TRENDS IN THE CZK DEVELOPMENT AND AR(I)MA FORECASTING

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Abstract

LONG TERM TRENDS IN THE CZK DEVELOPMENT
The European integration process has had severe impacts on the development of exchange rates of member states' currencies. For small and open economies which trade large part of both their production input and output in foreign currencies the real exchange rates are of a special importance. This paper looks at the drivers behind the evolution of the real exchange rate of CZK within the European integration process. Beside the decomposition of the general long term trend, several factors of exchange rate fluctuations are depicted. Furthermore the recent halt in long term trend in real CZK appreciation towards EUR is discussed. Finally the study shows statistical simulation of future nominal EUR/CZK development with help of AR(I)MA models employed on different data series. Models' findings picture the gaps between observed and predicted values in the period following the exchange intervention of the Czech National Bank (CNB) from November 2013.

Key words: real and nominal exchange rate, ARIMA, ARMA, effective exchange rate, appreciation, depreciation, forecasting, stationarity
JEL Classification: E31, E42, F31, F36

Introduction

There have been important developments in exchange rates in the context of European economic integration. Exchange rates are of paramount importance, due to several reasons, especially for small and open economies which trade large part of both their input and output in foreign currencies. This paper looks at one such case and deals with the evolution of the exchange rate of the Czech crown (CZK) and its long term drivers in last two decades.

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In the first section the development of the real exchange rate (RER) EUR/CZK is discussed while pointing out main drivers behind the long term appreciation trend in different time periods. We first start with period until 2002 where we follow the succession of various regimes of monetary policy. This is followed by inter-period of 2002–2004 which is marked by expansionary monetary policy and associated growth of money supply. Next we focus on post-2004 period where the financial and economic crisis became a trigger of interesting new developments. The long term real appreciation trend is subsequently decomposed into relevant contributions form nominal exchange rate movements and price levels differential. Also the recent interruption of the long term appreciation trend is discussed in the context of current post-crises performance of the economy. Lastly the paper provides a perspective on the Czech National Bank's (CNB) decision to use the CZK exchange rate as an additional instrument for easing the monetary conditions in the economy.

In the last section AR(I)MA models are employed on exchange rate time series to carry out statistical estimation of future EUR/CZK values in the absence in of the CNB exchange rate interventions. Firstly the data and methodology are described, followed by models construction using different time series. We thus provide an unchanged policy scenario whereby one can observe the likely developments of the nominal exchange rate without the CNB intervening in the FX market. Time series analysis gives valuable insight into data characteristics discussed in model compilation section.

1. The evolution of the real exchange rates of CZK

This part of the paper will discuss the evolution of the exchange rate of CZK before and after the Czech Republic became a member of the European Union. Brief history of the exchange rate movements in the 1990s will be presented. Subsequently the period right before joining the EU will be described in more details. Finally, the remaining time period will be commented on with attention to post crisis adjustments of the economy. Special attention will be given to real exchange rate movements of EUR/CZK, as EUR is the single most relevant foreign currency.

1.1 The period until 2002

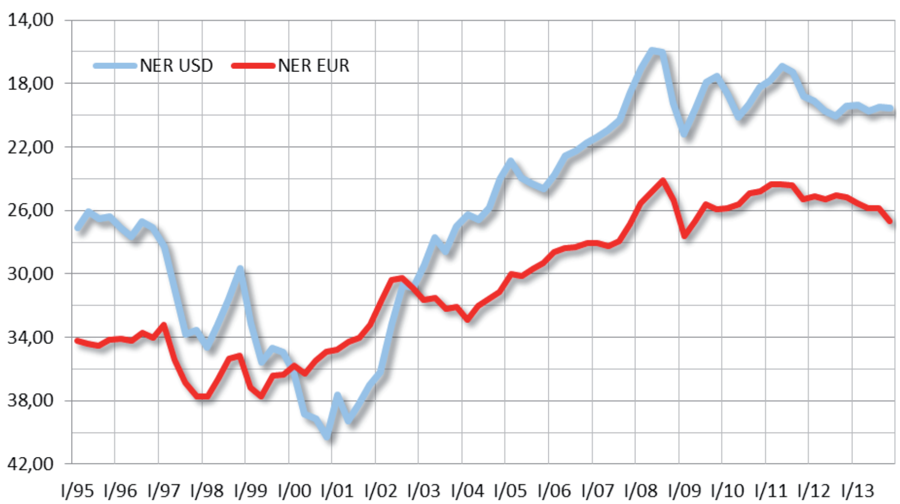
The development of the RER of CZK is marked by a long term appreciation trend. We can observe real appreciation of CZK since 1991, however, with different drivers in respective periods. It is also important to mention, that such development occurred within different regimes of monetary policy. Indeed there had been a fixed exchange rate regime until 1997 when the central bank moved to (almost) clean floating of the exchange rate.

In the beginning of the 1990s the exchange rate system was still highly distorted by the legacy of the central planning framework. The official exchange rate was far from the one on the unofficial market (Winiecky 1993). To stabilize the currency, the government opted for the fixed exchange rate regime with anchor to a basket of five foreign currencies. The exchange rate was meant to be the stabilizing variable of the whole transformation process. After couple of devaluations in 1990, the currency was clearly undervalued (Kopits 1995). This served as a temporary assistance to exporters until the real appreciation emerged. Later on modest fluctuation intervals were introduced as well as narrowing down the basket of base currencies to German mark and the US dollar only. The currency crisis in 1997 documented the unsustainability of the regime, followed by exchange rates adjustments (figure 1).

At first the above mentioned devaluations of the NER led naturally to depreciation of the real exchange rate, however, starting from 1991 the NER was, as a matter of fact, fixed. Yet due to tax reforms, price deregulations and also high inflation expectations the price level movement rocketed above those of the trading partners. Relatively higher inflation rate resulted in appreciation of the real exchange rate. Several countries in the region, namely Poland and Hungary, witnessed a different story owing to introduction of crawling peg allowing for gradual adjustment of the exchange rates (Kopits 1995). As a result their real exchange rate did not strengthen as much as in the case of CZK.

Following the currency crisis in 1997, when the central bank intervened strongly trying to safeguard the fixed exchange rate regime[1], the bank opted for inflation targeting framework, whereas fixed exchange rate regime was swapped to managed floating. In fact, the CNB only seldom intervened on the market making it "almost" clean floating regime. Within the new framework the CNB was able to force down the inflation to levels similar or lower to those in trading partner countries. However the existing real appreciation did not vanish and the process continued further, yet due to different reasons. The nominal appreciation of CZK vis-à-vis foreign currencies became the main driver after 1997. It is possible to observe different developments of NER of CZK towards EUR (ECU) and USD (figure 1).

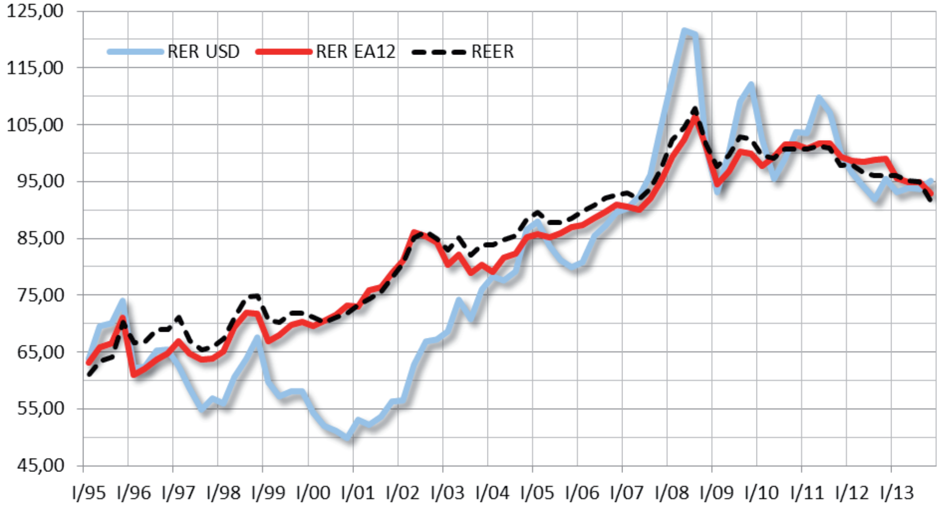
Figure 1a | Nominal and real exchange rates, 1995–2014



1 The central bank intervened by selling 3 bl. USD to halt the depreciation of CZK.

Figure 1b also pictures the development of the real effective exchange rate (REER), which gives a hint of the domestic currency strength vis-à-vis major trading partners and can serve as one of the indicators of the level of international competitiveness. As such REER is not calculated for each foreign currency separately, yet it rather depicts what is happening to the value of the domestic currency against a basket of foreign currencies. Therefore it is important to notice the proximity of RER EA12 and the REER lines. Currencies' weights in the basket are given by the shares of the economy's trade partners in the total trade turnover thus making EUR the principal currency in the basket.

Figure 1b | Nominal and real exchange rates, 1995–2014



Quarterly averages

Source: ARAD

1.2 The period of 2002–2004

In the period 2002–2004 a change in a long-term trend of the currency pair EUR/CZK can be seen (figure 1a, b). The process of the real convergence to the EU took place virtually since 1999 and was marked by systematic appreciation of the real exchange rate as discussed above. Beside main drivers of the real appreciation mentioned in previous section, other factors as increase in labour productivity in the domestic economy and increase the quality of goods can be quoted as well (Mandel and Tomšík 2003).[2] In early 2002, the trend of real appreciation of CZK strengthened, mainly through nominal appreciation of CZK vis-à-vis EUR (figure 1 and 5) where the exchange rate strengthened up to 30 EUR/CZK from 36 EUR/CZK over the course one year.[3] Since September 2002, however,

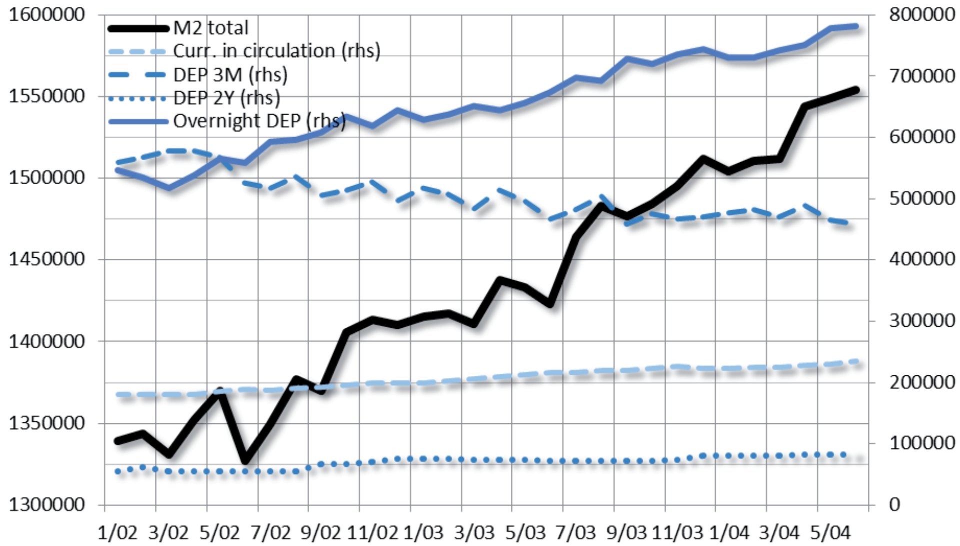
2 Other factors that can be referred to: Balassa-Samuelson effect, FDI effect, reducing trade barriers.

3 Almost 17% appreciation of CZK on YoY basis.

the NER depreciated by approximately 10% to 33 EUR/CZK at the end of 2003 and beginning of 2004.

Indeed, the period of 2002–2003 was marked by a significant decline in interest rates triggered by expansionary monetary policy pursued by the CNB with the growth of the monetary base and consequently the growth of money supply. It is possible to notice in figure 2 that the nominal money supply in the Czech Republic (as measured by the monetary aggregate M2) has increased since June 2002 until early 2004 by approximately 13% particularly due to growth in overnight deposits.

Figure 2 | Monetary aggregates and counterparts – M2 (total), millions of CZK

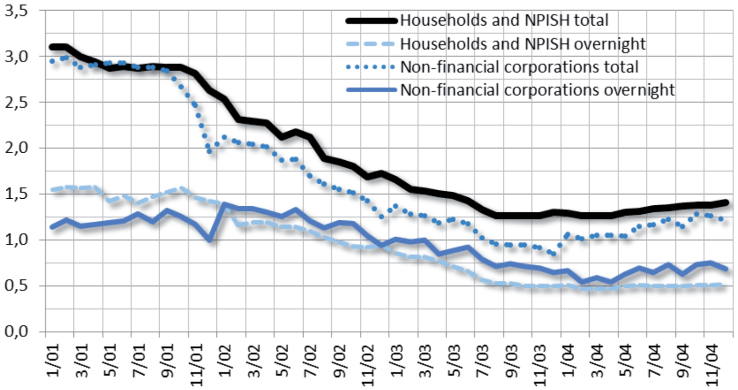


Monthly averages, January 2002 – June 2004, millions of CZK

Source: ARAD database, Monetary aggregates and counterparts

This should have led in the long run to weakening of the domestic currency in accordance with the theory of purchasing power parity. As a result the depreciation expectations have increased in the currency markets which, consistently with the uncovered interest rate parity theory, implied a higher return on foreign financial assets. The currency market investors expected higher interest rates in the domestic economy. However, already low interest rates started to fall considerably in the period of 2002–2003. The domestic market interest rates as measured by the interest rate on bank deposits by Czech residents reached its low in the fourth quarter of 2003 (Figure 3).

Figure 3 | Bank interest rates on CZK – denominated deposits by Czech residents – outstanding amount (%), 2001–2004

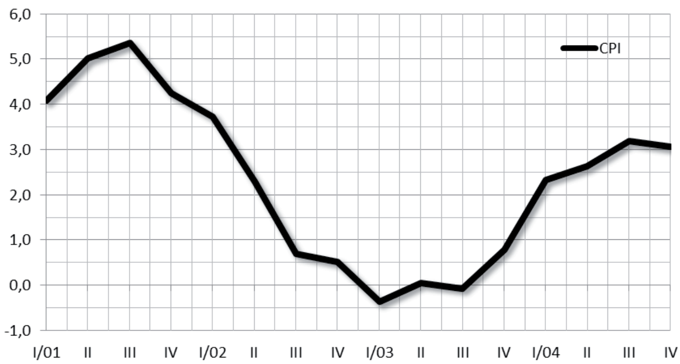


Monthly averages, January 2001 – December 2004

Source: ARAD database, Monetary aggregates and counterparts

Continuous depreciation expectations and declining domestic interest rate resulted in domestic assets denominated in CZK losing their value. However, despite such developments, investors did not turn their demand towards foreign assets, which was prevented by signs of economic slowdown in main trade partners' economies (Mandel et al. 2009). The excess of money supply would, according to economic theory, imply the price level to increase, as businesses and households are encouraged to investment and consumption. Thus higher aggregate demand would be reflected in higher prices (Obstfeld and Rogoff 1996). Figure 4 shows that the prices reached their low at the beginning of 2003 and begin to grow throughout the year and then in 2004 particularly.

Figure 4 | Consumer price index, 2001–2004



Quarterly averages, YoY changes, in %

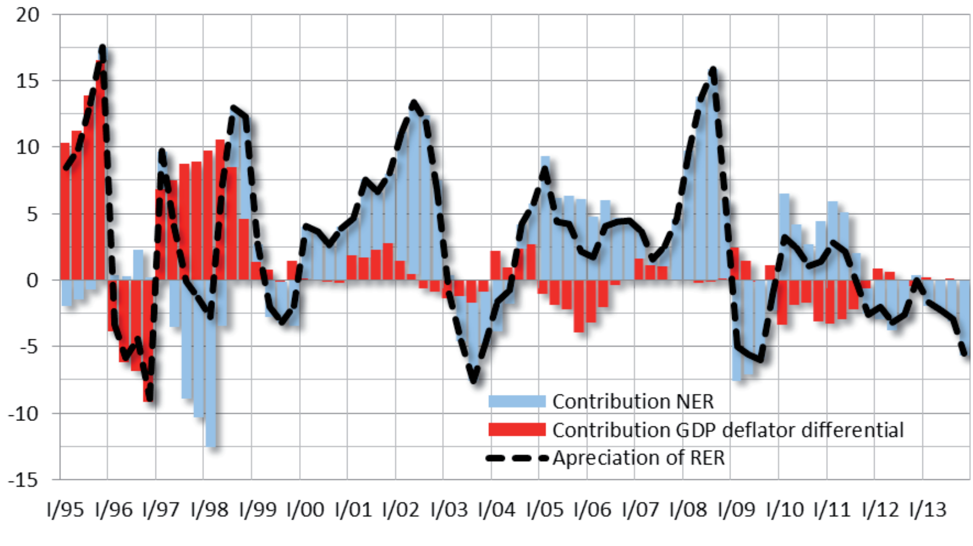
Source: Ministry of Finance database

1.3 The period after 2004

Indeed 2004 was marked by the gradual increase in domestic aggregate price level measured by the consumer price index, a gradual increase in interest rates and the appreciation of the domestic currency against EUR. In this period, the NER returned to its long-term systematic appreciation trend, which can be seen in figures 1 panel a. This resulted again in real exchange rate appreciation. The nominal appreciation was partly compensated by the increase in labour productivity and rise in produced goods quality and also by minimal inflation differential vis-à-vis main trading partners (Komárek 2010). As such REER appreciated as shown in Figure 1, panel b.

The long term appreciation trend was, however, interrupted by crisis-linked developments triggered in particular by outflow of financial assets and investment from emerging markets, resulting in nominal depreciation of CZK vis-à-vis relevant foreign currencies. On the other hand such movement helped the exporters to cope with negative effect of the crisis on external demand (Komárek 2010). As shown in figure 5 on decomposition of real exchange rate, the fluctuations in CZK vis-à-vis EUR were caused almost solely by contributions of the NER movements in the period 2008–2009. In 2009 the drop in the nominal exchange from the previous year was partly reversed due to rising confidence and reduction of the capital outflows (OECD 2011).

Figure 5 | Real exchange rate to EUR (decomposition), 1995–2013



Deflated by the GDP deflators, YoY growth in %, contributions in percentage points

Source: ARAD, Ministry of Finance database

However weak GDP growth performance of the economy and negative interest rate differential resulted in halting the general long-term trend of appreciation of EUR/CZK in 2011. Though the CZK gradually appreciated, with no major fluctuations, in the first three quarters of 2011 to a September average of 24.56 CZK/EUR, in the fourth quarter, as flurry on financial markets increased owing to the escalation of the debt crisis in the euro area, investors turned away from the Central and Eastern European region and the currencies of these countries depreciated quite dramatically. This was particularly the case of the Polish zloty and Hungarian forint (OECD 2012).

The CZK weakened in nominal terms to an average of 25.51 CZK/EUR in December 2011. Investors abandoned their positions in the region in general, as they were unable to distinguish the varying macroeconomic conditions of individual countries (MoF 2012). This was caused to a great extent due to the growing aversion to risk in portfolios and hasty decision making. In 2012 the exchange rate fluctuated slightly above 25 EUR/CZK with no significant trend. The CZK weakened against the euro by 2.2% in 2012, to which a gradual lowering of the main interest rates by the CNB assisted. Also verbal interventions by the Bank concerning the potential further easing of monetary conditions contributed in this context. In the absence of major appreciation pressures the CZK has continued to depreciate slightly towards the euro in the course of 2013 (by 2,4% in first three quarters).

Recently the CNB has been pursuing quite loose monetary policy which is consistent with current development of the economy. Key interest rates were lowered in November 2012 and the CNB followed with exchange rate interventions measures in November 2013 which send the CZK above 27 EUR/CZK level. By using the exchange rate as another monetary policy instrument the CNB has set a floor on the NER and announced the commitment to carry out interventions at volumes required for fulfilling the inflation target. However it is beyond the scope of the paper to assess the CNB's steps in terms of potential short term impacts. In the last section the current NER level is discussed in the context of a model exercise which statistically simulates a no-intervention scenario.

1.4 Summary of historical perspective

There has been a general long term trend of both nominal and real appreciation of CZK. While the main driving factor of the RER appreciation until 1997 has been the inflation differential, where prices in the domestic economy surpassed their foreign counterparts, nominal appreciation of CZK became the key propeller since then. With interruption in the period of 2002–2003, where the exchange rate depreciated both nominally and in real terms due to expansionary monetary policy and economic slowdown, we can observe such long term trend, with minor fluctuations, until 2009. Since then the exchange rate fluctuates, within the environment of weak economic performance and negative interest rate differential, in the absence of substantial appreciation or depreciation pressures. The CNB's response on current inflation development triggered abrupt nominal depreciation of the CZK, precisely as intended by the central bank. However one might be interested what would be the likely development of the exchange rate given no FX intervention by the CNB.

2. Nominal exchange rate forecast – statistical approach

In this section we want to highlight one of the possible methods for exchange rate forecasting, namely the univariate autoregressive integrated moving average models (ARIMA), using the nominal exchange rates of CZK vis-à-vis EUR. This paper abstracts from methods based on macroeconomic fundamentals and rather focuses on purely statistical exercise. Interesting conclusions are drawn by discussing methods to stationarize the data series, employing different series samples for models construction and interpreting the forecasting results. One of the objective of the paper is also to employ the above mentioned methods to see the likely development of the nominal exchange rate of CZK vis-à-vis EUR in case of no intervention on the side of the CNB.

The first section introduces the data used in the following analysis. It specifies how the data are treated and adjusted for modelling exercise. As such time series plots are succeeded by issues of seasonal adjustment methods, unit root testing and stationarity, and relevant correlograms investigation. Section 2 deals with designing ARIMA models while employing different time series assessed in previous analyses. Chosen model settings are justified on the basis of standard ARIMA procedure, to a great extent following the Box-Jenkins model identification process. Three models are finally designed, all of which are employed in forecasting exercise in the last section of the paper.

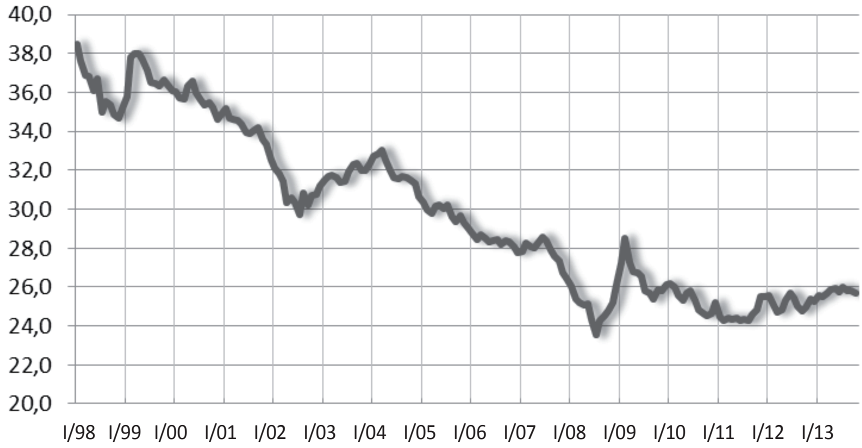
2.1 Methodology and data

This section of the paper introduces autoregressive-moving average (ARMA) model and its generalization in form of autoregressive integrated moving average (ARIMA) model for description of the time series and estimating future values. The models are employed primarily to simulate the likely development of the NER, similarly to Csajbók (2003) and Maniatis (2012), in the absence of the exchange rate interventions carried out by the CNB in November 2013.

The data

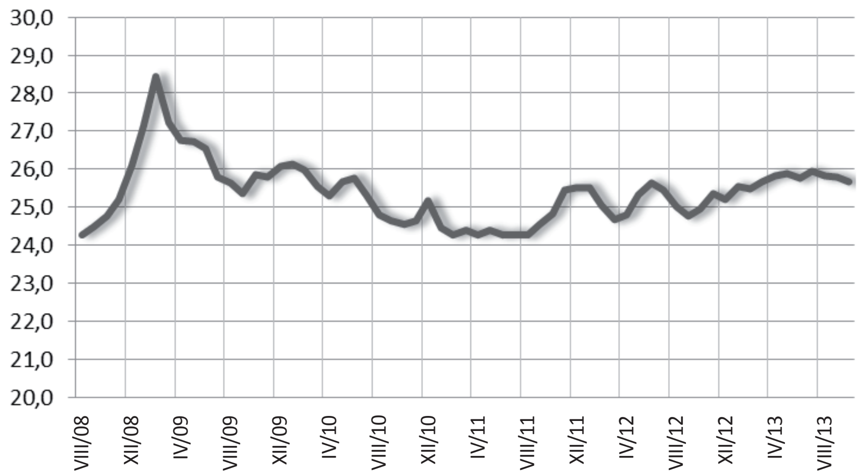
The data used in the paper contain monthly series of the bilateral nominal exchange rate (NER) of CZK vis-à-vis EUR. Monthly series covers the period starting from January 1998 until the exchange rate interventions of the CNB in November 2013. The series comprises of 190 observations ranging from January 1998 to October 2013. The CNB Arad database is used, more accurately the data are obtained from Financial markets statistics section. The observations are monthly average values. Data beyond October 2013 are used for comparing the observed values with the forecasting results. Figure 6 plots the full sample time series later used for modelling exercise.

Figure 6 | Analysed time series, NER EUR/CZK, 1998 M1–2013 M10



Furthermore analysis and model construction are applied on the full sample series as well as on the post crisis sample[4] only (figure 7) in order to show varying forecasting outcomes resulting from different series samples. The start of the full sample series has deliberately been chosen to January 1998 as the CNB swapped from fixed exchange rate regime to inflation targeting.

Figure 7 | Analysed time series, NER EUR/CZK, 2008 M8–2013 M10



4 The data contain 63 observations ranging from August 2008 to October 2013 for monthly series.

2.2 Seasonality

Despite the fact that the selected time series capture the exchnage rate on monthly basis, the data are not burdened by seasonality. To test for an existence of seasonality in employed time series various approaches can be used. First it is possible to check for seasonal patterns against the graphical interpretations in figures 6 and 7 and also against the correlograms, neither of which show evidence for seasonality. Second it is possible to regress the time series against seasonal dummies and assess the coefficients values' significance. Third would be the report generated by Census X12 procedure while running seasonal adjustment where tests for both stable and moving seasonality can be found. Both the full range series and post-crisis sample series were tested.

Table 1 | Seasonality check, Census X12 procedure

***Full Sample**: 1998 M1–2013 M10*	t-Statistic	Prob.
F-test for stable seasonality	2.800	0.0022
F-test for moving seasonality	2.840	0.0008
***Sample**: 2008M8–2013M10*	t-Statistic	Prob.
F-test for stable seasonality	5.817	0.0000
F-test for moving seasonality	0.697	0.0008

2.3 Stationarity

While attempting to estimate future values with AR(I)MA techniques the first step is to check stationarity in the time series. First the correlograms are subject to visual inspection. Second we will proceed with a help of the augmented Dickey-Fuller (ADF) unit root tests. Both approaches are pictured below.

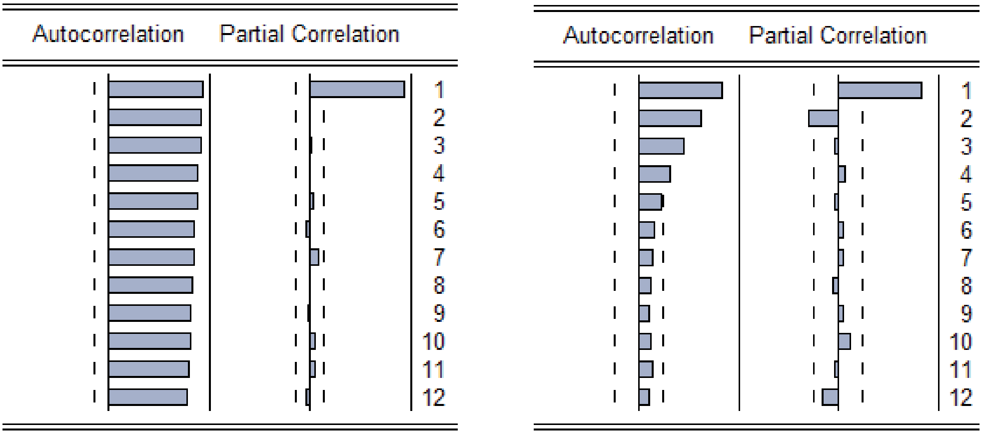
Table 2 | Unit root tests of monthly series

***Full Sample**: 1998 M1–2013 M10*	t-Statistic	Prob.
ADF test statistic: LEVEL	–2.489129	0.3332
***Sample**: 2008M8–2013M10*	t-Statistic	Prob.
ADF test statistic: LEVEL	–3.269676	0.0206

In case of full sample series the model with trend and intercept is considered as both elements turn out to be significant. For post-crisis sample unit root test with intercept only is performed.

The ADF tests as well as the ACF plot suggest that for the full sample, we cannot reject the null hypothesis of a unit root in levels. Therefore, within their full rage monthly series appear to be non-stationary. On the other hand, from observing the sample covering the post crisis period only it is possible to reject the null hypothesis in level since we find evidence for stationarity at level.

Table 3 | Correlograms of monthly series, full sample and post-crisis sample



2.4 Achieving stationarity in full sample series

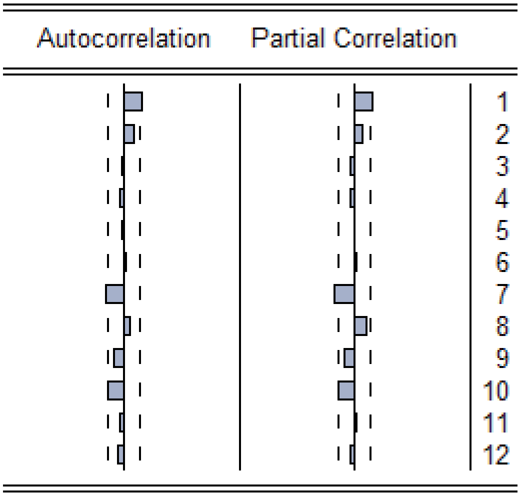
Elaborating on the full sample the Box-Jenkins methodology (1970) recommends differencing to achieve stationarity in the mean and log or power transformation to get stationarity in the variance. There is also a stream of literature suggesting different methods of stationarizing while arguing that differencing was in many cases not the appropriate way to get stationarity due to information loss (Pierce 1977, Nelson and Plosser 1982, Gil et al 2011). Clements and Hendry (2001) elaborate on trend stationary series while examining incorrect choice between these models for forecasting for both known and estimated parameters.

Differencing to achieve stationarity

We attempt to achieve stationarity through differencing the time series. We find stationarity in the first difference, as such we can conclude that the series is integrated of order 1, or I(1). We carried out the ADF unit root test on the differenced series with following results (see table 4). Neither trend nor intercept is considered in this exercise, since both components prove insignificant. We also provide correlogram plots for the differenced stationary series, since we later employ them while identifying the number of AR and MA terms in the ARIMA model.

Table 4 | Unit root test and correlogram, full sample series, differenced series

***Full Sample**: 1998M1–2013M10*	t-Statistic	Prob.
ADF test statistic: 1st difference	–11.65686	0.0000



2.5 Building ARIMA Models

Altogether two models would be constructed and later used for forecasting exercise. Firstly we employ full sample series and construct different model configurations while using differenced series. Secondly we shall work with post crisis period sample only, where we found stationarity in levels.

Modelling on differenced series

While working with the differenced series, ARIMA (p,d,q) model will be employed where parameters p and q represent the order of the autoregressive and moving average parts of the model respectively and parameter d gives the order of integration. To estimate a correct model we proceed by feeding AR and/or MA elements into the model. Following table gives a summary of tested model configurations with selection criteria for models that can be verified.

Also largest outliers were eliminated by means of dummy variables (1998m7, 1999m2, 2002m8, 2009m2). These outlying observations are regarded as effects of the crises described in the previous section of the paper and prove to be statistically significant in the model configurations.

Table 5 | Tested model configurations, ARIMA settings

Configurations/Information criteria	AIC[5]	BIC[6]	HQIC[7]
ARIMA (1,1,0)	0.825871	0.928409	0.867408
ARIMA (0,1,1)	0.807875	**0.910412**	**0.849411**
ARIMA (2,1,0)	**0.806797**	0.926424	0.855256
ARIMA (0,1,2)	Some AR/MA elements not significant		
ARIMA (2,1,1)	Some AR/MA elements not significant		
ARIMA (1,1,2)	Some AR/MA elements not significant		
ARIMA (3,1,0)	Some AR/MA elements not significant		
ARIMA (0,1,3)	Some AR/MA elements not significant		
ARIMA (3,1,1)	Some AR/MA elements not significant		
ARIMA (3,1,2)	Some AR/MA elements not significant		
ARIMA (1,1,3)	Some AR/MA elements not significant		
ARIMA (2,1,3)	Model not verified		

Various model configurations have then been designed, as seen in table 5. Out of these, ARIMA (1,1,0), ARIMA (0,1,1) and ARIMA (2,1,0) could be verified leading to a white noise processes. Naturally AR and MA terms present in these models prove to be statistically significant. Also over fitting and parsimony issues have been considered thoroughly when assessing higher order processes. On the basis of information criteria ARIMA (0,1,1) is chosen, though AIC is slightly lower for ARIMA (2,1,0). However many authors tend to recommend using the more parsimonious model selected by SIC, in case AIC and SIC do not select the same model. Furthermore HQIC supports the selection of a model with MA(1) term.

Also while visually inspecting the correlogram in table 4 we might arrive to mixed conclusions. However the ACF plot seems to have one or more spikes, the rest being essentially zero, which would lead us to construct a moving average model, order of which would be determined on the basis the ACF plot. The partial autocorrelation function is generally not helpful for identifying the order of the moving average process. The resulting model characteristics would likely be ARIMA (0,1,1). What follows is the general notation for of the selected model:

$$\Delta y = \gamma + \delta_1 \varepsilon_{t-1} + \varepsilon_t \qquad where\ \Delta y_t = y_t - y_{t-1} \ .$$

5 Akaike information criterion.

6 Schwarz information criterion.

7 Hannan-Quinn information criterion.

Table 6 | Estimation output of ARIMA (0,1,1), 1998 M1–2013M10

Variable	Coefficient	Std. Error	t-Statistic	**Prob.**
C	–0.082413	0.035141	–2.345175	0.0201
D1	1.892740	0.335020	5.649638	0.0000
D2	–2.132251	0.344593	–6.187743	0.0000
D3	1.442812	0.336669	4.285546	0.0000
D4	1.527338	0.334495	4.566098	0.0000
MA(1)	0.351876	0.071698	4.907742	0.0000
R-squared	0.352865			

We tested the regression model for presence of autocorrelation in the errors by applying the Breusch-Godfrey serial correlation LM Test. The statistics shows that the null hypothesis of absence of serial correlation of any order cannot be rejected. Furthermore normality test and heteroskedasticity test results are shown below to further verify the model.

Table 7 | Model verification, differenced series, 1998 M1–2013 M10

	t-Statistics	**Prob**.
Breusch-Godfrey Serial Correlation LM Test	0.823449	0.5641
Jarque-Bera normality test	4.149318	0.68523
ARCH heteroskedasticity test	1.551134	0.4161

Modelling on stationary post-crisis period sample

Similarly for monthly series sample covering only the post-crisis period ARIMA (p,d,q) model will be used. Since the ADF test rejects the hypothesis of existence of unit root in the series (table 2), parameter d that gives the order of integration is zero as the time series is stationary in level.

Again several model configurations are constructed as shown in table 8. The ARIMA(1,0,2) and ARIMA(0,0,3) qualify in terms of statistical significance of the components and model verification. For this data sample ARIMA (2,0,0) seems to be the optimal setting given the lowest SIC value. The selection can be also confirmed by investigating the ACF a PACF plots in table 3. We can identify exponentially decreasing appearance of the sample autocorrelation function pointing to a AR process. We then exploit the partial autocorrelation function to identify the order of the autoregressive model. The PACF becomes zero at lag 3, pointing out to the AR(2) process with general notation:

$$y_t = \alpha + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \varepsilon_t \ .$$

Table 8 | Tested model configurations, ARIMA settings

Configurations/Information criteria	AIC	BIC	HQIC
ARIMA (1,0,0)		Model not verified	
ARIMA (0,0,1)		Model not verified	
ARIMA (2,0,0)	0.598611	**0.737029**	**0.652858**
ARIMA (0,0,2)		Model not verified	
ARIMA (2,0,1)		Some AR/MA elements not significant	
ARIMA (1,0,2)	**0.585756**	0.757299	0.653108
ARIMA (3,0,0)		Some AR/MA elements not significant	
ARIMA (0,0,3)	0.714164	0.884254	0.781062
ARIMA (3,0,1)		Some AR/MA elements not significant	
ARIMA (3,0,2)		Some AR/MA elements not significant	
ARIMA (1,0,3)		Some AR/MA elements not significant	
ARIMA (2,0,3)		Some AR/MA elements not significant	

The largest outlier (2009 m) has been eliminated by means of dummy to remove effects caused by an abrupt depreciation of CZK owing to the impact of the onset of the financial crisis. The results are shown below.

Table 9 | Estimation output of ARIMA (2,0,0), 2008 M8–2013 M10

Variable	Coefficient	Std. Error	t-Statistic	**Prob.**
C	25.44936	0.259496	98.07229	0.0000
D1	1.046509	0.191264	5.471555	0.0000
AR(1)	1.269525	0.120511	10.53454	0.0000
AR(2)	−0.426538	0.119031	−3.583411	0.0007
R-squared	0.856025			

Following test are shown to verify the model settings similarly to previous cases.

Table 10 | Model verification, Sample: 2008 M8–2013 M10

	t-Statistics	**Prob.**
Breusch-Godfrey Serial Correlation LM Test	0.708415	0.1736
Jarque-Bera normality test	2.611510	0.2488
ARCH heteroskedasticity test	1.352583	0.9610

2.6 Forecasting with ARIMA models

The final step in working with the models would be the estimation of future values of the time series. Forecasts are conducted for period following the exchange rate intervention of the CNB until the end of 2014. As such it is possible to statistically simulate the likely development of the NER in the absence of the CNB's intervention.

First in case of differenced series, we may have seen that determining the model specification can be tricky. We finally estimated the model which qualified both in terms of components significance and verification criteria. The forecast in the first panel of figure 8 shows nominal exchange rate further appreciating towards 24,48 in the end of 2014 as seen in the first panel in figure 8. We can notice that the non-stationarity of the original time series is projected within the forecast.

The second panel in figure 8 show quite distinct results as the sample covering the post-crisis period only is considered here. The forecast based on stationary series suggest EUR/CZK almost unchanged throughout the forecast horizon and close to pre-intervention levels – reaching 25,5 in December 2014. There is no evidence of nominal appreciation in the post-intervention period as the original data series show stable development with the nominal exchange rate moving around its mean.

Naturally, different prediction results can be observed due to the character of considered series samples. Though simulated on purely statistical basis the forecasts give clear picture of the differences between observed and predicted values. The gap would be larger in case of full sample as reflecting the trend in the forecasted values pushes the CZK further from the observed values in the post-intervention period. Comparing the last observed values with forecasts for 2014M10 gives differences of approximately 2,93 and 2,13 for full sample series and post-crisis sample respectively. The post-crisis sample shows greater proximity to observed values due to absence of a long term trend component.

Figure 8a | Model forecasts – ARIMA (0,1,1) and ARIMA (2,0,0) models

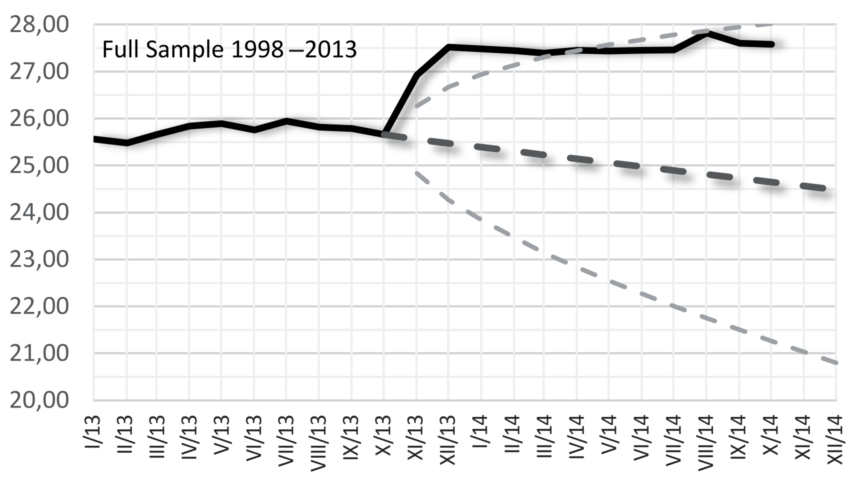
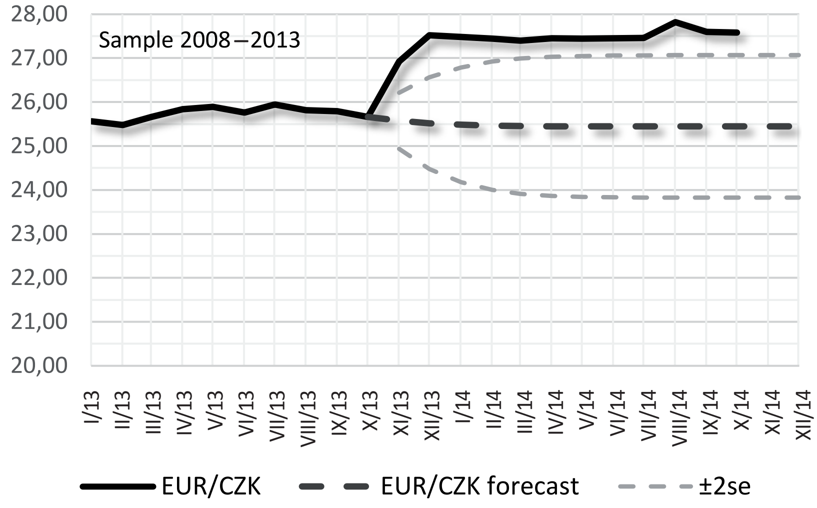


Figure 8b | Model forecasts – ARIMA (0,1,1) and ARIMA (2,0,0) models



Conclusion

There has been a general long term trend of both nominal and appreciation of CZK. While the main driving factor of the RER appreciation until 1997 has been the inflation differential, where prices in the domestic economy surpassed their foreign counterparts, nominal appreciation of CZK became the key propeller since then. With interruption in the period of 2002–2003, where the exchange rate depreciated both nominally and in real terms due to expansionary monetary policy and economic slowdown, we can observe such long term trend, with minor fluctuations, until 2009. Since then the exchange rate fluctuates, within the environment of weak economic performance and negative interest rate differential, in the absence of substantial appreciation or depreciation pressures. The CNB's response on current inflation development triggered abrupt nominal depreciation of the CZK. Effort to simulate the post-intervention period in the absence of the interventions gives clear picture of the likely NER development where different results are obtained owing to the character of data series employed.

This paper also attempted to highlight one of the possible methods for exchange rate forecasting, namely the autoregressive integrated moving average models, using the nominal exchange rates of CZK vis-à-vis EUR. Interesting conclusions are drawn by employing different series samples for models construction and interpreting the forecasting results. The paper specifies how the data are treated and adjusted for modelling exercise. As such time series plots are followed by issues of seasonality, unit root testing and stationarity, and relevant correlograms investigation. It also deals with designing ARIMA models while employing different time series samples, to a large extent elaborating on the Box-Jenkins methodology. Two models are finally designed, both are employed in forecasting exercise in the last section of the paper. The objective of the paper is to see the likely development of NER in case of no intervention on the side of the CNB. Effort to simulate the post-intervention period in the absence of the interventions gives clear picture of the likely NER development where different results are obtained owing to the character of data series employed.

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