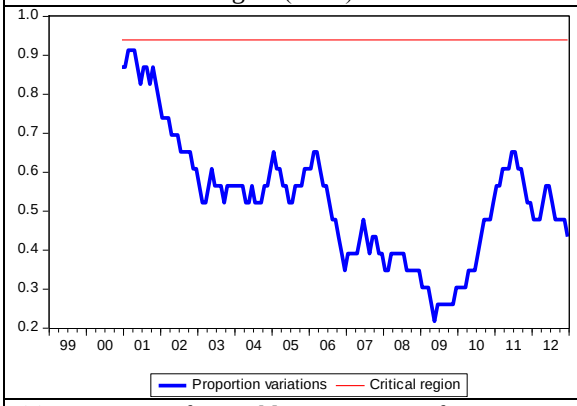
(a): Probability of monthly variations of Hungarian forint within bands of 1% using Reinhart and Rogoff (2004)'s method.



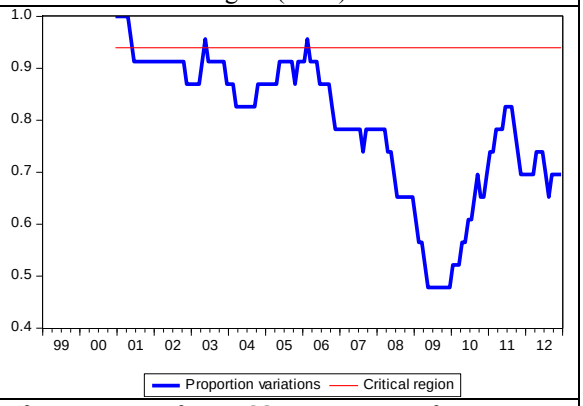
(b): Probability of monthly variations of Hungarian forint within bands of 2% using Reinhart and Rogoff (2004)'s method.



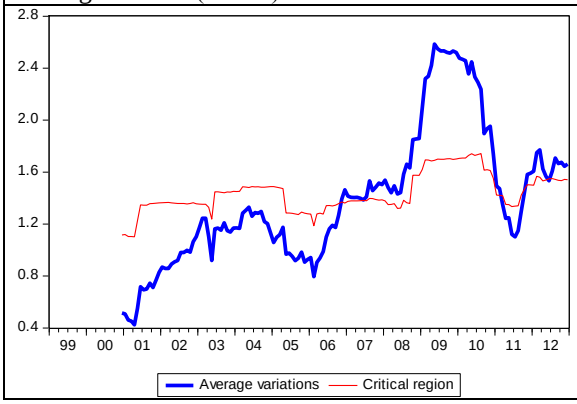
(c): Probability of monthly variations of Hungarian forint within bands of 1% using statistical test in the Reinhart and Rogoff (2004)'s method.



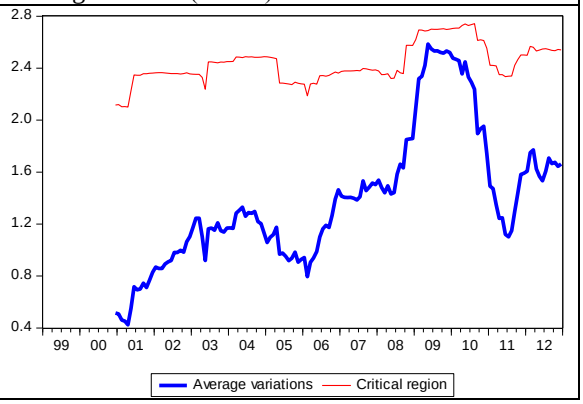
(d): Probability of monthly variations of Hungarian forint within bands of 2% using statistical test in the Reinhart and Rogoff (2004)'s method.



(e): Average of monthly variations of Hungarian forint within bands of 1% using Ledesma-Rodríguez *et al.* (2005b)'s method.



(f): Average of monthly variations of Hungarian forint within bands of 2% using Ledesma-Rodríguez *et al.* (2005b)'s method.

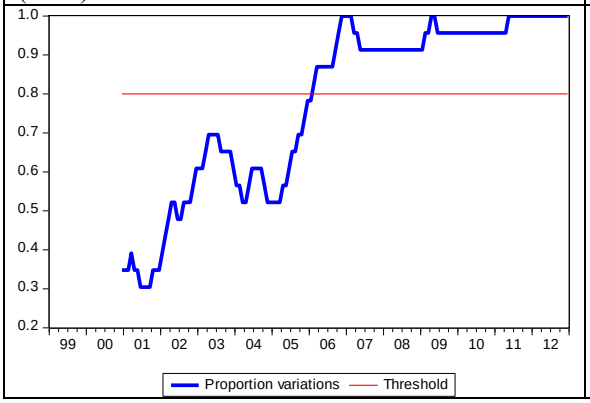


Latvia: The formal statistical test delimits further sub-periods in which the evolution of the Latvian lat/Euro exchange rate (LVL/EUR) is bounded by ± 1% or ± 2% fluctuation bands compared to Reinhart and Rogoff (2004) method. In particular, this test determines a 33.33% of the sample period [2006:10-2007:04 and 2009:02-2012:12, Fig.

5 (c)] and a 56.14% [2005:04-2012:12, Fig. 5 (d)] for the ±1% and ±2% fluctuation bands, respectively. Using the first method, such bands are detected in a 50.29% (2006:02-2012:12) and in a 69.60% of the sample (2002:11-2003:04, 2003:07-2003:11 and 2004:04-2012:12), respectively [Fig. 5 (a) and (b)]. Finally, the existence of a *de facto* fixed exchange-rate with fluctuation bands is further reinforced when analysing the results from the statistical test directly applied upon the rolling percentage variation during 24 consecutive months. As can be seen in Fig. 5 (e), from 2002:10 to 2012:12, the critical region is over the average of monthly variations indicating the presence of ±1% fluctuation bands in a 73.68% of the sample period and the existence of ±2% fluctuation bands in the whole sample period [Fig. 5 (f)].

Fig. 5: Detection of *de facto* fluctuation bands of Latvian lats

(a): Probability of monthly variations of Latvian lats within bands of 1% using Reinhart and Rogoff (2004)'s method.



(b): Probability of monthly variations of Latvian lats within bands of 2% using Reinhart and Rogoff (2004)'s method.

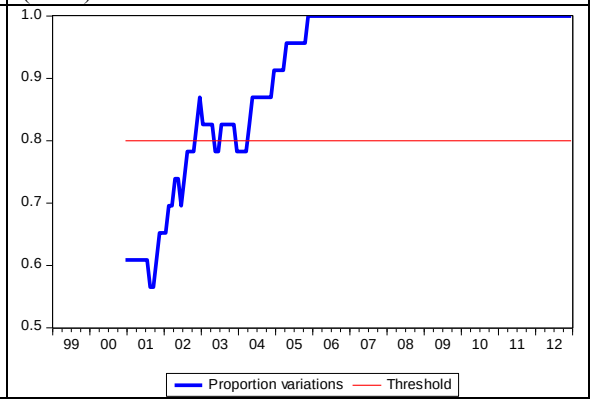
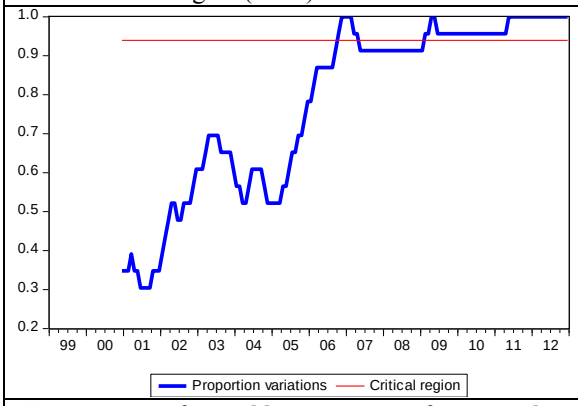
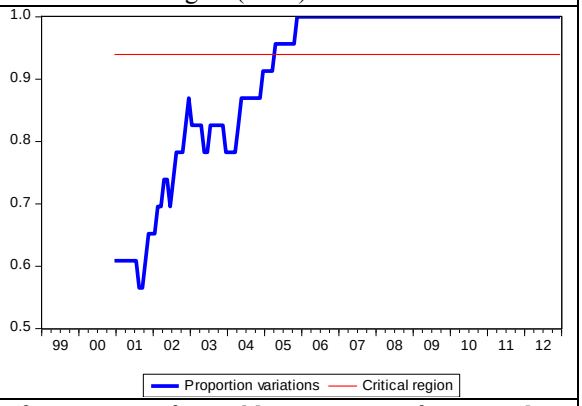


Fig. 5: Detection of *de facto* fluctuation bands of Latvian lats (continuation)

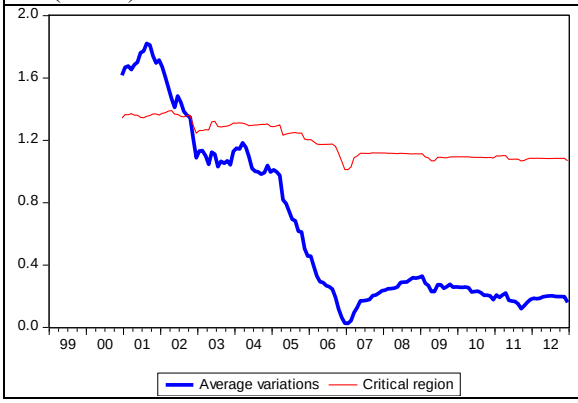
(c): Probability of monthly variations of Latvian lats within bands of 1% using statistical test in the Reinhart and Rogoff (2004)'s method.



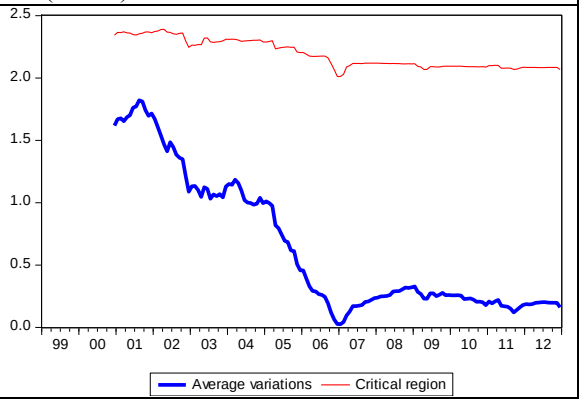
(d): Probability of monthly variations of Latvian lats within bands of 2% using statistical test in the Reinhart and Rogoff (2004)'s method.



(e): Average of monthly variations of Latvian lats within bands of 1% using Ledesma-Rodríguez *et al.* (2005b)'s method.



(f): Average of monthly variations of Latvian lats within bands of 2% using Ledesma-Rodríguez *et al.* (2005b)'s method.

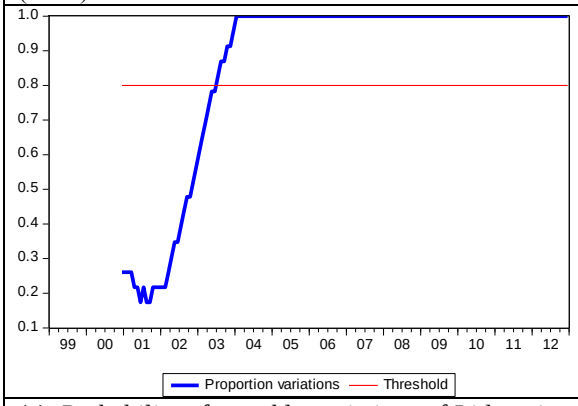


Lithuania: As can be seen in Fig. 6 (a), the probability that the percentage variation of the Lithuanian lita/Euro exchange rate (LTL/EUR) is within ±1% fluctuation bands exceeds the 80% threshold during the period 2003:07 to 2012:12 (68.42% of the sample). This sub-period is nearly the same to that identified when using the statistical test (2003:12-2012:12, a 65.50% of the sample), but shorter to that detected when employing the last method (2002:08-2012:12, a 74.85% of the sample) as can be seen in Fig. 6 (e). If we evaluate the presence of implicit ±2% fluctuation bands, the duration of the identified sub-periods increases, nesting that previously identified as one could expect. In this case, the first method detect the sub-period 2002:11 to 2012:12 (a 73.10% of the whole simple), the second method identifies the 2003:07-2012:12 sub-period (a 68.42% of the sample) and, finally, when using the procedure suggested by

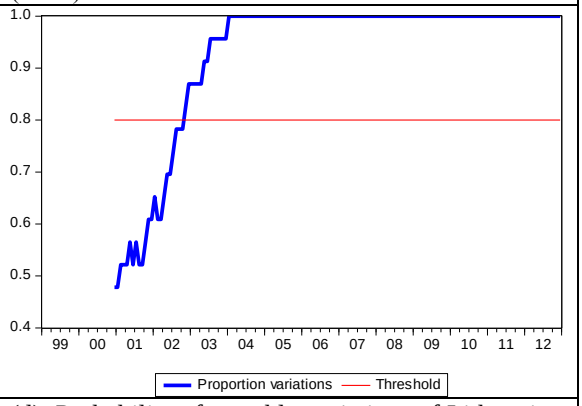
Ledesma-Rodríguez *et al.* (2005b), there is evidence of such bands in the sub-period 2001:10-2012:12 (a 85.38% of the sample) [see Fig. 6 (b), (d) and (f), respectively]. This reduced volatility detected by the three criteria could be one of the key determinants of the entrance of the Lithuanian lita in the ERM II on June, 27th 2004.

Fig. 6: Detection of *de facto* fluctuation bands of Lithuanian lita

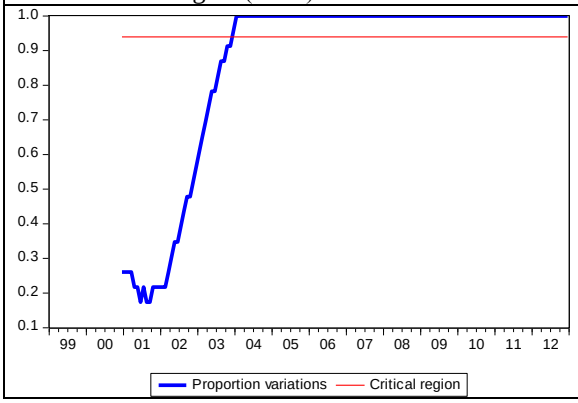
(a): Probability of monthly variations of Lithuanian lita within bands of 1% using Reinhart and Rogoff (2004)'s method.



(b): Probability of monthly variations of Lithuanian lita within bands of 2% using Reinhart and Rogoff (2004)'s method.



(c): Probability of monthly variations of Lithuanian lita within bands of 1% using statistical test in the Reinhart and Rogoff (2004)'s method.



(d): Probability of monthly variations of Lithuanian lita within bands of 2% using statistical test in the Reinhart and Rogoff (2004)'s method.

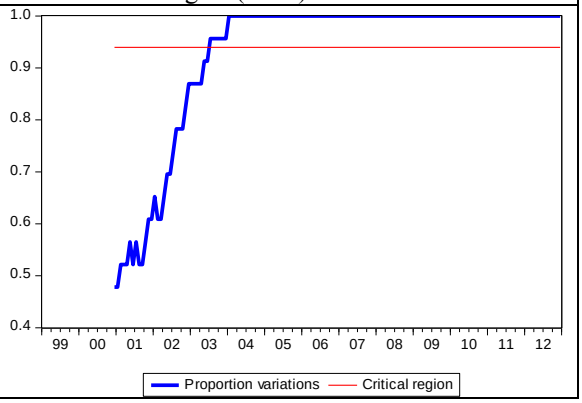
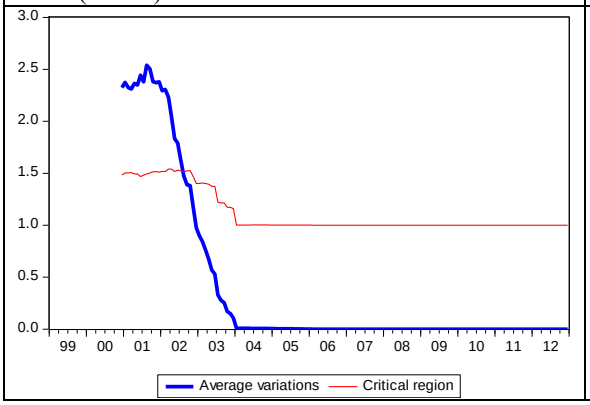
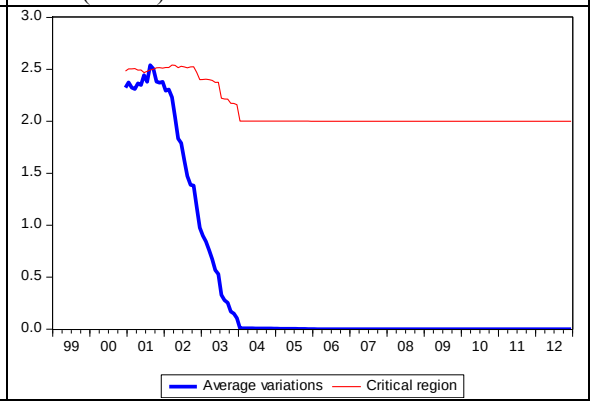


Fig. 6: Detection of *de facto* fluctuation bands of Lithuanian lita (continuation)

(e): Average of monthly variations of Lithuanian lita within bands of 1% using Ledesma-Rodríguez *et al.* (2005b)'s method.



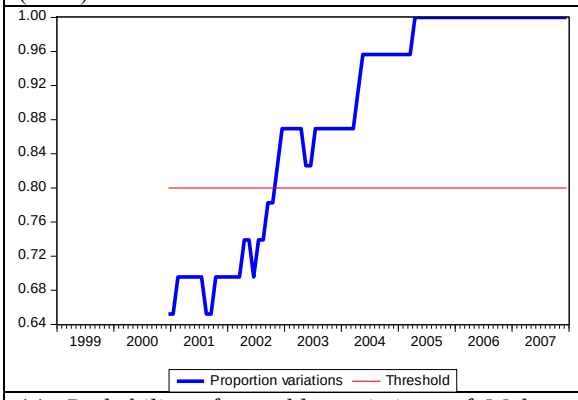
(f): Average of monthly variations of Lithuanian lita within bands of 2% using Ledesma-Rodríguez *et al.* (2005b)'s method.



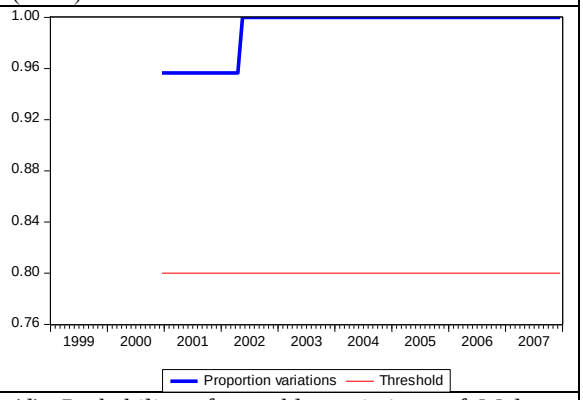
Malta: Before joining EMU on January, 1st 2008, the Maltese lira registered great exchange-rate stability during the sample under study. The requirement of the absence of severe exchange rate fluctuations to join the Euro Zone is corroborated by the results of the three criteria. These methods used to detect the existence of implicit fluctuation bands suggest that from January 1999 to December 2012, the Maltese lira/Euro exchange-rate (MTL/EUR) moved within ±2% fluctuation bands [see Fig. 7 (b), (d) and (f)]. Furthermore, when applying the procedure proposed by Ledesma-Rodríguez *et al.* (2005b) we find evidence in favour of ±1% fluctuation bands for the whole sample period [Fig. 7 (e)]. The other two methods identify the presence of ±1% fluctuation bands for the sub-period 2002:11-2007:12 (57.40% of the total sample period) and from 2004:05-2007:12 (40.74% of the sample) [Fig. 7 (a) and (c), respectively].

Fig. 7: Detection of *de facto* fluctuation bands of Maltese lira

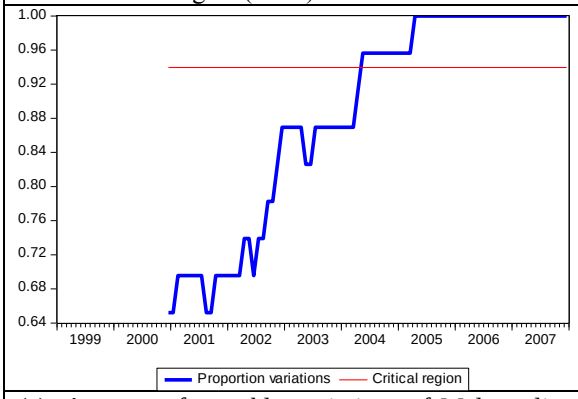
(a): Probability of monthly variations of Maltese lira within bands of 1% using Reinhart and Rogoff (2004)'s method.



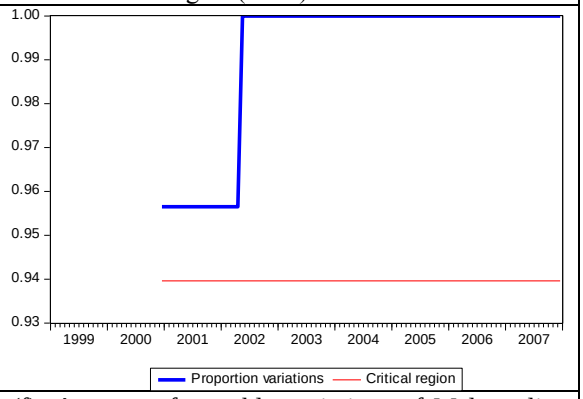
(b): Probability of monthly variations of Maltese lira within bands of 2% using Reinhart and Rogoff (2004)'s method.



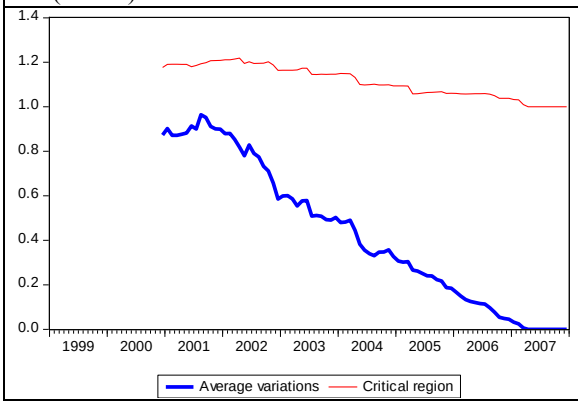
(c): Probability of monthly variations of Maltese lira within bands of 1% using statistical test in the Reinhart and Rogoff (2004)'s method.



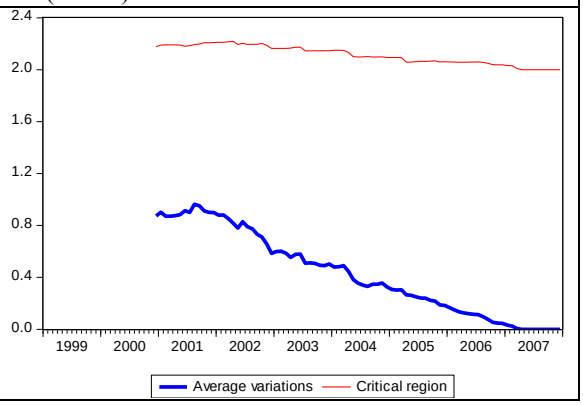
(d): Probability of monthly variations of Maltese lira within bands of 2% using statistical test in the Reinhart and Rogoff (2004)'s method.



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



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

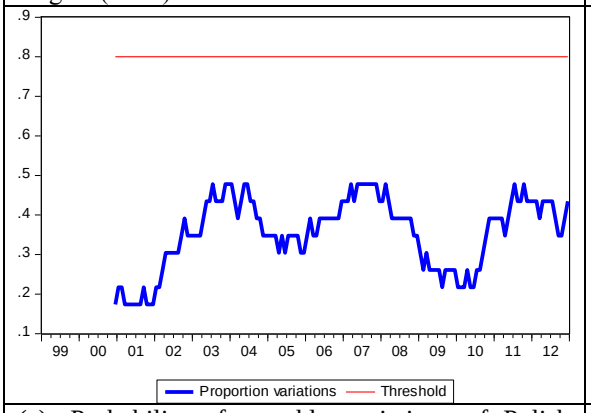


Poland: Given the flexible exchange-rate regime officially declared in this country, it seems sensible the results obtained when using our three methods. We do not find empirical evidence of the existence of ±1% fluctuation bands for the Polish zloty/Euro (PLN/EUR) when employing either Reinhart and Rogoff (2004)'s procedure or a

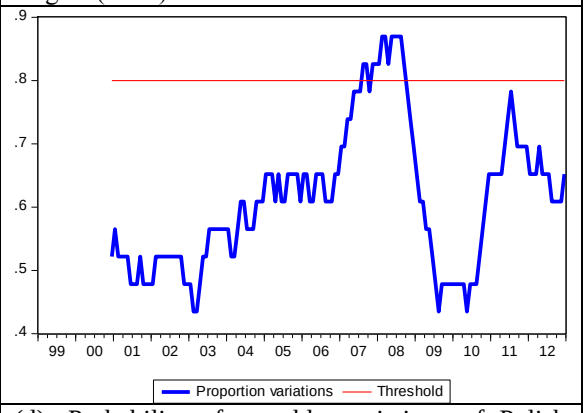
statistically improved version of it [Fig. 8 (a) and (c), respectively]. Only a 5.26% of the sample is identified by the latter procedure [Fig. 8 (e)]. The former method is able to identify the presence of ±2% fluctuation bands during the following sub-periods: 2007:08 to 2007:09 and 2007:11 to 2008:09 [a 7.60% detected the sample period, Fig. 8 (b)], while when using the statistical test [Fig. 8 (d)] we do not find evidence of such bands since the probability of percentage variations in the exchange-rate does not exceed the critical region. Nevertheless, when applying the procedure proposed by Ledesma-Rodríguez *et al*. (2005b) we detect the presence of ±2% fluctuation bands in a 78.95% of the sample under study (1999:01 to 2009:07 and 2010:09 to 2012:12) as can be seen in Fig. 8 (f).

Fig. 8: Detection of *de facto* fluctuation bands of Polish zloty

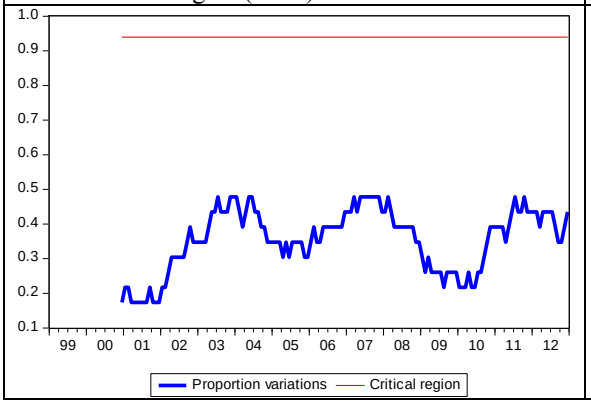
(a): Probability of monthly variations of Polish zloty within bands of 1% using Reinhart and Rogoff (2004)'s method.



(b): Probability of monthly variations of Polish zloty within bands of 2% using Reinhart and Rogoff (2004)'s method.



(c): Probability of monthly variations of Polish zloty within bands of 1% using statistical test in the Reinhart and Rogoff (2004)'s method.



(d): Probability of monthly variations of Polish zloty within bands of 2% using statistical test in the Reinhart and Rogoff (2004)'s method.

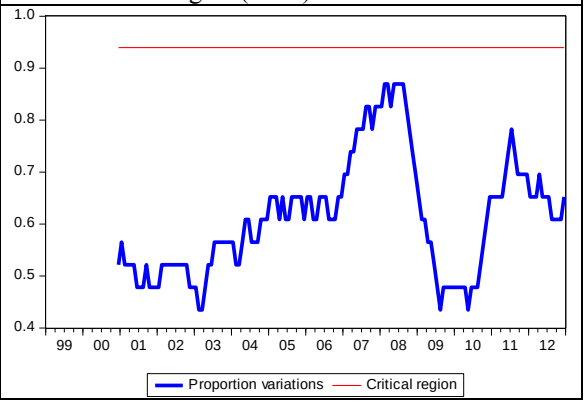
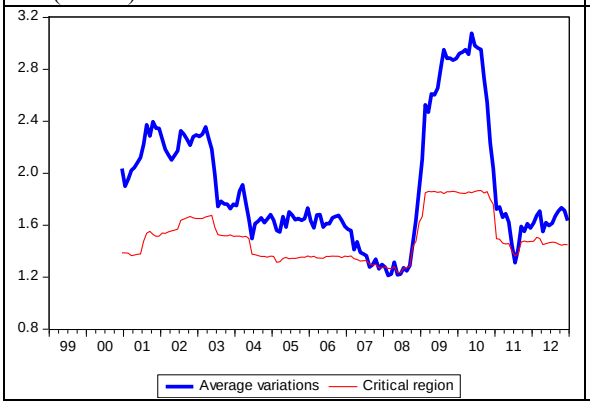
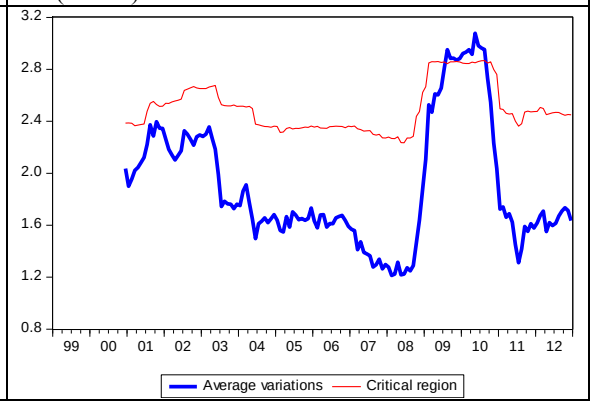


Fig. 8: Detection of *de facto* fluctuation bands of Polish zloty

(e): Average of monthly variations of Polish zloty within bands of 1% using Ledesma-Rodríguez *et al.* (2005b)'s method.



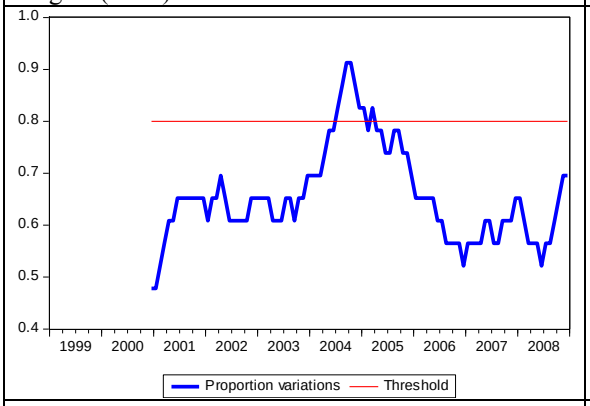
(f): Average of monthly variations of Polish zloty within bands of 2% using Ledesma-Rodríguez *et al.* (2005b)'s method.



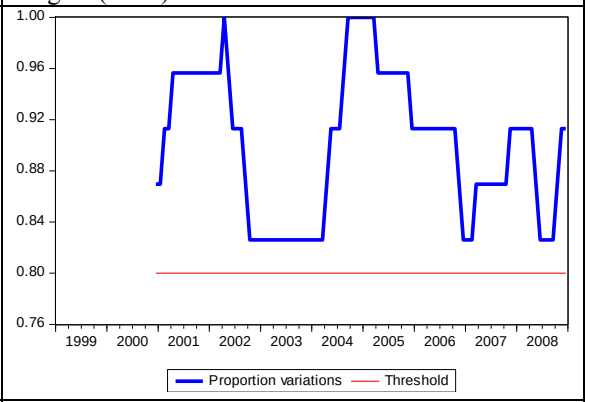
Slovak: As in the case of Poland, for this country we obtain a significant discrepancy between the first two methods and the third one when examining the existence of ±1% fluctuation bands for the Slovak koruna/Euro exchange-rate (SKK/EUR). Even though Fig. 9 (a) shows that only in a 6.67% of the sample (2004:07 to 2005:01 and 2005:03) the probability of percentage variations in the exchange-rate exceeds the 80% threshold, there is no evidence of such bands when using the statistical test [Fig. 9 (c)]. On the contrary, only in a 20% of the observations in sample do not agree with the presence of implicit ±1% fluctuation bands [Fig. 9 (e)]. When examining the possible existence of ±2% fluctuation bands, the discrepancy between the three criteria is reduced. Both the first and the third method render empirical evidence in favor of such bands in the whole sample period. However, the statistical test indicates that ±2% fluctuation bands could only be detected during the sub-periods 2001:04 to 2002:05 and 2004:08 to 2005:11 (representing a 25% of the sample).

Fig. 9: Detection of *de facto* fluctuation bands of Slovak koruna

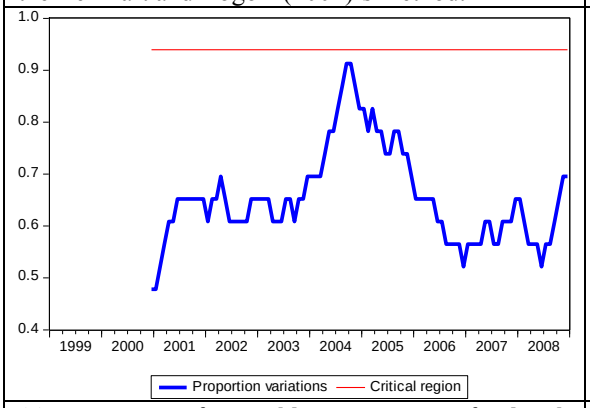
(a): Probability of monthly variations of Slovak koruna within bands of 1% using Reinhart and Rogoff (2004)'s method.



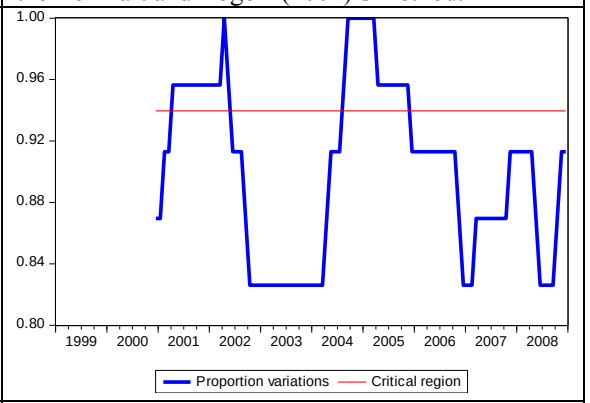
(b): Probability of monthly variations of Slovak koruna within bands of 2% using Reinhart and Rogoff (2004)'s method.



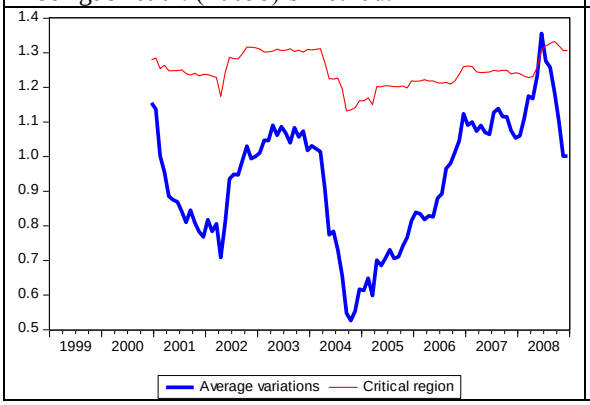
(c): Probability of monthly variations of Slovak koruna within bands of 1% using statistical test in the Reinhart and Rogoff (2004)'s method.



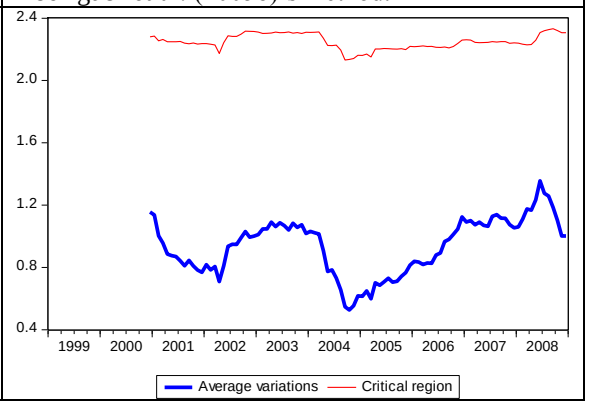
(d): Probability of monthly variations of Slovak koruna within bands of 2% using statistical test in the Reinhart and Rogoff (2004)'s method.



(e): Average of monthly variations of Slovak koruna within bands of 1% using Ledesma-Rodríguez *et al.* (2005b)'s method.



(f): Average of monthly variations of Slovak koruna within bands of 2% using Ledesma-Rodríguez *et al.* (2005b)'s method.

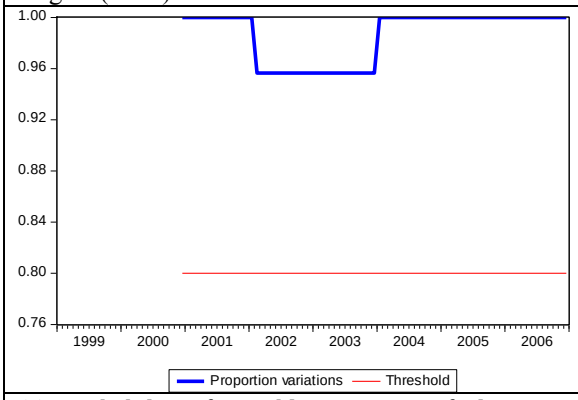


Slovenia: All sequential procedures coincide in suggesting the presence of implicit ±2% fluctuation bands in the whole sample period for the Slovenian tolar/Euro exchange-rate (LTL/EUR) [Fig. 10 (b), (d) and (f)] or even ±1% fluctuation bands [Fig. 10 (a), (c) and (e)]. This finding could indicate the existence of a *de facto* fixed exchange-rate regime

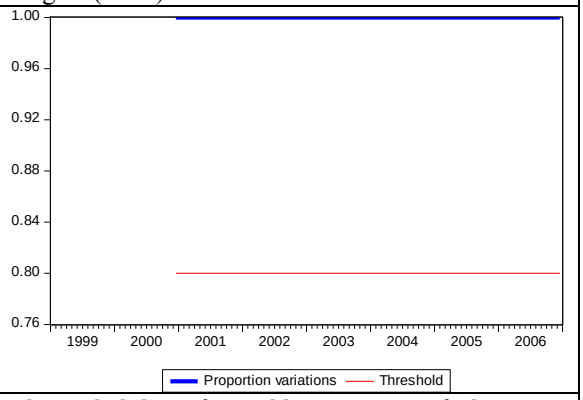
very closed to the ERM II before officially joining it on June, 27th 2004 and later becoming EMU member on January, 1st 2007.

Fig. 10: Detection of *de facto* fluctuation bands of Slovenian tolar

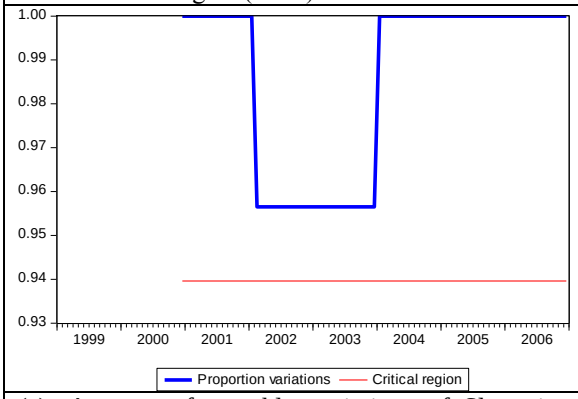
(a): Probability of monthly variations of Slovenian tolar within bands of 1% using Reinhart and Rogoff (2004)'s method.



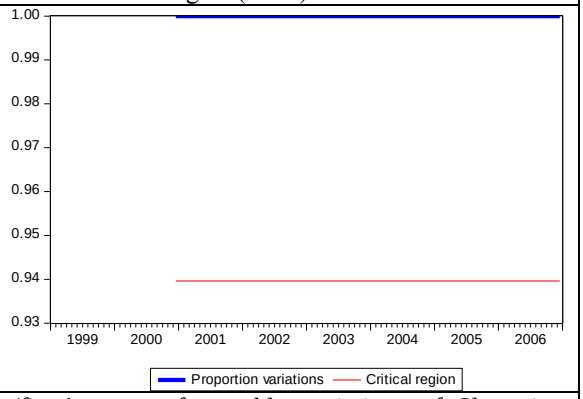
(b): Probability of monthly variations of Slovenian tolar within bands of 2% using Reinhart and Rogoff (2004)'s method.



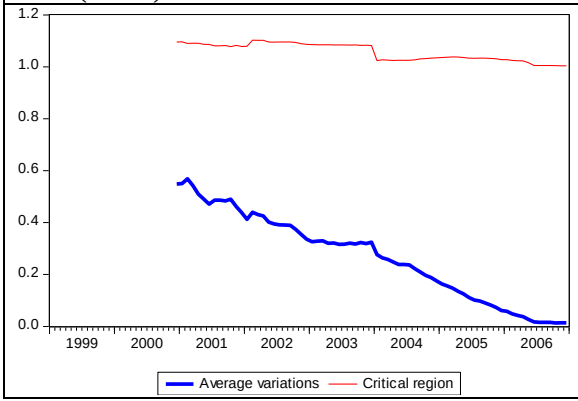
(c): Probability of monthly variations of Slovenian tolar within bands of 1% using statistical test in the Reinhart and Rogoff (2004)'s method.



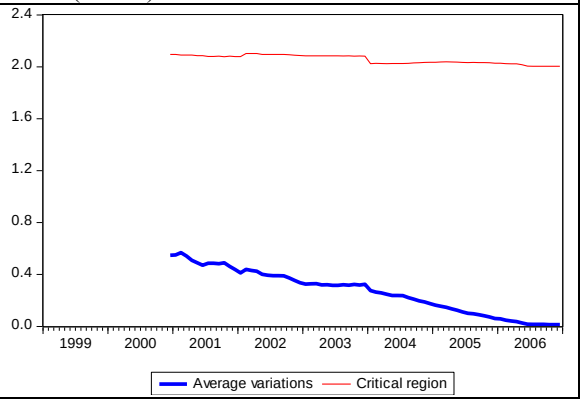
(d): Probability of monthly variations of Slovenian tolar within bands of 2% using statistical test in the Reinhart and Rogoff (2004)'s method.



(e): Average of monthly variations of Slovenian tolar within bands of 1% using Ledesma-Rodríguez *et al.* (2005b)'s method.



(f): Average of monthly variations of Slovenian tolar within bands of 2% using Ledesma-Rodríguez *et al.* (2005b)'s method.

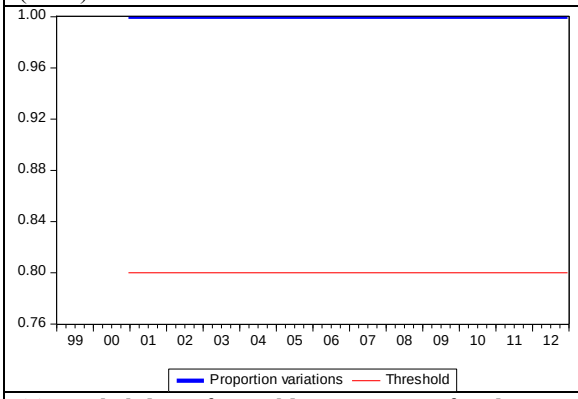


Bulgaria: From July 1997 the *de iure* exchange-rate regime in Bulgaria has been a *currency board*. Our three criteria for identify the presence of implicit fluctuation bands

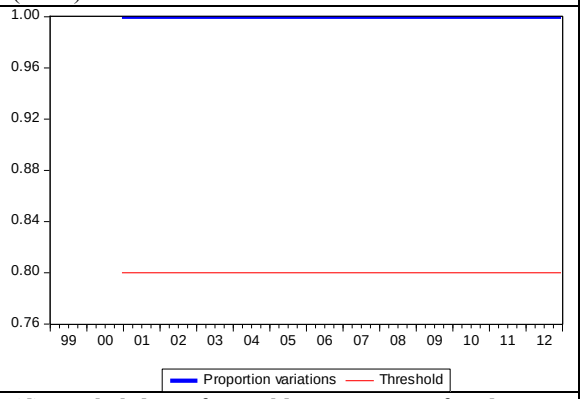
have been able to detect a behavior in the Bulgarian lev/Euro exchange-rate (BGN/EUR) consistence with such *de facto* regime. We do not only find evidence in favour of the existence of ±2% fluctuation bands in the whole sample period [Fig. 11 (b), (d) and (f)], but we also detect the presence of ±1% fluctuation bands for all the period under study [Fig. 11 (a), (c) and (e)]. Nevertheless, the Bulgarian lev has not yet joined the ERM II nor it is expected to apply for EMU membership before 2016.

Fig. 11: Detection of *de facto* fluctuation bands of Bulgarian lev

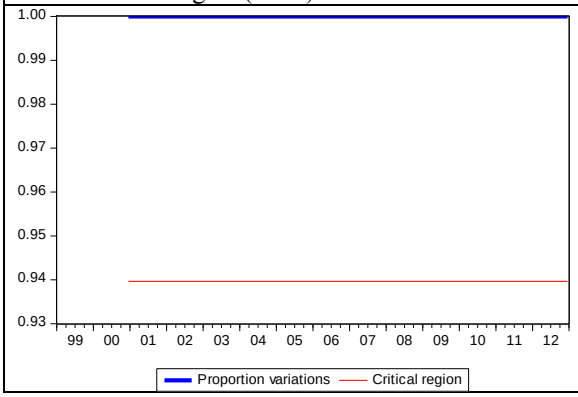
(a): Probability of monthly variations of Bulgarian lev within bands of 1% using Reinhart and Rogoff (2004)'s method.



(b): Probability of monthly variations of Bulgarian lev within bands of 2% using Reinhart and Rogoff (2004)'s method.



(c): Probability of monthly variations of Bulgarian lev within bands of 1% using statistical test in the Reinhart and Rogoff (2004)'s method.



(d): Probability of monthly variations of Bulgarian lev within bands of 2% using statistical test in the Reinhart and Rogoff (2004)'s method.

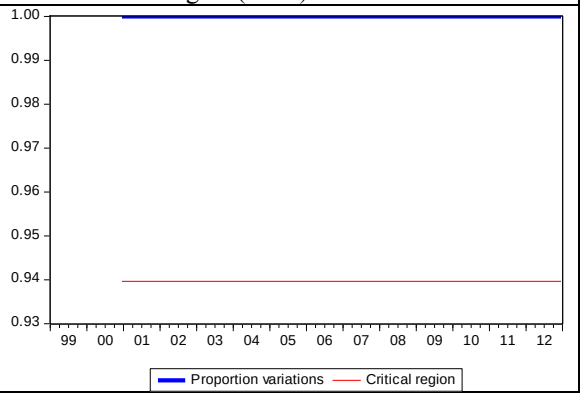
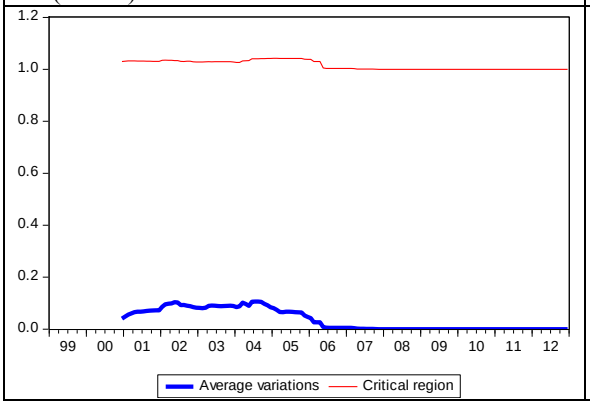
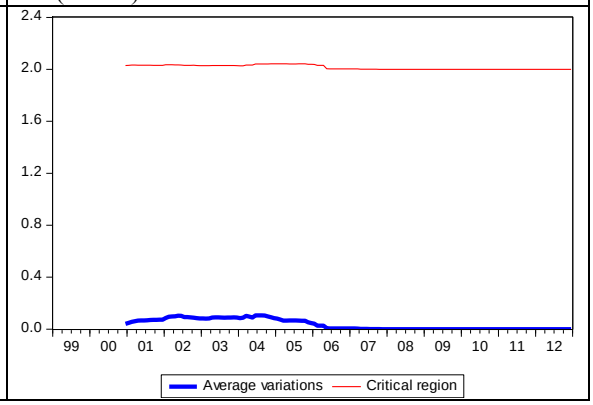


Fig. 11: Detection of *de facto* fluctuation bands of Bulgarian lev (continuation)

(e): Average of monthly variations of Bulgarian lev within bands of 1% using Ledesma-Rodríguez *et al.* (2005b)'s method.



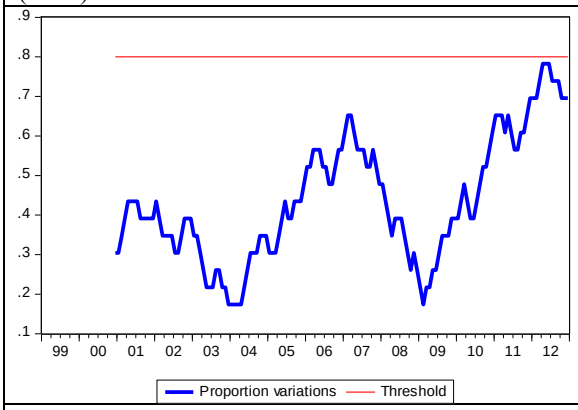
(f): Average of monthly variations of Bulgarian lev within bands of 2% using Ledesma-Rodríguez *et al.* (2005b)'s method.



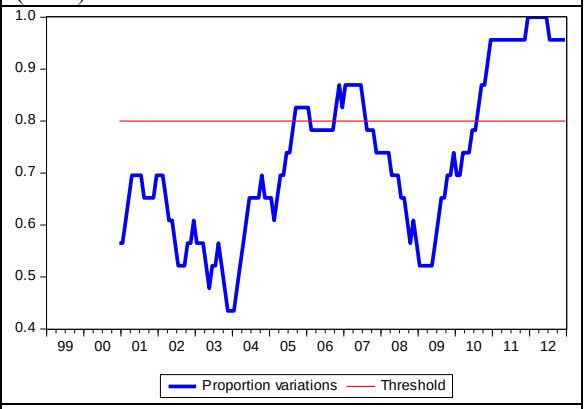
Romania: Even though we reject the null hypothesis that the probability of monthly variations in the Romanian leu/Euro exchange-rate (RON/EUR) fluctuate within a ±1% bands using the first and second methods [Fig. 12 (a) and (c), respectively], using the first method we do not reject the existence of ±2% fluctuation bands during the following sub-periods: 2005:09-2006:01, 2006:10-2007:07 and 2010:08-2012:12 (representing a 27.49% of the sample period), while employing the second method we do not reject it for the sub-period 2010:12 to 2012:12 (14.62% of the sample) [Fig. 12 (b) and (d), respectively]. The third method suggests the presence of implicit ±2% fluctuation bands during the entire sample period as well as the existence of ±1% fluctuation bands during the following sub-periods: 2005:05 to 2007:12, 2009:12 and 2010:02 to 2012:12 (representing a 41.52% of the sample), corresponding most of them with the EU membership from January 1st 2007.

Fig. 12: Detection of *de facto* fluctuation bands of Romanian leu

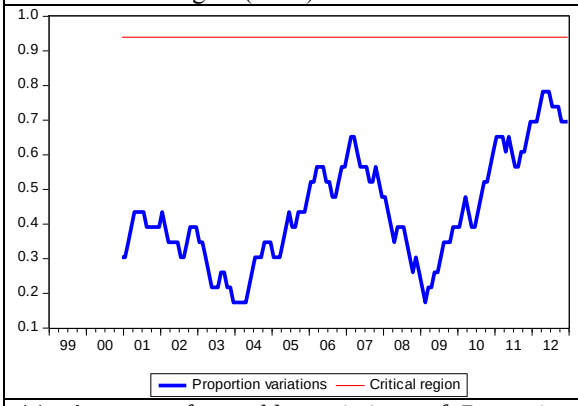
(a): Probability of monthly variations of Romanian leu within bands of 1% using Reinhart and Rogoff (2004)'s method.



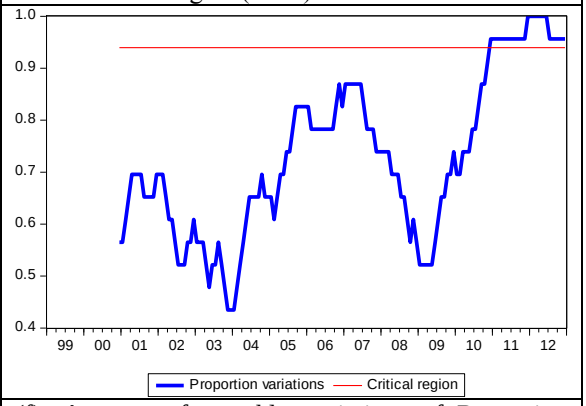
(b): Probability of monthly variations of Romanian leu within bands of 2% using Reinhart and Rogoff (2004)'s method.



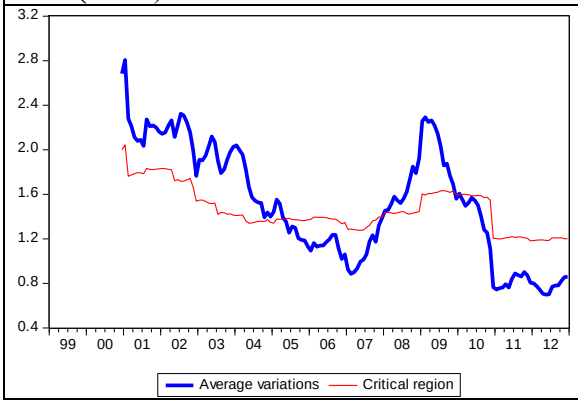
(c): Probability of monthly variations of Romanian leu within bands of 1% using statistical test in the Reinhart and Rogoff (2004)'s method.



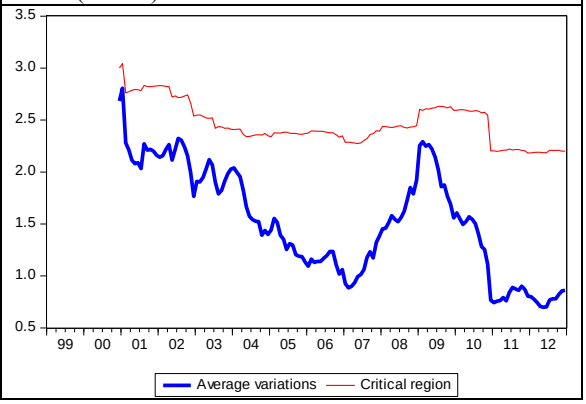
(d): Probability of monthly variations of Romanian leu within bands of 2% using statistical test in the Reinhart and Rogoff (2004)'s method.



(e): Average of monthly variations of Romanian leu within bands of 1% using Ledesma-Rodríguez *et al.* (2005b)'s method.



(f): Average of monthly variations of Romanian leu within bands of 2% using Ledesma-Rodríguez *et al.* (2005b)'s method.



IV. Conclusions

Having applied three sequential procedures based on the evolution of the exchange rate vis-à-vis the euro on twelve Central and Eastern Europe countries, that in 2012 joined to

EU, our results suggest the presence of ± 2% and ± 1% implicit fluctuation band in high percentages of the sample period even reach 100% in countries such as Bulgaria, Cyprus and Slovenia, among others. 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.

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).

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