

Simulation of the Czech koruna's participation in ERM II – alternative approaches

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Abstract. The fulfillment of the exchange rate stability criterion requires at least a two-year participation of the given currency in ERM II “without severe tensions”. The Czech koruna does not participate in ERM II, inter alia because of risks which are connected with fixed exchange rate. The aim of this paper is to find out how to simulate such participation. At the beginning of the paper, current methods of assessment of the criterion fulfillment by the Czech authorities, European authorities and other authors are analyzed. We conclude that these approaches are inappropriate. We offer our two own assessments which are different and reflect the change in the exchange rate regime since November 2013 (when massive interventions on the foreign exchange market took place). First, to evaluate only the period prior those interventions. Second, to determine the trend of the exchange rate development in 2010-2013 (i.e. the period from the reassuring of the sharp fluctuations of the exchange rate CZK/EUR to the start of interventions) and extrapolate it into present time. In both cases, we come to the same conclusion: the convergence criterion was fulfilled.

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1. INTRODUCTION

The Czech Republic is one of the Members States of the European Union with a derogation regarding the implementation of the euro (Member States with the derogation). However, in spite of the above, much institutional and organizational preparation work for an entry to the euro area has been made. The assessment of fulfillment of Maastricht convergence criteria, including an exchange rate stability criterion (exchange rate convergence criterion) is also part of this preparation work.

However, the fundamental condition for the fulfillment of this criterion is the accession to ERM II mechanism where the Czech koruna does not participate (with a fixed exchange rate there are risks of speculative attacks – see Part 5.1). The aim of this paper is to create a hypothetical participation of the Czech koruna in ERM II and evaluate hypothetical fulfillment of the exchange rate convergence criterion. To achieve this, an analysis of the currently known approaches to this hypothetical participation in ERM II and assessment of the consistence of these with the interpretation of the exchange rate converge criterion have been made. It is not possible to apply these current methods for simulation of the Czech koruna's participation in ERM II during the period from the end of year 2013, when massive interventions started on the foreign exchange market. The extrapolation of the CZK/EUR exchange rate development using linear trend function and exponential trend function is our another method.

After an overview of literature and methodology, the next (fourth) part of the paper deals with the interpretation of the exchange-rate convergence criterion (different notions of fluctuation margins, criteria of the so-called severe tension) and gives an overview of the approach of the countries that are not members of the euro area towards ERM II mechanism. It also includes a commentary regarding the development of the CZK/EUR exchange rate. The next (fifth) part analyses approaches to the assessment of the exchange rate stability criterion, approach of Czech authorities, European authorities and other authors. The last (sixth) part of the paper critically evaluates these approaches mentioned above and rejects them. We offer two of our own alternatives for simulation of the Czech koruna's participation in ERM II. We conclude that the exchange rate stability criterion has been met.

2. AN OVERVIEW OF LITERATURE

The literature dealing with the exchange rate converge criterion *and its simulation* can be divided into three areas.

First area – monetary integration and entry criteria for the euro area. General characteristics of this criterion are included in the publications of the European monetary integration, including its history and development. The key literature dealing with the theory of monetary integration is De Grauwe *Economics of Monetary Union* (2016). In our paper, especially the following publications were also used: Baldwin, Wyplosz *The Economics of European Integration* (2012), Dědek *Doba eura (The Era of the Euro, 2014)* and Dědek *Historie evropské měnové integrace (The History of European Monetary Integration, 2008)*. We also quote a study focusing on the entry of new Member States into the euro area Schadler S. et al. *Adopting the Euro in Central Europe* (2005).

When studying problems were related to the entry of the Czech Republic into the euro area, we mostly used the following publications: Lacina, Rozmahel et al. *Euro: ano/ne? (Euro: yes / no?, 2010)* and Helísek et al. *Euro v ČR z pohledu ekonomů (The Euro in the Czech Republic from the Perspective of Economists, 2009)*. E.g. Palankai deals general circumstances of the introduction of the euro in Central and Eastern Europe in *The Introduction of the Euro and Central Europe* (2015).

The literature from the first area generally explains the criteria for nominal and real convergence, including the exchange rate convergence criterion, which is set out below. However, the simulation of this criterion is not addressed (with the two exceptions listed below in the third area of literature).

Second area – exchange rate convergence criterion. Specifically, the studies of e.g. Égert, Kierzenkowski *Asymmetric Fluctuation Bands in ERM and ERM II* (2003) or Michalczyk *An Overview to the Exchange Rate Stability as a Criterion of the Accession to the Euro Zone* (2011) are oriented at the analysis of the fulfillment of the exchange rate criterion. Experience with different exchange rate regimes in Central and Eastern European countries is summarized in Mooslechner *The Choice of Exchange Rate Regimes* (2007).

Krawczyk analyzes in *A Currency Crisis in Europe?* (2005) the risks of participation in ERM II (i.e. pegged exchange rate) due to the free movement of capital.

The problems of the exchange-rate criterion with respect to the Czech economy are particularly dealt with in Komárek et al. *Kurzové aspekty v procesu přistoupení České republiky k eurozóně* (*Exchange Rate Problems in the Process of the Czech Republic's Accession to the Euro Area*, 2005), Helísek et al. *Vstup ČR do eurozóny* (*Accession of the Czech Republic to the Euro Area*, 2007) or Marková *Strategie vstupu České republiky do kurzového mechanismu ERM II* (*Strategy of the Czech Republic's Entry into ERM II*, 2011).

Nonetheless, the literature listed in the second area will not be used to simulate the fulfillment of the exchange rate criterion (with two exceptions - see below in the third area of the literature).

Third area of the literature – simulation of the Czech koruna's participation in ERM II. The hypothetical accession of the Czech koruna to the ERM II mechanism is annually analyzed in the study of the Ministry of Finance of the Czech Republic and the Czech National Bank *Assessment of the Fulfillment of the Maastricht Convergence Criteria and the Degree of Economic Alignment of the Czech Republic with the Euro Area*. Simulation of the Czech koruna's participation in ERM II, current for our research, is explicitly done here. This simulation is also partially in *Convergence Reports* of the European Central Bank (ECB). As we can see below, the approaches used by the Czech National Bank (CNB) and the ECB are not applicable for the current period. The reason is that *the special developments in recent years*, i.e. the massive intervention of the Czech National Bank in the foreign exchange market, are not taken into account.

The simulation of the exchange rate criterion (involvement of the Czech koruna in ERM II) is also addressed by the authors in the first area of literature, namely Lacina, Rozmahel a kol. (2010) and Helísek a kol. (2009) and in the second area, namely Helísek et al. (2005) and Krawczyk (2004). Their simulations, as in the case of the ECB and the CNB, do not take into account the special development of the CZK/EUR foreign exchange market. Therefore, the CNB, ECB and other authors' methods cannot be applied to assess the hypothetical involvement of the Czech koruna in ERM II in the period from the end of 2013.

3. METHODOLOGY

For the simulation of the Czech koruna's participation in the mechanism ERM II, the actual CZK/EUR exchange rate over the last two years of the monitored period is used mostly. Approaches of different studies vary in two directions (for details, see Section 5):

- in the method of determining the hypothetical central parity,
- defining the fluctuation band.

An example of this approach is the Czech National Bank, which, in its annual *Assessment of the Fulfillment of the Maastricht Convergence Criteria*, evaluates the development of the CZK/EUR exchange rate to the hypothetical central parity in the $\pm 15\%$ fluctuation band around the central parity. The CNB always examines developments over the past two years.

As explained in detail in Section 6, this approach is not appropriate for the past few years, as strong CNB interventions have taken place since November 2013 on the foreign exchange market. Interventions in the foreign exchange market are one of the circumstances in which the so-called “severe tension” has not been met when the exchange rate stability criterion is met – see Section 4.

That is why we are looking for another method of simulating the Czech koruna's involvement in ERM II, by which we would evaluate the hypothetical fulfillment of the exchange rate stability criterion. We use two methods (Section 6):

- assessment of exchange rate stability only in the period *prior* to the foreign exchange market interventions,

– *extrapolation* of exchange rate developments from pre-interventions period to the present (January 2016). Beginning of the period before the interventions started is January 2010 (i.e. after appeasement of the fluctuations in the exchange rate caused by the financial crisis; see picture no. 1), the end of this period is October 2013 (interventions started in November 2013).

We have examined five extrapolation models. We chose two of them, namely *the linear trend function* and *the exponential trend function*. Regarding the fluctuation band, in our simulation of the Czech koruna's involvement in ERM II, we strictly hold the opinion of the European Commission, which has the lead in evaluating the fulfillment of the convergence criteria. Therefore, we use an asymmetric band, which is explained in section 4.1.

4. EXCHANGE RATE CONVERGENCE CRITERION (DATA)

4.1 Criterion definition

The formulation of the exchange-rate stability criterion, one of the Maastricht criteria, is included in the Treaty Establishing the European Community (Article 121 (1) and in Protocol No. 21 (Article 3). The verbatim wording of the criterion requires “the observance of the *normal fluctuation margins* provided for by the exchange rate mechanism of the European Monetary System, for at least two years, without devaluing against the currency of any other Member State.” “The protocol then specifies the requirement that “a Member State has respected the normal fluctuation margins provided for by the exchange rate mechanism on the European Monetary System *without severe tensions* for at least the last two years before the examination. In particular, the Member State shall not have devalued its currency's bilateral central rate against any other Member State's currency on its own initiative for the same period.” Since 1999, Resolution of the European Council on the Establishment of an Exchange-rate Mechanism in the Third Stage of Economic and Monetary Union – the so-called Amsterdam resolution – of June 1997 substitutes “the currency of another member state” with the euro. At the same time, some attention must be paid to the interpretation of the “normal fluctuation margin” and “without severe tension” (For more detailed discussion refer to Helíšek et al., 2007).

As early as in 1998, in the period of the original ERM, the European Commission (EC) pointed out to the ambiguity of the “fluctuation margin” in its Convergence Report. More specifically, it means whether this margin should be the original margin set when the European Monetary System was established in 1979, i.e. $\pm 2.25\%$, or extended fluctuation margin $\pm 15\%$. This extension was the result of the crisis of the European Monetary System in 1993 (regarding this currency crisis, refer either to Dědek, 2008, or Baldwin, Wyplosz, 2012). The Commission unanimously leans towards the narrower fluctuation margin. At the same time, the Commission explicitly states that it was ruled out that fluctuations above the 2.25% limit in the appreciation direction would result in non-fulfillment of the criterion.

The requirement of the narrower fluctuation margin is also repeated in the circumstances of ERM II in the following arguments (Commission of the European Communities. 2000, Annex D, p. 67):

- Maastricht Treaty was designed to consider the narrow margin as standard,
- The wider margin allowed a large flexibility to the exchange rate stability assessment,
- The wider margin was introduced “as temporary measure with the expectation of returning to the narrow margins”,
- Therefore, the aim of the wider margin was not to allow for higher variability of the exchange rate, but to face speculation pressure within ERM.

With regard to the so-called severe tension, “a range of elements was taken into account. These included: (i) the duration and amplitude of the deviation; (ii) the nature and extent of any policy response with particular reference to foreign exchange intervention and/or changes in short term interest rates and (iii) whether the pressure has been towards appreciation or depreciation of the currency.” (Ibid, p. 67/68)

Also analytical studies point out to the overly extensive fluctuation margin. “Despite the fact that formal elements of fixed exchange rate were maintained [in ERM II] they only masked the free float. [...] Its margins $\pm 15\%$ were too wide to discipline national economic policies, and particularly budget behavior of governments.” (Dědek, 2014, pp. 146-147). Similarly: “However, the issue remains whether with such wide margin for fluctuation of the member state currency in ERM II from the set central parity against the euro may function in the stabilizing manner and whether it will test the country's ability to protect stability of its currency against the euro” (Lacina, Rozmahel et al., 2010, p. 138).

The European Central Bank (ECB) in the *Opinion of the Governing Council* (European Central Bank, 2003, p. 6) refused to evaluate the exchange rate criterion in relation to the explicitly set fluctuation margin: “The assessment of exchange rate stability against the euro will focus on the exchange rate being close to the central rate while also taking into account factors that may have led to an appreciation, which is in line with what was done in the past. In this respect, the width of the fluctuation band within ERM II shall not prejudice the assessment of the exchange rate stability criterion.” Therefore, it can be expected that it is willing to accept the exchange rate fluctuation around the central rate within the 15% range in both directions (15% results from the necessity to remain in ERM II).

This interpretation is also used by Paul De Grauwe when characterizing ERM II: “The requirement prevents countries from manipulating their exchange rates [...] The stringency of this requirement, however, has been reduced considerably since the Maastricht Treaty was signed [...] Since August 1993, the »normal« band within the EMS has been $2 \times 15\%$, a considerably larger band of fluctuation”. (De Grauwe, 2016).

The so-called severe tension is interpreted as follows by ECB: “Moreover, the issue of absence of »severe tensions« is generally addressed: i) by examining the degree of deviation of exchange rates from the ERM II central rates against the euro; ii) by using indicators such as short-term interest rate differentials vis-à-vis the euro area and their evolution; and iii) by considering the role played by foreign exchange interventions.” (European Central Bank, 2003, p. 6). This means that the evaluation of the exchange rate stability can vary in different ways:

- the exchange rate fluctuated in the fluctuation band, but only through strong foreign exchange interventions – the criterion of exchange rate stability would not be met,
- the exchange rate exceeded the fluctuation band, but only to a small extent, and the foreign exchange intervention did not take place - then the stability criterion would be met.

We conclude that when assessing whether the exchange rate convergence criterion is met, the circumstances specific to each individual case (currency, time) are taken into account. It also states the summary of experience with the exchange rate regimes: “The assessment on the fulfillment of the criteria is made on a case-by-case basis, taking into account the specific situation of each individual country.” (Mooslechner, 2007, p. 25).

4.2 Participation of the Czech koruna in ERM II

The Czech koruna does not participate in the ERM II mechanism, with the reason being an official strategy of the government according to which “the Czech Republic will participate in the ERM II exchange rate mechanism for the minimum permissible period.” (*The Czech Republic's Updated Euro-area Accession Strategy*, 2007, p. 1). Therefore, the participation will only commence when the entry date in the euro area is

set. The original “working date” for an entry in the euro area, i.e. as of 1 January 2010, determined in the *Institutional Arrangements for the Euro Changeover in the Czech Republic* (Ministry of Finance, 2005), was cancelled in October 2006. From 2007 until present, the government annually approves recommendation of the Czech National Bank (CNB) and the Ministry of Finance not to set a date for adoption of the euro and also not to participate in the ERM II mechanism.

The Czech Republic is not alone in its attitude to the participation in ERM II. Table 1 shows an overview of exchange rate regimes maintained by EU member states with a different currency than the euro. Only Denmark's currency acceded to ERM II (only since 1 January 1999) with the original fluctuation margin of $\pm 2.25\%$ and the central parity of 7.460380 DKK/EUR.

Table 1

Exchange-rate regimes of EU member states outside the euro area

Country (currency)	Exchange-rate regime
Sweden (SEK)	free floating
Czech Republic (CZK)	managed floating ¹⁾
Poland (PLN)	free floating
Hungary (HUF)	free floating
Romania (RON)	managed floating ²⁾
Bulgaria (BGN)	currency board EUR ³⁾
Croatia (HRK)	managed floating
Denmark (DKK)	fixed exchange rate in ERM II ($\pm 2,25\%$)
Great Britain (GBP)	free floating

Note: ¹⁾ From 7 November 2013 intervention preventing the appreciation under 27 CZK/EUR have been employed. ²⁾ In July 2005, the Romanian leu (ROL) was replaced by new leu (RON) using 1:10 000 rate. ³⁾ Originally against DEM, then against EUR, 1.95583 BGN/EUR.

Sources: European Commission (2014) and websites of central banks.

4.3 Development of CZK/EUR exchange rate

With regard to further analysis of the simulated participation of the Czech koruna in ERM II and hypothetical assessment of the fulfillment of the exchange rate convergence criterion, the development of CZK/EUR exchange rate must be commented on. Figure 1 shows a long-term trend of the CZK/EUR appreciation, which is a result of a long-term trust of financial investors in the Czech currency and its economics. Since 1999 there have been significant fluctuations in the CZK/EUR exchange rate in the following years:

- depreciation in 2002-2003 (result of the persisting economic and political uncertainty in the development of all Central European currencies),
- significant depreciation in 2007 and 2009 (result of financial crisis and outflow of capital predominantly motivated by concerns regarding the future development of the region).



Figure 1. CZK/EUR exchange rate development (daily rates)

Source: <https://www.ecb.europa.eu/stats/exchange/eurofxref/html/eurofxref-graph-czk.en.html>

For our analysis, hence the period since 2010 is important. The rate was stabilized at the level around 25 CZK/EUR until November 2013 when its strong depreciation occurred. Since 7 November 2013, the Czech National Bank started interventions in the CZK/EUR exchange rate with the aim to prevent the rate appreciation under the limit of 27 CZK/EUR. The exchange rate development was as follows:

- There was an immediate depreciation from 25.83 to 26.97 CZK/EUR,
- By 20 December 2013, the depreciation reached 27.66 CZK/EUR,
- The highest depreciation was achieved on 13 January 2015 at 28.29 CZK/EUR,
- After that time, there was a gradual appreciation (without significant deviations) to 27 CZK/EUR towards the end of 2015.

The volume of foreign exchange interventions is not published by the central bank. It may be assumed from the “reserve assets” item in the balance of payments. For example, in its Inflation Report from February 2016 ČNB states: “Their growth reached CZK 173.4 billion, due above all to the CNB’s foreign exchange interventions” (Czech National Bank, 2016, p. 60). Table 2 shows quarterly increases in ČNB reserve assets from the start of intervention of the foreign exchange market. When converted using an average exchange rate for this period (27.324 CZK/EUR), the increase in reserve assets amounted to EUR 22.2 billion.

Relatively, as regarding a ratio of foreign exchange reserves (state as of the year end) to nominal GDP, the indicator posted the following increase (https://www.czso.cz/csu/czso/hmu_ct):

- 2012 ... 21.2 %
- 2014 ... 29.2 %
- 2015 ... 35.8 %

Table 2

Increases in reserve assets of the Czech National Bank (quarterly, CZK billion)

Year	Quarter	Increase
2013	IV	182.6
2014	I	25.1
	II	32.8
	III	-14.4
	IV	29.7
2015	I	38.0
	II	81.2
	III	173.4
	IV	58.6
Cumulatively		607.0

Source: http://www.cnb.cz/cs/statistika/platbni_bilance_stat/platbni_bilance_q/index.html

There is no “reference value” in size of foreign exchange reserves (as e.g. in the Maastricht criteria). We believe that their almost double growth due to foreign exchange market interventions would be evaluated by the ECB as a “severe tension”. This would lead to the conclusion that the exchange rate stability criterion was not met (see section 6.1 below).

5. HYPOTHETICAL PARTICIPATION OF THE CZECH KORUNA IN ERM II – APPROACHES UP TO THE PRESENT DAY

5.1 Approach of the Czech authorities

The assessment of the fulfillment of criteria of both nominal convergence and real convergence of the Czech economy to the economy of the euro area is included in *Assessment of the Fulfillment of the Maastricht Convergence Criteria and the Degree of Economic Alignment of the Czech Republic with the Euro Area*, which is prepared by analytical departments of the Ministry of Finance and CNB as of the year end. Due to the non-participation of the Czech koruna in ERM II, the assessment of the fulfillment of the exchange-rate convergence criterion is performed “only on the analytical level”.

Assessment from December 2015 includes the following simulation:

- It expects the hypothetical adoption of the euro at the beginning of 2016,
- Therefore, the assessment of the fulfillment of Maastricht criteria would be performed in Q2 2015,
- Thus the assessment of the two-year participation in ERM II would be performed for Q2 2013 – Q1 2015,
- Therefore, the hypothetical central parity of CZK/EUR is set as an average exchange-rate value in Q1 2013 (i.e. the quarter preceding the "entry" in ERM II) at 25.5650 CZK/EUR,
- CNB expects fluctuation margin around this central parity of 15% in both directions.

Figure 2 shows this hypothetical participation of the Czech koruna in the exchange rate mechanism ERM II. The *Assessment* notes that CZK/EUR rate would oscillate in the permissible fluctuation margin $\pm 15\%$, as of the year 2013 end when the rate was significantly depreciated as a result of the start of exchange rate interventions on the foreign exchange market. By implication, the fulfillment of the exchange-rate convergence criterion is shown here.

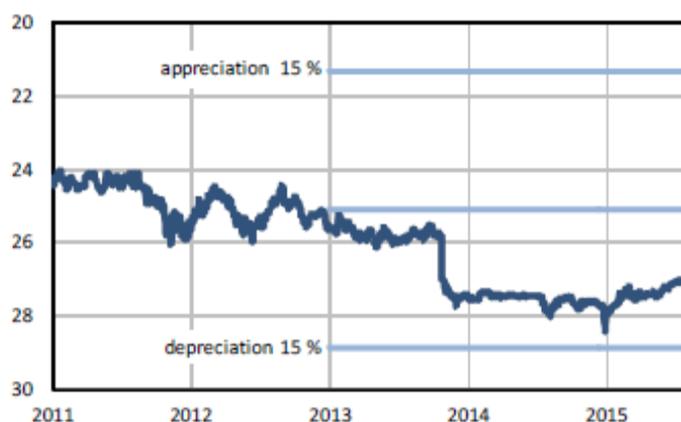


Figure 2. Simulation of the Czech koruna's participation in ERM II by Czech authorities (CZK/EUR daily exchange rates)

Source: Ministry of Finance of the Czech Republic and the Czech National Bank, 2015, p. 6.

Note: According to the commentary by CNB, the assessed period should be Q2 2013 – Q1 2015, however the figure shows the period of Q1 2013 – Q2 2015. Also the hypothetical central parity is slightly moved in the appreciation direction. The explanation is not given.

5.2 Approach of the European Central Bank and the European Commission

The last available assessment of Maastricht convergence criteria by **the European Central Bank** is included in the Convergence Report of June 2014. The assessed period is 16 May 2012 – 15 May 2014. ECB noted that:

- the Czech koruna does not participate in the ERM II mechanism,
- the Czech koruna was traded in floating exchange rate regime, however since 7 November 2013, there were interventions with the aim to prevent further exchange rate appreciation,
- The development of CZK/EUR rate was rather volatile: the initial appreciation was caused by restored trust of the investors in the region, the subsequent depreciation which lasted for more than a year (until the beginning of 2013) was related to the decrease of Czech interest rates.

When assessing the fulfillment of the convergence criterion, ECB uses the term “for illustrative purposes”. The hypothetical central parity is at the level of actual average rate in the first month of the monitored period, i.e. in May 2012 (25.313 CZK/EUR). Figure 3 shows maximum deviations:

- in the appreciation direction of 3.5%
- in the depreciation direction of 9.6%
- At the end of the monitored period, there was a depreciation of the rate against the hypothetical central parity by 8.4 % (to 27.440 CZK/EUR).

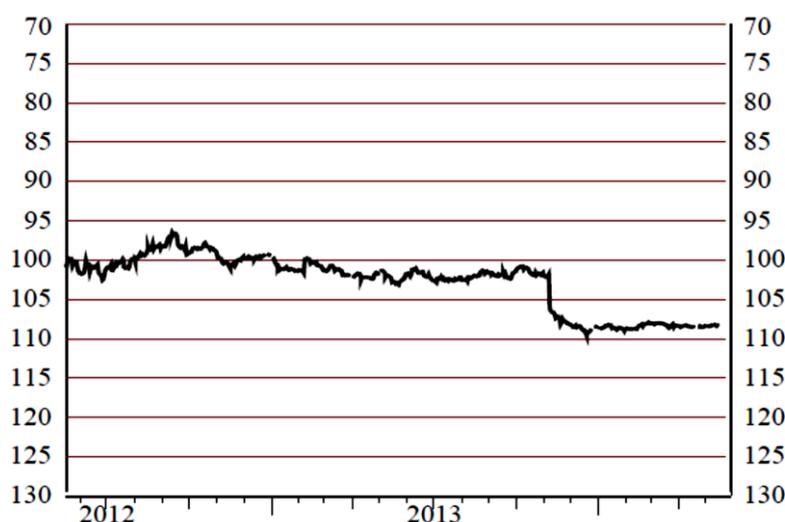


Figure 3. Simulation of the Czech koruna's participation in ERM II by European Central Bank (CZK/EUR daily exchange rates, average for May 2012 = 100)

Source: European Central Bank, 2014, p. 137.

ECB does not state the formulation “fulfils - does not fulfill” for any of the assessed criteria in its converge reports. Neither does it comment on deviation of the rate against the fluctuation margin. The opinion of ECB regarding the hypothetical fulfillment of the exchange-rate convergence criterion is not stated.

The European Commission issued its last Convergence Report in June 2014 (as well as ECB). The monitored period is identical to the period in the ECB report. EC characterizes the development of the exchange rate as follows:

- The Czech koruna does not participate in the ERM II system,
- The exchange-rate regime is identified as "floating exchange rate regime, allowing for foreign exchange market interventions by the central bank, "
- Until interventions of November 2013, the exchange rate of the Czech koruna to the euro had been in principle stable, then a steep depreciation occurred,
- During the two assessed years there was a depreciation of the CZK/EUR rate by almost 11%.

Conclusion: “The Czech Republic does not fulfill the exchange rate criterion.” (European Commission, 2014, p. 10). The Convergence Report of EC does not contain hypothetical participation of the Czech koruna in the ERM II mechanism.

5.3 Other approaches

The simulation of the Czech koruna's involvement in ERM II is dealt with by Lacina, Rozmahel et al. (2010, pp. 145-146). However, they are examining not only the two-year period, but the period from May 1997, when the Czech koruna's exchange rate regime switched from peg to managed floating, by mid-2009. As a hypothetical central parity, they used the exchange rate from the beginning of this period, i.e. May 1997. Throughout this parity, the fluctuation band was $\pm 15\%$. They concluded that the CZK/EUR exchange rate had appreciated for a long time. During 2002, it exceeded the fluctuation bands appreciation

limit over the short term. It consistently crossed this border from 2005 until the end of the period under review.

Other simulations (Helísek et al., 2007, pp. 35-36; Helísek et al., 2009, pp. 30-31) investigate only two-year periods with a hypothetical central parity CZK/EUR determined according to the ECB method and the asymmetric fluctuation band, i.e. 2.25% for depreciation and 15% for appreciation. Two periods are examined in these two books, namely 2006-2007 and 2007-2008. In just one case, the depreciation threshold was slightly exceeded by 2.25% (June 2007). In one case only, the appreciable 15% threshold was slightly exceeded (July 2008).

Krawczyk (2004, p. 4) also examines a two-year period and uses fluctuation band $\pm 15\%$. Unlike the previous ones, however, it does not use graphical expressions, i.e. a graph with exchange rate development and with fluctuation bands. The average rate in the two-year examined period was calculated and further the exchange rate deviation at the end of the examined period from this average rate was included in the calculations. In the period 1998-1999, there was a slight appreciation (1.0%), and stronger appreciation (2.6%) between 2001-2002. We will not evaluate this method in the next part of our paper (Discussion). We do not consider it appropriate because a random fluctuation of the exchange rate at the end of the year cannot be a good indicator for the entire period under review.

6. DISCUSSION – OUR ALTERNATIVE APPROACHES

6.1 Interpretation of the exchange rate convergence criterion

The above mentioned assessments of the CZK/EUR rate development in recent years (Czech authorities, European Central Bank, other authors) dealt with the time horizon of the preceding two years as of the relevant report date. In addition, in case of Czech authorities, the fluctuation margin of $\pm 15\%$ around the hypothetical central parity was used.

The occurrence of “severe tension” in the monitored period

Regarding the assessed two-year period, we must remember the requirements of both the European Commission and the European Central Bank to meet the requirement “*without severe tension*” where, among others, the assessment is made “*with particular reference to foreign exchange intervention*” (EC) and with regard to “*by considering the role played by foreign exchange interventions*” (ECB). Neither EC nor ECB do quantify permissible volumes of foreign exchange interventions by any of the indicators nor they make explicit comments regarding the directions that the interventions operate (to mitigate appreciation or depreciation of the rate).

However, for the period from November 2013 when extensive interventions on the foreign exchange market were made (see part 4.3), *we may not assume that the requirement of “without severe tension” would be met.* Why? It is unsure whether the exchange rate would exceed the 15% appreciation limit of the fluctuation margin. Therefore, contrary to the approaches of the ECB, the CNB or Helísek et al. (2007, 2009), **the evolution of the actual exchange rate in the last two years cannot be observed.** That is why the alternative assessment below takes a different approach, as follows (see part 6.2):

- 1) two-year period *before* the start of foreign exchange interventions,
- 2) *extrapolation* of the CZK/EUR exchange rate trend development in the period following the start of foreign exchange interventions by the Czech National Bank until the end of monitored period (January 2016).

Fluctuation band

With regard to the fluctuation margin, its determination is problematic as the criterion is not clearly defined (see part 3.1). In our alternative approach (unlike the approach of the CNB or Lacina, Rozmahel et al., 2010), we will take *an asymmetric interpretation*, using 15% in the appreciation direction and 2.25% in the depreciation direction. The reason for the application of narrower fluctuation margin is the fact that the decision regarding the termination of derogation (from the implementation of the euro) is taken under Article 122 (2) of the Treaty Establishing the European Community by a qualified majority of the Council (composed of the ministers of finances – ECOFIN) upon the *proposal of the Commission, not ECB*, even though such decision is undoubtedly influenced by ECB (see Helísek et al., 2009). A similar approach (asymmetric fluctuation margin) is also applied by e.g. Komárek et al. (2005) or Égert, Kierzenkowski (2003). Appropriately, this asymmetry is described by Schadler et al. (2005, p. 7): [...] exchange rates would almost certainly be judged stable if they remained within $\pm 2\frac{1}{4}$ percent of parity. Appreciations above this (but well within 15 percent of the ERM II band) would be allowed in some cases.”

Duration of simulated engagement in ERM II

Unlike the approach of Lacina, Rozmahel et al. (2010) we choose *only a two-year period*. The choice of two-year (no longer) period which is also part of the official strategy is subject to economic reasons, as explained by Marková (2011):

- CNB currently applies a strategy of inflation targeting. The entry in ERM II will follow these two objectives – internal and external monetary stability,
- The regime of fixed exchange rate (particularly, if fluctuation margin of $\pm 2.25\%$ was applied) is more jeopardized by speculative attacks on the given currency.

Also other authors point out to the risk of speculative attacks: “[...] it must be remembered that formal accession to the ERM II, although assumed to result in a higher degree of the exchange rate stability, may cause tensions in the foreign exchange market, being a consequence of speculation and the desire to “test” the authorities by market entities (vide European currency crisis in first half of the nineties)” (Michalczyk, 2011, p. 128).

6.2 Our two alternative approaches

As described in Part 3 *Methodology*, we use two alternative approaches.

In the first instance, we will make an assessment of the hypothetical accession of the Czech koruna to ERM II *in a two-year period preceding the start of interventions by ČNB on the foreign exchange market*, i.e. from 7 November 2011 to 6 November 2013. To determined hypothetical central parity, the method of ECB will be used, i.e. actual average rate in November 2011 (25.464 EUR/CZK). In addition, we will set the fluctuation margins:

A) for depreciation limit:

- + 15%: 29.284 CZK/EUR
- + 2,25%: 26.037 CZK/EUR

B) for appreciation limit:

- - 15%: 21.644 CZK/EUR

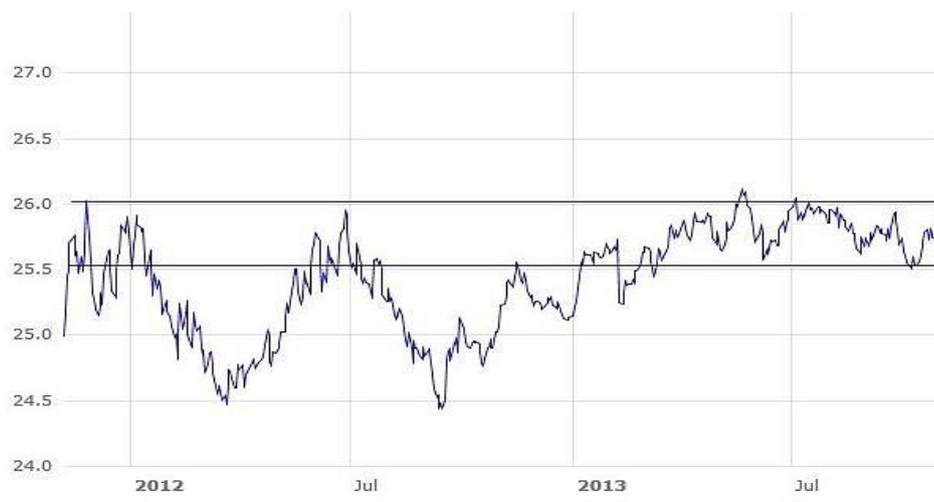


Figure 4. CZK/EUR exchange rate development from 7 November 2011 – 6 November 2013 (daily rates)

Source: <https://www.ecb.europa.eu/stats/exchange/eurofxref/html/eurofxref-graph-czk.en.html>

Own processing.

Notes:

- 1) Central parity = 25.464 EUR/CZK
- 2) Depreciation margin limit + 2.25% = 26.037 CZK/EUR
- 3) Limits $\pm 15\%$ are not shown in the figure due to their far distance from the line showing the rate development.

It follows from Figure 4 that in this period the CZK/EUR rate fluctuated in both directions around the hypothetical central parity. With regard to the limit of fluctuation margins:

- The rate was far from reaching neither the upper or lower fluctuation margin limit of $\pm 15\%$,
- In the depreciation section of the fluctuation margin of +2.25%, the limit was slightly exceeded during the four days from 20 - 23 May 2013, reaching a maximum of 26.121 CZK/EUR.

If we apply this method of hypothetical accession of the Czech koruna to ERM II, the exchange rate convergence criterion would be fulfilled.

In the second instance: the extrapolation of the CZK/EUR exchange rate trend development in the period following the start of foreign exchange interventions by the Czech National Bank until the beginning of 2016 was second form of simulation of the hypothetical accession of the Czech koruna to ERM II and subsequent assessment of how the exchange rate convergence criterion is fulfilled.

The trend period is defined as follows:

- It starts from the beginning of 2010 when a relative calm on the foreign exchange market was reached (as opposed to high fluctuations in 2008 and 2009),
 - It ends before the start of foreign exchange interventions, i.e. towards the end of October 2013.
- Therefore, it is a 46-month period.

The extrapolated period starts in November 2013 and ends in January 2016. From this period, we chose last 24 months of the simulated participation of the Czech koruna in ERM II, i.e. from February 2014 to January 2016. Again, the hypothetical central parity was determined using the ECB method, i.e. as a hypothetical average rate in February 2014.

We examined five extrapolation methods (see Appendix):

- constant mean
- linear trend
- quadratic trend
- exponential trend
- S-curve trend

The best result (in terms of error rate - the MAE column in the Appendix) was a **quadratic trend**, but from the point of view of economic interpretation this method is inapplicable as the extrapolated rate only increased strongly. The second best result was **linear trend**. This function means that the increments of the changes in the given variable (exchange rate) are approximately the same, and it is assumed that their further development will be the same as previous development. The third best result was **exponential trend**. This function means that the increments of the examined variable grow with a geometric series. The other two methods, namely the **constant mean** and the **S-curve trend**, were not used as they displayed a large error rate.

First, we use a **linear trend function**.

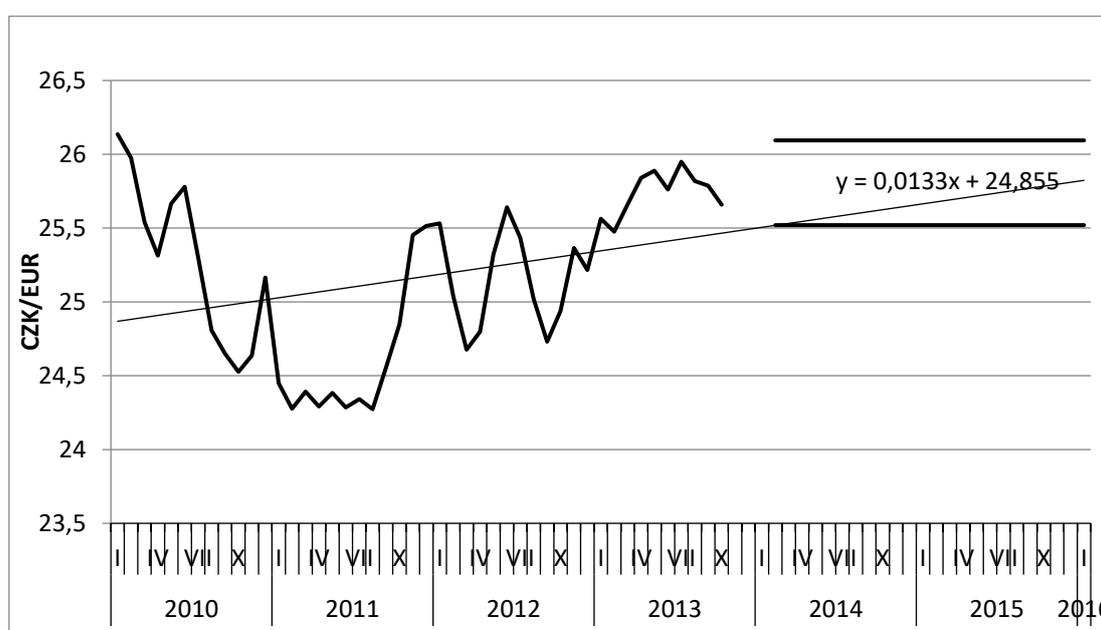


Figure 5. Extrapolation of CZK/EUR rate development (linear trend function) (monthly averages)

Source: <https://www.ecb.europa.eu/stats/exchange/eurofxref/html/eurofxref-graph-czk.en.html>

Own processing of the extrapolation.

- 1) Central parity = 25.520 EUR/CZK
- 2) Depreciation margin limit + 2.25% = 26.096 CZK/EUR
- 3) The limits of $\pm 15\%$ are not shown in the figure due to their far distance from the line showing the rate development. (Similarly as in Figure 4)

Equation of the linear trend function:

$$T_t = 0.0133 t + 24.855$$

Variables and constants mean:

T_t ... sought extrapolated exchange rate

0.0133 ... average monthly increment of the extrapolated exchange rate

T ... number of months (50 months for central parity, i.e. extrapolated exchange rate in February 2014, 73 months for exchange rate in January 2016)

24.855 ... extrapolated exchange rate in January 2010 (beginning of the trend period)

From the equation we will calculate the extrapolate exchange rate in February 2014 expressing hypothetical central parity (extrapolated exchange rate in February 2014):

$$T_{50} = 0.0133 * 50 + 24.855$$

$$T_{50} = 25.520$$

In addition, fluctuation margins will be determined:

A) for depreciation limit:

- + 15%: 29.348 CZK/EUR
- + 2.25%: 26.094 CZK/EUR

B) for appreciation limit:

- - 15%: 21.692 CZK/EUR

It follows from Figure 5 that in the assessed period from February 2014 – January 2016 the extrapolated rate was only in the depreciation section of the fluctuation margin. Towards the end of the assessed period, the extrapolated exchange rate amounted to 25.826 CZK/EUR ($T_{73} = 0.0133 * 73 + 24.855$). It means that it did not exceed the more “stringent” depreciation limit of the fluctuation margin. Therefore, should this method of the hypothetical accession of the Czech koruna to ERM II, the exchange rate convergence criterion would also be fulfilled.

Almost the same results are obtained when using *exponential trend function*. Equation of the exponential trend function:

$$T_t = \exp(3.21283 + 0.00053018 t)$$

Variables and constants mean:

T_t ... sought extrapolated exchange rate

3.21283 ... the initial value of the natural logarithm of the trend

0.00053018 ... the average monthly increment of the natural logarithm of the trend

T ... number of months (see above)

We calculate following values:

– hypothetical central parity is 24.902 CZK/EUR (extrapolated exchange rate in February 2014)

– depreciation limit of fluctuation margin +2,25% is 25.462 CZK/EUR

– extrapolated exchange rate amounted in January 2016 to 25.208 CZK/EUR.

This exchange rate did not exceed the depreciation limit of the fluctuation margin even if we used this method.

The graphical representation of the development of the extrapolated rate using the exponential trend function is almost the same as in the case of the linear trend function, so we do not mention it.

7. CONCLUSION

Neither the Czech koruna nor currencies of other non-member states of the euro area participate in the ERM II mechanism (with the only exception being the Danish krone). However, an accession to this mechanism can be simulated and the hypothetical fulfillment of the exchange rate convergence criterion may subsequently be assessed.

The Czech authorities, European Central Bank and European Commission deal with the assessment of Maastricht convergence criteria. In case of the exchange rate stability criterion these assessments focus on the CZK/EUR exchange rate development in the last two years. However, we do not consider this approach to be suitable with the reason being strong interventions on the foreign exchange market performed by the Czech National Bank since the beginning of November 2013. These interventions contradict the requirement to achieve a stable rate “without severe tensions”.

Therefore, we propose two alternative approaches with the first being an assessment of the exchange rate stability only in the period preceding the interventions above and the second, an extrapolation of the CZK/EUR rate development from 2010-2013 into the present time (using the linear and exponential trend functions). At the same time, we believe it is more suitable not to use fluctuation margin around the hypothetical central parity of $\pm 15\%$, but an asymmetric margin of 2.25 % in the depreciation direction and 15% in the appreciation direction.

The first method concludes that the narrow depreciation limit (2.25 %) of the fluctuation margin was exceeded only slightly and for a short period of time. The second method arrived at the conclusion that the CZK/EUR rate came close to this depreciation limit but did not exceed it in the monitored two-year period (II 2014 – I 2016). Thus, the exchange rate convergence criterion was fulfilled with regard to this hypothetical accession to ERM II.

The Czech Republic fulfills the remaining Maastricht criteria (this is not covered by our paper). The evaluation of *de facto* fulfillment of this exchange rate stability criterion is therefore crucial to assessing readiness for entry into the euro area.

The limits of our conclusions lie in uncertainty in two ways: 1) What is the permissible amount for intervention on the foreign exchange market? 2) Are these interventions assessed equally in appreciation and depreciation?

Meeting the Maastricht exchange rate stability criterion *de jure* means that the Czech koruna will be officially involved in the mechanism ERM II. There are two questions to it. 1) What will be the central rate CZK/EUR? 2) What exchange rate regime will the Czech koruna apply? Our research will continue in these directions.

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APPENDIX

Models of exchange rates' extrapolation

- (A) Constant mean = 25,167
 (B) Linear trend = $24,8554 + 0,013261 t$
 (C) Quadratic trend = $25,7368 + -0,0969104 t + 0,00234407 t^2$
 (D) Exponential trend = $\exp(3,21283 + 0,00053018 t)$
 (E) S-curve trend = $\exp(3,22137 + 0,0408018 / t)$

Model	MSE	MAE	MAPE	ME	MPE
(A)	0,318892	0,496585	1,97863	1,15849E-15	-0,0494951
(B)	0,293736	0,457179	1,82088	2,31699E-16	-0,04454
(C)	0,154698	0,321467	1,27976	1,77636E-15	-0,0230848
(D)	0,293341	0,457137	1,82027	0,00559316	-0,022243
(E)	0,296718	0,46567	1,85699	0,00566527	-0,0226066

Model	RMSE	RUNS	RUNM	AUTO	MEAN	VAR
(A)	0,564705	**	***	***	***	**
(B)	0,541974	**	***	***	OK	***
(C)	0,393317	**	**	***	*	OK
(D)	0,541609	**	***	***	OK	***
(E)	0,544718	**	***	***	***	OK

Source: Own processing.