Charles University

Faculty of Social Sciences
Institute of Economic Studies

MASTER'S THESIS

What is the equilibrium exchange rate of the Czech koruna?

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Academic Year: **2016/2017**

Declaration of Authorship

The author hereby declares that he compiled this thesis independently; using only the listed resources and literature, and the thesis has not been used to obtain a different or the same degree.

Prague, May 15, 2017

Signature

Acknowledgments

I would like to thank to PhDr. Jaromír Baxa, Ph.D. for all his energy, time and guidance throughout my work on a thesis. Also, I would like to thank my family and girlfriend for all help and support in my studies.

Abstract

The aim of this thesis is to estimate bilateral equilibrium exchange rate of the Czech koruna relative to Euro and to determine if the Czech currency is undervalued or overvalued relative to the market equilibrium. We employ fundamental (FEER) and behavioral (BEER) equilibrium exchange rate models, which enables to measure the currency position relative to the market rate. To tackle the uncertainty of the implied equilibrium exchange rates that differ among alternative specifications of the models, we aggregate the estimates via principal components analysis. The perception on the market is that Czech koruna is undervalued, since the intervention regime imposed by the Czech National Bank in the 2013, was defending the exchange rate floor of 27 Czech korunas to Euro. Then, we extend conventional specifications of BEER models for variables representing exchange rate interventions and forward rates offered on the market because both can have protracted effects not only on spot rates but on adjustment towards long-term equilibrium as well. The original models with fundamental factors show equilibrium exchange rate near to 25 CZK/EUR. However, extended models with interventions show higher equilibrium exchange rate, near to 27 CZK/EUR. Thus, there is possibility of slow adjustment near to the fundamental equilibrium.

JEL Classification	F12, F21, F23, H25, H71, H87
Keywords	exchange rate, equilibrium, FEER, BEER, interventions, forex reserves

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Abstrakt

Cílem práce je odhadnout rovnovážný směnný kurz české koruny vůči euru a určit, zda je česká měna podhodnocena nebo nadhodnocena vzhledem k tržní rovnováze. Používáme modely fundamentálních (FEER) a behaviorálních (BEER) rovnovážných směnných kurzů, které umožňují měřit měnovou pozici vůči tržní hodnotě kursu. Abychom řešili nejistotu implikovaných rovnovážných směnných kurzů, které se liší mezi alternativními specifikacemi modelů, shromažďujeme odhady pomocí analýzy hlavních komponent. Situace na trhu je taková, že česká koruna je podhodnocena, neboť intervenční režim, do kterého vstoupila Česká národní banka v roku 2013 a začala hájit kurz na minimálné hodnotě 27 korun za euro. Potom jsme rozšířili konvenční specifikace modelů BEER pro proměnné představující intervence směnných kurzů a forwardových sazeb nabízených na trhu, protože oba mohou mít dlouhotrvající účinky nejen na spotové sazby, ale i na přizpůsobení se dlouhodobé rovnováze. Rovnovážný kurz podle základních modelů je téměř 25 CZK/EUR. Rozšířené modely s intervencemi vykazují vyšší rovnovážný kurz, který je téměř 27 CZK/EUR. Existuje tedy možnost pomalého přizpůsobení kurzu k rovnováze.

Klasifikace	F12, F21, F23, H25, H71, H87
Klíčová slova	směnný kurz, rovnováha, FEER, BEER, intervence, devizové rezervy

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Author:	Bc. Pavel Jančovič
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Defence Planned:	June 2017

Proposed Topic:

What is the equilibrium exchange rate of Czech koruna?

Motivation:

The Czech National Bank (CNB) is defending Czech koruna´s exchange rate through exchange rate commitment on rate 27 CZK/EUR from November 2013. The economy flourishes with GDP growth among the highest in Europe in 2015. Also, European Central Bank (ECB) is using Quantitative easing (QE) to weaken euro and persuade inflation in Eurozone. Therefore, the exchange rate of Czech koruna to euro is near 27 CZK/EUR from November 2015 until now. There is growing pressure on the CNB regarding the end of the interventions, with forecasted growing inflation rate, which should meet the inflation target in the following months. In the economical field, there is small number of analyses on the Czech currency and its equilibrium, even in this turbulent time of interventions. There is even smaller number of analyses, which are evaluating the effect of the interventions and Forward rates on the equilibrium exchange rate. These effects of these variables among the other can be interesting for the policy implication perspectives. The CNB is using interventions to defend the floor exchange rate to euro and doesn´t want to release its intervention regime, at least for now. Is Czech koruna undervalued or overvalued? Where is the equilibrium exchange rate of Czech koruna? What is the role of the Interventions made by CNB? These will be main questions answered in this diploma thesis.

Hypotheses:

1. Question #1: Is Czech koruna undervalued or overvalued in comparison to situation where is Czech koruna market driven?
2. Question #2: Where is the equilibrium exchange rate of Czech koruna at the end of 2016?
3. Question #3: What is the performance of presented models in comparison with previous research?
4. Question #4: What is the role regarding the equilibrium of the Interventions made and Foreign exchange reserves held by the Czech National Bank?
5. Question #5: Is there any effect of the past forward rates on the equilibrium exchange rate?

Methodology:

The Fundamental Equilibrium Exchange Rate (FEER) is the real exchange rate which produces a current account that is exactly matched by equilibrium medium-term capital flows and therefore is consistent with macroeconomic balance. (Clark et al., 1998). I will conduct FEER model according to the Clark et al. (1998) with vector error- correction (VEC) method. The second FEER model will be conducted according to the Komárek et al. (2012) again with VEC method.

Behavioral Equilibrium exchange rate model will be illustrated by model of real effective exchange rate and with equations with Euro. I will build BEER models according Clark et al. (1998) with VEC method, next Babetski et al. (2005) with autoregressive distributed lag (ARDL) model and finally according Pošta (2010) with VAR method.

In the next part of my thesis I will conduct extended analysis on the effect of the currency interventions, according to the Dynamic ordinary least squares (DOLS), according Levy – Yeyati et. al. (2013)

The data will be obtained mostly from Czech statistical office, system ARAD of ČNB and from statistical offices of European union and European Central Bank (ECB).

Expected Contribution:

I will conduct Behavioral Equilibrium and Fundamental Equilibrium exchange rate models, which will show the present exchange rate equilibrium in the economy.

I will make comparison of presented models of Czech koruna over time. The contribution will be in presentation of these five models, without any bias to current state of the equilibrium exchange rate. The combined model can be taken as some sort of benchmark, in what range would be Czech koruna, when the currency will be freely floating. The results can be used in future modelling of Czech economy and could be used as range, where will approximately exchange rate of Czech koruna go after the end of the interventions set by CNB. I will extend the analysis for the Interventions as short and long-term variable in the behavioral models. I will show the effect of the forward rates in the economy as forecasting factor for the equilibrium. Furthermore, I will compare presented results of the models with results presented by CNB and other institutes which presented research on this topic.

Outline:

1. Introduction
2. Literature review
3. Data and Methodology
4. Results
    a. Behavioral Equilibrium models
    b. Fundamental Equilibrium models
    c. Extended Behavioral Equilibrium models
5. Concluding remarks

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Author **Supervisor**

1 Introduction

Czech Republic and its exchange rate to other currencies has taken rough path since 1993. First years of competitive devaluation or preparations to still not finished Euro adoption are just few pieces of the history of this still young currency. Current chapter of the Czech koruna history is written right now. Since the end of 2013, the Czech National Bank started interventions on the Czech koruna, virtually fixing its lower bound to Euro to 27 CZK to EUR. The goal was to prevent Czech economy from falling into the depreciation and possibly depreciation spiral. Now in start of the 2017, the deflation threat seems to be averted and still more voices are asking what is going to happen with the end of the Czech National Banks interventions and where is the equilibrium exchange rate of the Czech koruna towards Euro and how fast will Czech economy converge to this equilibrium. The Czech National Bank was already signalling interventions will come to the end during the second quarter of 2017. The Czech National Bank took upon their promise and at their first possible meeting in that quarter, interventions were ended by the bank. The exchange rate commitment lasted almost 3 years and 5 months from the 7th of November 2013, until the 6th of the April in 2017.

This diploma thesis should show, how is Czech koruna behaving in the intervention regime, where is its equilibrium state and what are the determinants of the real exchange rate. This diploma thesis is not about evaluating the Czech National Bank policies. This thesis is mapping different approaches to measure real equilibrium exchange rates and its misalignments. In total, we conduct 3 Behavioral equilibrium (presented by Clark & MacDonald (1998), Pošta (2010) and Egert & Babetski (2005)) and 2 Fundamental equilibrium exchange rate models (Clark & MacDonald (1998), Komárek & Motl (2012)), which we will combine they outcomes by principal components analysis to assert the best equilibrium exchange rate of the economy. The principal component analysis is used to phase out individual nuances and inconsistencies, which can arise in the various spectre of the equilibrium models. On top of that, we will show short-term and long-term effect of the Foreign exchange rate reserves of the Czech National Bank, which were the most important instruments for the bank to hold the exchange rate of the Czech koruna to Euro. We will test various scenarios, one is that foreign exchange reserves are effective just in short-term, hence holding of them by national bank has no long-term effect. But if the Czech National Bank put the new Czech koruna to the market and bank has no intention to work with them since, there is possibility of the foreign exchange reserves having effect on the currency in the medium to long-term. Also, we would like to asess to what extent the equilibrium exchange rate is driven by market expectations about the future exchange rate by itself, through forward trades of the exchange rates.

And why do this analysis at all? Because the most recent models are working mostly with one type of the Behavioral or Fundamental model and are often conducted on the data before the interventions, often with the data until the end of last decade. Even when authors are working with two or more types of the models (such as Komárek and Motl, 2012), the predicted values show relatively big discrepancies.

Thesis is structured as follows. The first part of the thesis is theoretical, where basic methods and models to real exchange rate values are descripted. Secondly, we state the situation in the Czech economy, basic methodological features in the models for estimation. Also in that part, we state all data used and its transformation. In the third part, we conduct basic models, followed by the extended models. Lastly, we conclude all policy implications and conclusions related to the results.

2 Literature review

In the first part of my thesis, we will go through Exchange rate Equilibrium theories. We will also go through Exchange rate models (mostly FEER and BEER) and its properties and estimation methods.

2.1 Exchange rates and Exchange Rate Equilibrium

What exactly connects countries internationally? Main bonds are among international trade and finance. International trade allows specialization on domains, where country has comparative advantages. Exchange rates are behaving similarly as other prices, they rise and fall because of changing supply and demand. (Samuelsson, 2005, pg. 598 – 604)

"*Exchange rate is the amount that one needs in order to buy one unit of another currency, or it is the amount of a currency that one receives when selling one unit of another currency*" (Sercu, 2009)

The basic exchange rate relationship with demand and supply can be represented in the example of US Dollars and Yen:

$$supply\ for\ yen = demand\ for\ dollars * yen\ per\ dollar, \qquad (1)$$

When the Treasury buys Yen to keep Dollar from appreciating, it can be for several reasons. For example, for controlling inflation, maintaining trade competition or to maintain financial stability. (Kennen, 1994)

Exchange rates are not only influenced by relative prices of products, but also local currency prices. It is common fact that inflation or deflation affects the exchange rate changes in the long run. The monetary authorities can in a fact affect inflation and therefore also exchange rates. An unrealistic policy could cause exchange rate crisis. Thus, there is a need for methods to determine realistic exchange rate target realistically and fully consistent with other policy targets. (Arthus, 1978)

The real exchange rate, which is defined with respect to the price level, such as Consumer price index (CPI), is:

$$q_t = s_t - p_t^F + p_t, \tag{2}$$

where q_t is real exchange rate, s_t is nominal spot exchange rate, p_t denotes a price level and F denotes foreign price level. Data are in logarithms (MacDonald, 1998)

Equilibrium Exchange rate (EER) can be signalling the weak and steady attractor to actual rate, pulling it towards itself. The easiest method to calculate EER is Purchasing power parity or shortly PPP. PPP compares prices of goods in one country, with the prices of the foreign country. PPP is useful to estimate the long-term EER, but in short and medium term EER, it is not strongly supported. The other methods consider the real exchange rate as part of the macroeconomic system, which are influenced by macroeconomic factors. (Wren-Lewis, 2003)

The key to understand equilibrium exchange rates is to understand the real exchange rate. The real exchange rate combines the nominal exchange rate with domestic and foreign prices. If there is in country with the flexible exchange rate system, deviations of EER are often substantial and prolonged and adjustments can be sudden. If the nominal exchange rate is fixed, adjustments are likely to be steadier, but should involve substantial macroeconomic costs. (Wren-Lewis, 2003)

Given that exchange rates are link between domestic and foreign economies, significant misalignment in the exchange rate can have significant consequences for the country. If there is undervaluation, for example of Czech koruna to Euro, economy should face inflatory pressure in the economy. On the other hand, overvaluation should result in to competitiveness of the economy, regards to the others, mostly in export measures. These possible situations are resulting into estimation of equilibrium exchange rate of Czech Republic and its major trading partners (Giannellis and Kukouritakis, 2011)

After introducing PPP model, improvements on the measurement of the real exchange rate have been introduced. Accounting for market nontradable prices, the Balassa-Samuelson effect was introduced. This hypothesis claims that there is faster technological progress in traded goods, then in nontraded goods. This growth supposed to rise the internal price ratio and appreciate the Real exchange rate. The need for sustainable factors in the equilibrium exchange rate is later introduced by Fundamental equilibrium exchange rate model, where current account position relative to the GDP is the cornerstone of the model. (Égert, 2007)

The notion of the eternal sustainability and equilibrium real exchange rate was first advocated by Nurkse (1945) and Artus (1978). The concept gained popularity with Williamson (1994). Williamson introduced firstly Fundamental equilibrium Exchange rate for sustainable external account- based equilibrium real exchange rate. The FEER is satysfying Real equilibrium exchange rate (REER), that simultaneously secures internal and external balance for a country, or for the number of countries. Internal balance is defined as non-accelerating inflation rate of unemployment (NAIRU). External balance is achieved if the balance of payments is in sustainable position in medium-term horizon. (Égert et al., 2006)

Fundamental Equilibrium Exchange Rate model, is the model for medium to long run analysis. It indicates that exchange rate has its equilibrium value when it meets condition of internal and external balance, with full employment and sustainable net capital flows. Very similar model to Fundamental model is the Desired Equilibrium Exchange Rate (DEER) approach or Natural Real Exchange Rate (NATREX), for both medium and long run periods. NATREX refers to a rate which prevails if speculative and cyclical factors are removed, while unemployment is at its natural rate. The Behavioral Equilibrium Exchange rate on the other hand, is concept which involves direct econometric analysis of the exchange rate behaviour. It´s not relying on theoretical model and the equilibrium rate is designed by the long run behaviour of the macro variables, which should determine it. The Permanent Equilibrium Exchange Rate (PEER) approach is similar, and differs from behavioural approach in the way that exchange rate is a function of these variables with persistent effect. (Giannellis and Kukouritakis, 2011)

The equilibrium exchange rate can be derived from the panel model estimates in the same way as in the time-series analysis. Firstly, the actual misalignment is determined and then total misalignment is obtained by putting long time values of the fundamentals in the equations. (Égert et al., 2006)

For our analysis, we have chosen Fundamental and Behavioural Equilibrium Exchange Rate model together with Five Area Bilateral Equilibrium Exchange Rate model, proposed by Wren-Lewis (2003). We have chosen these models, since they depict medium to long-term equilibrium rates. To add on this, the first two models mentioned (BEER and FEER) are most used in the theory and their weighted average will be sufficient to estimate equilibrium rates of Czech koruna. Bilateral Equilibrium Exchange Rate model was never used in the literature for Czech koruna and it will be interesting plus to compare them with other models used.

2.2 Estimating equilibrium Exchange rate for the Czech Republic

In this section I will summarize past real exchange rate models and studies used on the Czech economy. Égert et al. (2006) summarizes the real exchange rate models and their estimates in the past for Central and Baltic European countries. Most of the models were performed in the era, when adoption of the Euro was the main reason, why these studies were published. Most of the studies mentioned are considering BEER model, 26 out of 34 in total. 14 studies in total were considering Czech Republic and its exchange rate, 11 of them were performed with BEER model, 3 were performed with FEER model.

Égert et al. (2006) comes to conclusion that deriving precise figure for equilibrium real exchange rates in general in transition economies of Europe is near to mission impossible, since there is great deal of uncertainty related to the theoretical background on set of the fundamentals chosen. That is why in our study, we are conducting various models to determine equilibrium exchange rate.

In Czech economy after recession years, there are several studies conducted from the Czech National Bank research regarding Equilibrium exchange rate. Babecký et. al (2009) argue that most of the pegged currencies to euro are overvalued after economic crisis, but other, mostly freely floating currencies are neither over or undervalued. Czech Republic and its currency is very slightly overvalued, but very near to its fundamental equilibria at the end of 2009. The study stands on the Sustainable real exchange rate model, with net external debt and foreign direct investment as cornerstones of the study. Their forecasts are showing that Czech koruna will stay at this state for further years.

On the other hand, Audzei and Brázdik (2015) have data after the Czech National Bank interventions. They argue that exchange rate and its volatility is not source of additional volatility of macroeconomic variables, except price volatility in the economy. This is due to being small open economy, therefore very prone to export and import price changes, which are strict consequence of the exchange rate. According to authors computations, the shock is lagged, which reflects exchange rate pass-through. They also conclude that exchange rate is shock absorbent for the economy.

For the recent studies on Czech koruna equilibrium, Babetski and Egert (2005) are predicting slightly undervalued Czech koruna from the 2000 until 2002, after that brief overvaluation of the Czech koruna in 2002. Finally, during 2003 until 2004 we can say that Czech koruna is again slightly undervalued, very near to the equilibrium rate. Regarding to the BEER model presented by Pošta (2010), the Czech koruna seems to be undervalued through whole analysis, which is from 2001 until 2010. The analysis presented by Komárek and Motl (2012) have presented two models, both BEER and FEER. The FEER analysis yielded undervalued Czech koruna from 2000 until 2007, then slightly overvalued during the following years until the end of 2011. In the BEER model, there was over and under valuation oscillating around market exchange rate from 2000 until 2007. In 2008, the Czech koruna was overvalued again followed with undervaluation of the currency during 2009 and 2010. Finally, during 2011, the BEER model presented by Komárek and Motl (2012) results in to the overvalued Czech koruna.

Among the models not used in the diploma thesis, Bulíř and Šmídková (2005) were reporting overvaluation of the Czech koruna from 2000 until 2004. Comparable results are shown by the Kim and Korhonen (2005), where the overvalued period of the Czech koruna is in the 2002. Finally, Rahn (2003) uses BEER and PEER models to estimate equilibrium exchange rate, which yields to the overvaluation of the currency from the 2001 until 2002.

2.3 Behavioral Equilibrium Exchange Rate model

The Behavioral equilibrium exchange rate (BEER) model is approach which links fundamental economic variables with real exchange rate. The BEER analysis is direct, which in contrast with Fundamental equilibrium exchange rate model is econometric analysis of the behaviour of exchange rate. (Égert and Babetski, 2005)

The basic framework of the model can be represented as follows:

$$q = \beta_1 * Z_1 + \beta_2 * Z_2 + \beta_3 * Z_3 + \varepsilon \tag{3}$$

Where Z_1 is vector of economic fundamentals, persistent over long run, Z_2 is vector of fundamentals which affect the exchange rate over medium run, Z_3 is vector which affects the exchange rate in short run and ε is an error term. (Clark and MacDonald, 1998)

The model builds on the uncovered interest rate parity condition, which states that return on the domestic assets must equal the expected return on foreign assets in the domestic currency. (Pošta, 2010)

For the estimation of the many equilibrium models, vector autoregressive method (VAR) is used. The VAR model is the model of several series of autoregressive equations. If we have two series equations looks like:

$$y_t = \delta_0 + \alpha_1 y_{t-1} + \gamma_1 z_{t-1} + \alpha_2 y_{t-2} \ldots \tag{4}$$

And

$$z_t = n_0 + \beta_1 y_{t-1} + \rho_1 z_{t-1} + \beta_2 y_{t-2} \ldots, \tag{5}$$

Where each equation contains an error that has zero expected value given past information on y and z. The number of lags should be set, by information criteria. (Wooldridge, 2009)

Most of the regression techniques require the variables to be covariance stationary. But in our case, if we want not lose data in levels, it is likely that this data will be not stationary, the cointegration is in place. The cointegration is the state in which combination of two nonstationary variables results in to the stationarity of the residuals.

The existence is usually supported in economic theory, such as in our case. Cointegration implies error-correction, which is current movement of a variable as a function of its past deviation from the equilibrium. Presence of error correction implies existence of cointegrating relationship. (Engle and Granger, 1987)

To use VAR specification and to loose levels in our variables, we use Vector error correction model (VECM), which is Engle and Granger (1987) and Johansen (1988), formulated this method. The method used in the software used is based on maximum likelihood method developed by Johansen (1995). The VECM basic formula can be developed as:

$$\Delta y_t = \alpha\beta' y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-1} + v + \delta t + \epsilon_t, \tag{6}$$

Where δ is vector f parameters (matrix *K x 1*), $\alpha\beta'$ are parameters of cointegrated vectors (matrices *r x K*, rank r), Γ_i are *K x K* matrices of parameters. If $\alpha\beta'$ cointegrates, the VAR is misspecified, since lagged term, $\alpha\beta' y_{t-1}$, is omitted. δt is a quadratic trend of the data in the levels. Rest is as typical VAR model, stated above. (Johansen, 1995)

Because we know that α is *K x r* matrix, we can rewrite components as:

$$v = \alpha\mu + \gamma \tag{7}$$

$$\delta t = \alpha\rho t + \tau t, \tag{8}$$

Where μ and ρ are *r x 1* vectors of parameters and γ and τ are *K x 1* vectors of parameters. Thus, we can rewrite our original VECM equation as:

$$\Delta y_t = \alpha\left(\beta' y_{t-1} + \mu + \rho t\right) + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-1} + v + \gamma + \tau t + \epsilon_t, \tag{9}$$

Where we placed trends into our equation. There are 5 cases, what can be set for the trends. Firstly, we can have no restriction on parameters of trends, which implies quadratic trends in the levels of variables and cointegrating equations are stationary around time trends. If we put $\tau = 0$, we assume that trend is linear, if we add also $\rho=0$, we restrict possibility of quadratic trends and that cointegrating equations are stationary around constant means. In fourth possibility, we add on top of $\tau = 0$ and $\rho=0$ restriction that $\gamma = 0$, we assume there are no linear time trends of the data. This specification allows contegrating equations to be stationary around constant means but it allows no other trends. Finally, we also add $\mu = 0$, which assumes that there are no nonzero means or trends. It also assumes that cointegrating equations are stationary with means of zero and that differences and levels of the data have means equal to zero. (StataCorp., 2013)

Another approach to estimate the BEER analysed by autoregressive distributed lag model (ARDL). According to Pesaran, Shin and Smith (2001). The ARDL approach is way of assessing cointegration relationship. The variables are integrated by the different order, for example in I(0) and I(1). The model of the error correction is given by:

$$\Delta Y_t = \beta_0 + \rho\left(Y_{t-1} + \sum_{i=1}^{n} \beta_i X_{i,t-1}\right) + \sum_{j=1}^{l1} \eta_j \Delta Y_{t-j} + \sum_{i=1}^{n}\sum_{j=0}^{l2} \gamma_{i,j} \Delta X_{i,t-j} + \varepsilon_i \qquad (10)$$

The dependent variable in first differences is regressed on the lagged values of the dependent and independent variables in levels and first differences.

There are three BEER models used in this thesis. First one, presented by Clark and MacDonald (1998) is using VECM analysis with Czech long-term interest rates, Euro Area long-term interest rates, Terms of trade variable, Balassa-Samuelsson effect and government spending ratio of the Czech Republic relative to the Euro Area as long-term variables. The Model presented by Pošta (2010) is using the real differential of Czech and Euro Area interest rates, Balassa-Samuelsson effect, Brent oil price, Net foreign assets ratio of Czech Republic relative to the Euro Area and Government debt to GDP ratio of the Czech Republic relative to the same measure in Euro Area as explanatory variables in the VECM model. Finally, the ARDL model presented by Babetski and Égert (2005) is using average labour industry productivity in Czech Republic relative to the Euro Area industrial productivity and Share of the Net foreign Assets in the areas mentioned as explanatory variables for long run.

2.4 Fundamental Equilibrium Exchange Rate model

The Fundamental equilibrium exchange rate model (FEER) concept aims to balance macroeconomic in its external and internal dimension. Internal balance is level of output consistent with full employment and low sustainable rate of inflation. External balance is shown in sustainable desired net flow of resources between countries when they are in Internal balance. The approach aims to calculating exchange rates for economic conditions, it focuses on the economic fundamentals, which are likely to persist in medium or long run. (Clark and MacDonald, 1998)

Rather than specifying behavioral factors of the real exchange rate as it is in BEER, in FEER approach is the main aim on the determinants of the current account of the economy. The macroeconomic balance in FEER model is the identity of Current account and negative of capital account:

$$CA = -KA \tag{11}$$

Then the equation can be transformed into:

$$CA = \beta_0 + \beta_1 * q + \beta_2 * \bar{y}_d + \beta_3 * \bar{y}_f \; + \; \epsilon = -\overline{KA} \tag{12}$$

Where the current account is explained by home and foreign output or demand (y_d and y_f), the real effective exchange rate q and random disturbance term ε. If we solve this equation for q, we will get:

$$q = (-\overline{KA} - \beta_0 - \beta_2 * \bar{y}_d - \beta_3 * \bar{y}_f)/\beta_1 \tag{13}$$

(Clark and MacDonald, 1998)

The FEER analysis is constructed in a way to represent flow equilibrium and it is estimating medium term EER. The model doesn´t take into consideration longer – run stock variables to satisfy long-term relationships. The stock equilibrium relationship is depictured more in the BEER model. (MacDonald and Stein, 1999)

When it comes to FEER analysis, there are to issues to address. First is the GDP growth associated by low inflation. If the case, this can be addressed by Hodrick – Prescott (HP) filter. The second issue is the sustainability of the Current account position. One way is to determine current account sustainability is to equal and opposite capital account imbalance and if it stabilizes the debt-to GDP ratio at given level. Second approach involves the current in the terms of saving and investment balances. This macroeconomic balance approach, is aiming to regress current account on an array of explanatory variables. The FEER estimation have several steps which should be followed. Firstly, the targeted account position should be assessed. Next, determining the change in REER that places domestic and foriegn account at potential paths. Then calculating REER that makes current account adjusted for internal balances. The change in REER is effectively the total misalignment. Finally calculating bilateral nominal exchange rates from the equilibrium REER. (Égert et al., 2006)

Komárek and Motl (2012) have different approach. The model includes equations of the international trade and other equations for internal and external balance of the economy. The Export and Import equations are:

$$Export_t = f(MEMU, RERCZEURPPI, Prod), \tag{14}$$

$$Import_t = f(DD, RERCZEURPPI, Export), \tag{15}$$

Where *Export* is real export of the goods and services, Import is real import of the goods and services DD is the real domestic demand, MEMU is the real import of the goods and services from Eurozone, RERPPI is the real exchange rate deflated by Producers price index, *Prod* is the weight of the Czech labour productivity relative to the European Area productivity. All variables are in logarithms, model is estimated by Vector Error Correction model (VECM). The following identities are used to compose whole FEER model:

$$NX_t = Export_t - Import_t \tag{16a}$$

$$NX_t^N = P_t^X * NX_t + \left(1 - \frac{P_t^M}{P_t^X}\right) * P_t^X \tag{16b}$$

$$Y_t = DD_t + NX_t \tag{16c}$$

$$Y_t^{Gap} = Y_t - Y_t^{Eq} \tag{16d}$$

$$Y_t^N = Y_t * P_t^Y \tag{16e}$$

$$CA_t^{EB} = CA_t^{EQ} * Y_t^N \tag{16f}$$

$$CA_t^{Gap} = NX_t^N - CA_t^{EB} \tag{16g}$$

Where NX is real export balance, NX^N is nominal export, P^X are export prices, P^M are import prices, P^Y is deflator of the Gross domestic product (GDP). Y is real GDP, Y^N is nominal GDP, Y^{EQ} is the potential GDP, and finally Y^{Gap} is the difference between potential and real GDP. CA^{EQ} is the long-term current account balance, CA^{EB} is the sustainable amount of long-term current account relative to the GDP and CA^{Gap} is difference between long-term and actual current account balance. Optimization method is estimated with two goals, real exchange rate and real domestic demand. (Komárek and Motl, 2012)

Although the identities are part of the model presented by Komárek and Motl (2012), which departs from the typical FEER specifications since they are building on them the multi equation model with broad range of identifiers. To keep estimation methods comparable across presented models, We used VECM part of the model.

2.5 Further extensions to the BEER model

Since the Czech National Bank is using Foreign exchange reserves to maintain exchange rates of Czech koruna on certain level, there is different situation for equilibrium exchange rate of Czech koruna, at least for short-term. If we take into account the traditional BEER models, they tend to drive Real exchange rate persistently away from the equilibrium, since some variables are ignored. Thus, the omitted variable bias problem arise. In Czech Republic case, the omitted variable seems to be the change of the Foreign exchange rate reserves, used by the Czech National Bank, through which the exchange rate is affected. (Daude et. al., 2016)

Moreover, if we take just clear interventions as a variable, we may fall into endogeneity problem in some matter. Interventions are taking place when exchange rate is expected to go in opposite direction, which can give opposite sign for interventions effects on the exchange rates, as it is assumed affect the currency. Since that, for minimizing endogeneity bias, we propose to use proxy for intervention, which is change in reserves to M2 ratio. (Levy-Yeyati et. al., 2013)

Levy-Yeyati et. al. (2013) are proposing change in foreign exchange reserves as short-term variable, which is not affecting the long-term equilibrium relationship. On the other hand, the Czech National Bank can show no intentions to buy back the money which they have exchanged to foreign exchange reserves in the long-term. In further years, the much convenient way to appreciate Czech koruna would be to raise interest rates in the economy, which are right now on the zero-lower bound. The long-term level of the foreign exchange reserves can play the role in the long-term, since the money which was emitted by the Czech National Bank, are still on the market. Long-term effect of the Foreign exchange reserves is also persuade in Polterovich and Popov (2011).

For estimating proposed short-term relationships, we use Dynamic Ordinary Least Squares (DOLS) method, proposed by Stock and Watson (1993) and used by Levy – Yeyati et. al. (2013), since we are looking for short-term effects in the matter. For the distinction between currency exchanges with aim to affect the exchange rate, with those which are not aiming at affecting this matter, we will use distinction presented by Lízal (2013) until the 2013. From the start of the interventions, in November 2013, we will take data as "aiming to affect exchange rate". First variable used is *Intervention,* which is representing the aim of moving the exchange rate to some extent. Secondly, *Spot_trades* is the second variable which is representing just spot trades by National Bank, which are in tiny amounts, publicly presented by the bank before trade is made and should have no effect on the exchange rate.

More formally, the model can be represented as:

$$\begin{aligned} \Delta lRERCZEURPPI &= \beta_1 * CE + \beta_2 * L.\Delta lRERCZEURPPI + \beta_3 * \Delta X + \beta_4 \\ &* Intervention + \beta_5 * Spot\_trades + \beta_6, \end{aligned} \tag{17}$$

Where CE is error correction term from the VEC model, X is the matrix of all dependent variables in original model, Intervention and Spot_trades are our short-term variables.

In the next part, we will conduct models with Foreign exchange reserves as long-term variable. The important factor in evaluating the Foreign exchange reserves as long-term factor is that the Czech National Bank used interventions to emphasize the effect of the low interest rates in the economy. This variables are evaluated as the long-term effects in some BEER models. Even though that we state foreign reserves as long term, theory suggests that interventions, hence foreign reserves have impact just in the short term. There is no doubt, that conducted models will yield in shorter equilibrium, since transitory factor, at least according to theory, will be chosen as a variable in the model. The definition of short, medium and long term, variables is presented in Driver and Westway (2004).

Expectations are often important for economy in various parts. Some authors are claiming that expectations are important also for exchange rates in the economy. The straightforward forward-looking variables are in this matter forward rates. In the past, there were a few unsuccessful attempts to meet the rational expectations theory in this matter, performed by Dominguez (1986) or Agmon and Amihud (1981).

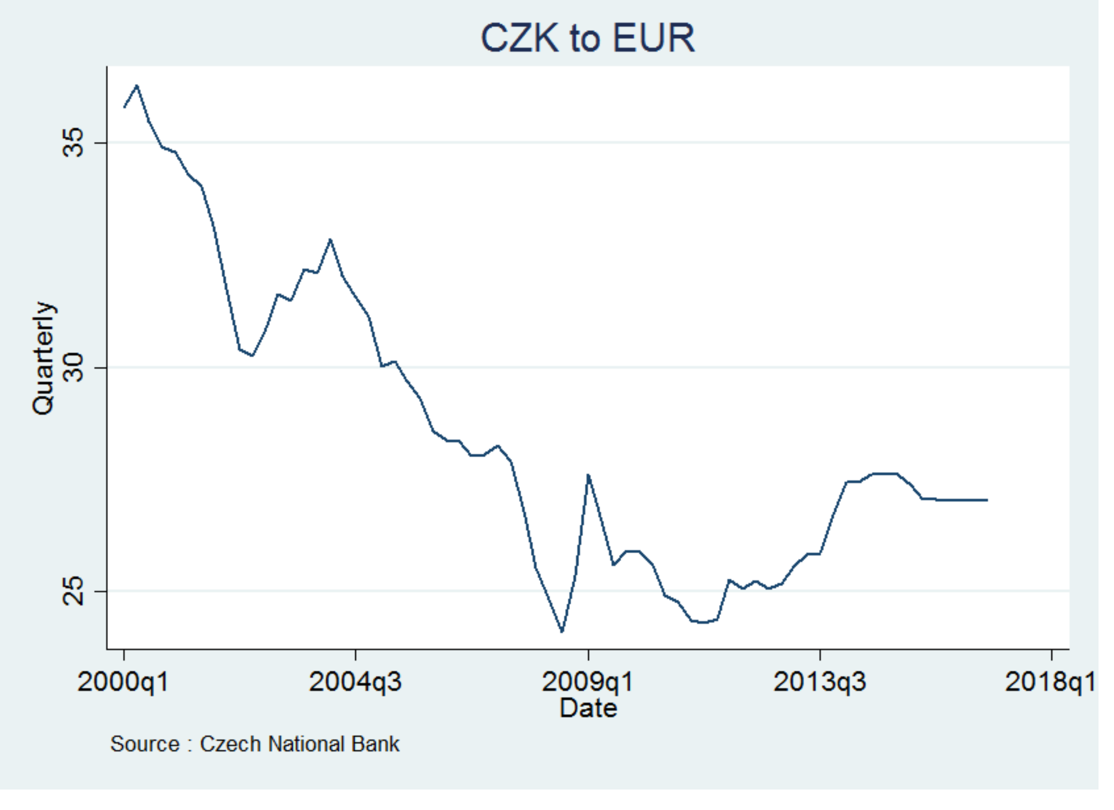
The problem with forward rates can arise when premiums change. Logically, the premiums in stable exchange rate are smaller, than in highly volatile economy. This distorts also the measurement of the forward rates as factor for future exchange rate. (Fama, 1984)

3 Data and Methodology

3.1 Current situation of the Czech koruna

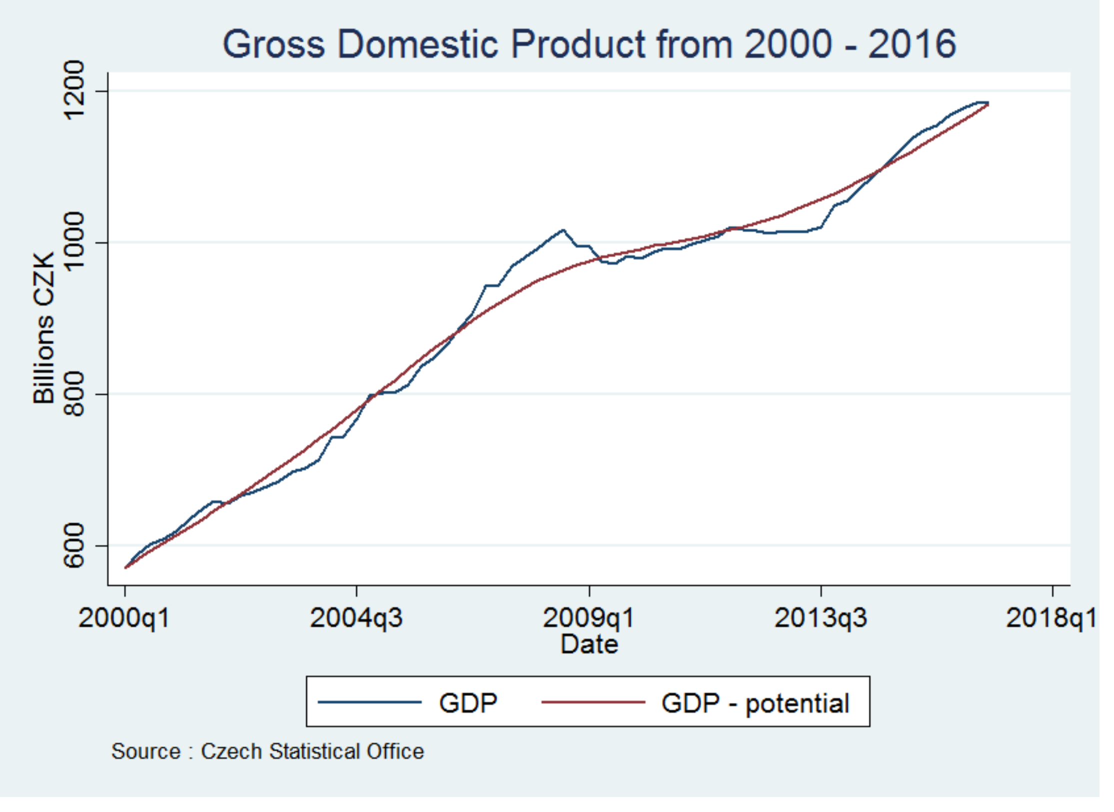
The Czech National Bank has two main goals. The first and the main goal is to hold price stability in Czech economy, which is expressed in inflation rate target, which is 2 %. Because the inflation was decreasing to the dangerous levels and the interest rates, which was the main monetary instrument, were not helping with the Czech National Bank started using exchange rate as instrument to drive monetary policy since start of the November.

Figure 1 - CZK to EUR



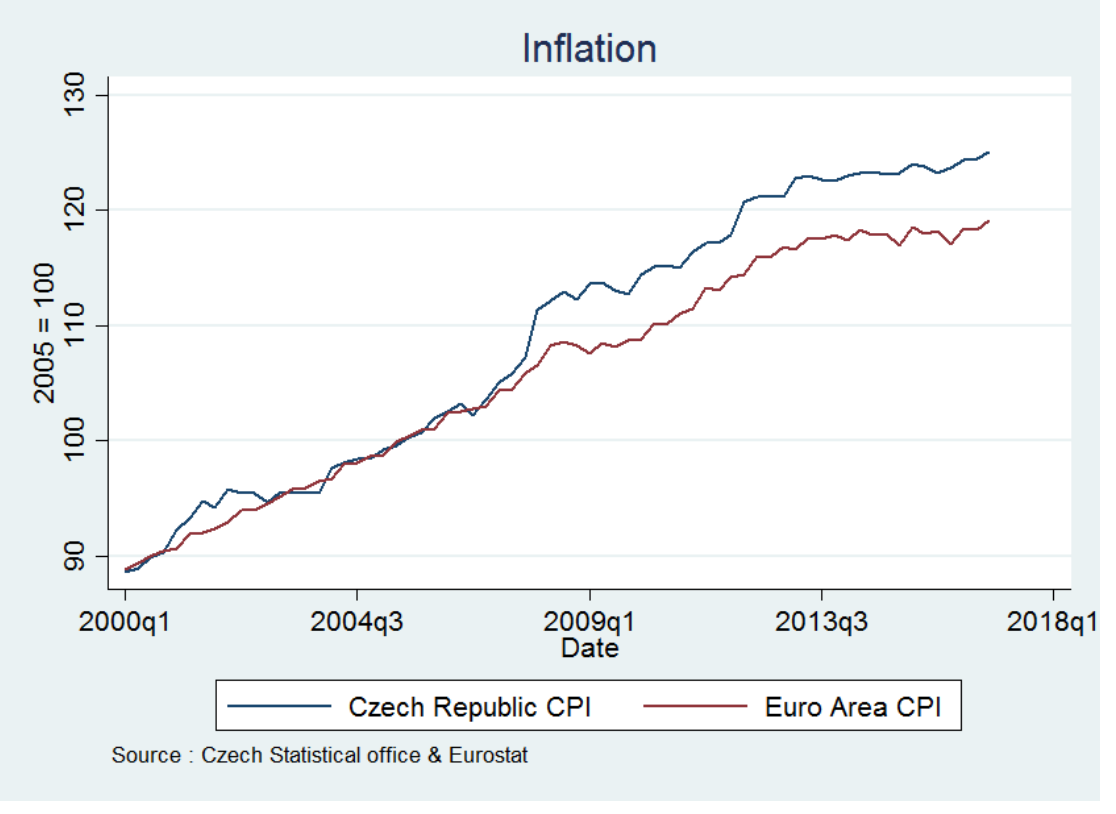
Exchange rate has moved from 25,78 CZK/EUR on the 6th of November to the 27 CZK/EUR average on the next day. The floor of the exchange rate is given as "level close to the 27 CZK/EUR". The Czech National Bank was holding the exchange rate just above 27CZK/EUR from the end of the 2015 until the April of 2016 when the pressure on the appreciation of the Czech koruna is on the rise, also due to the great economy results. The inflation, meanwhile, started to rise at the end of the 2016. The Czech National Bank met their policy to hold the intervention regime at least until the end of the first quarter of the 2017. In the graphs below, there are summarized main macroeconomic features of Czech economy.

Figure 2 - Czech GDP



The Gross Domestic Product (GDP) of the Czech Republic is Growing in past 3 years. In 2015, the Czech Republic was one of the best performing countries in Europe in terms of GDP growth, which was growing by 4.6% in year to year terms. The larger growth was mainly due to the finishing of the European Union projects. Annual growth in the 2016 was 2.8% and predicted growth by the Czech National Bank in the 2017 is 2.9%, which are both signalling the slower growth of the GDP, which is also due to bigger base of the GDP from the previous period. When we plot HP filtered GDP of the Czech Republic to the graph, we see that during the start of the interventions of the Czech National Bank, the GDP was still under the potential. In the recent years, the potential GDP seems to be under the real GDP growth.

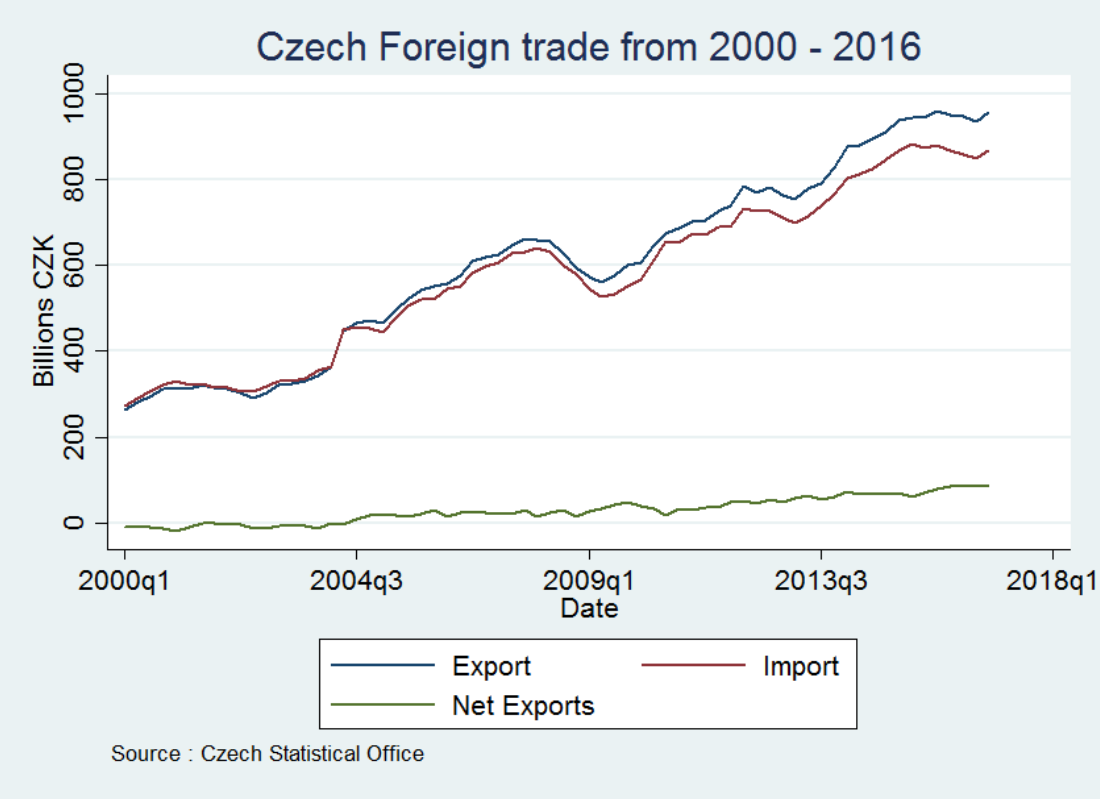
Figure 3 - Inflation



On the graph, it is clear to see concerns of the Czech National Bank. Until the start of the interventions, inflation was performing way under the target of the Czech National Bank and thus interventions were one of the possibilities to deal with the situation. In contrast of that, the situation seems to change in the recent months. The inflation is now performing near to the inflation target and forecast of the Czech National Bank is signalling that the inflation should stabilize near to the inflation target in the 2018 and further. If we look at the Euro Area situation, we see similar scenario. The one important difference with Czech koruna is that quantitative easing was used by European Central Bank to motivate inflation. Similarly, the inflation in Euro Area starts to pick up a pace in the second half of the 2016.

The unemployment rate in the Czech Republic is one of the lowest in the European Union, around 4%. The forecast of the Czech National Bank states that unemployment should stabilize just under this value and therefore move very nearly to natural unemployment rate of the Czech Republic.

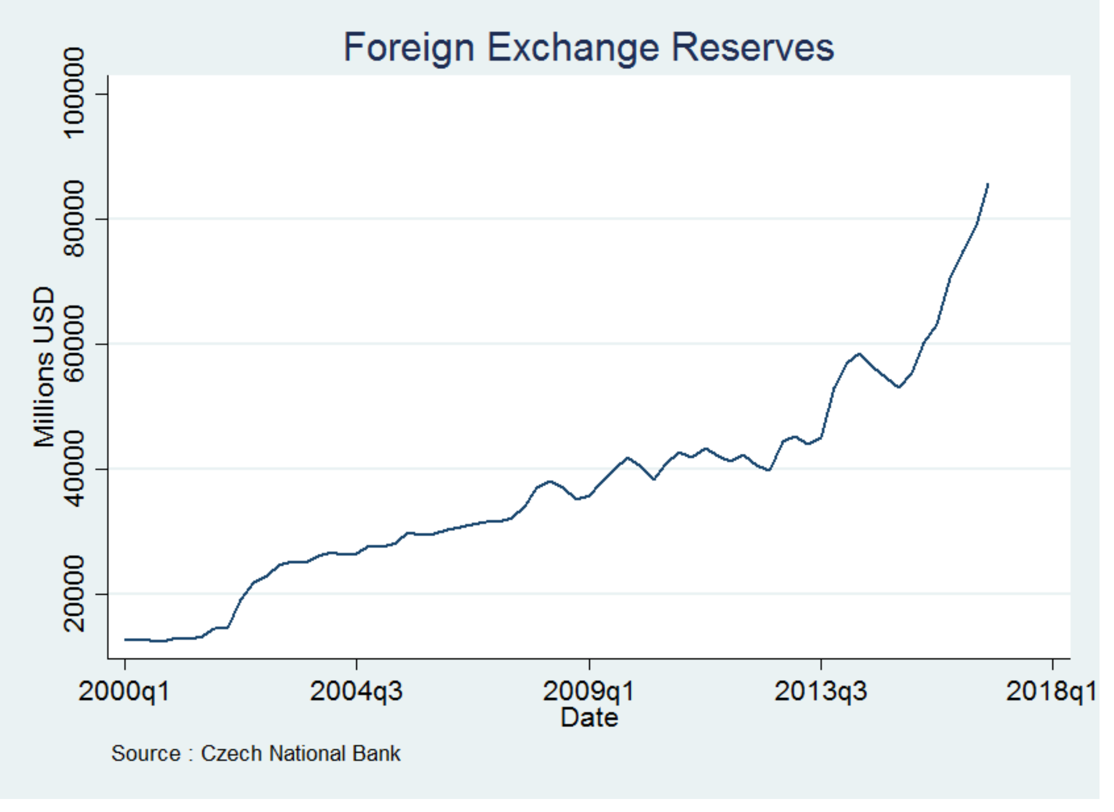
Figure 4 - Czech Trade



Czech Republic as central European country is mostly exporting country. Czech Republic entered the EU in the 2004 and has most of the trade connected to the European Union countries. The total balance of the trade was over 130 billion Czech korunas in favour of the Export, from the economy. Among the European Area countries, Germany is importing more than 32% of total exports of the Czech economy. To put it into contrast, the country with second most imports from the Czech Republic is Slovakia, with just 9%, followed by Poland with 5.8%.

Regarding the state before and after the interventions, the gap between exports and imports slightly shifted towards exports, after weakening of the Czech koruna. This was although ongoing trend even before the start of interventions. The important question for the economy is how the exporters will react for the changing environment and less stable currency. The Czech National Bank is stating that they gave them enough time to prepare for this state.

Figure 5 - Czech National Bank Reserves



In the meantime, the Czech National Bank balance sheet has inflated, due to new foreign exchange rate reserves bought by the bank to Czech koruna exchange rate on chosen level. Therefore, at the end of 2016, the Czech National Bank foreign exchange rate reserves almost doubled from the start of the interventions in 2013. What is not in our analysis, is the amount of the currency reserves from start of the 2017 until the end of march. The amount from the end of the year rose to the 131 billion of USD, which is representing the quarterly rise over 53 % in the reserves. This amount signalled that it was very crucial for the Czech National Bank to abandon the intervention regime as soon as possible. Luckily, the situation right now with the inflation target seems to be stable again.

3.2 Data

This diploma thesis uses two data sets. First one is used for time – series data and estimation of FEER and BEER models, second one is used solely to estimate FABEER model which is estimated with panel data. The period, which is estimated is running from the year 2000 until the end of the year 2016. We use quarterly data to estimation; every monthly subset is averaged to be used as quarterly data.

Euro Area is the composition of the countries, which are using euro as their currency. The name – list of the countries is: Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia and Spain.

The real exchange rates are deflated by the Producers price index (PPI, variable *RERCZEURPPI*) are calculated using nominal exchange rate averages against the euro obtained from the Czech National Bank database. The Czech real, Gross domestic product (*CZKGDP*) is taken by expenditure approach, with constant prices in millions of CZK, is used in logarithms. The data is taken from Czech Statistical Office. The Euro Area GDP (*EAGDP*) is taken same measures as Czech GDP, also in logarithms. The data is taken from Eurostat. The real Import (variable *Import*) and Export (variable *Export*) data are taken from Czech Statistical Office, taken in logarithms. The total foreign trade balance (real – *NX*) is Calculated from data Import and Export. The price levels of the Import and Export of the Czech Republic are given by Czech Statistical Office. The variables names are *ImportPr* and *ExportPr*, respectively.

The Czech national 10 year bond yield (*CZint*) is given by the Czech National Bank data system, deflated by Czech inflation, similar data was taken from European Central bank regarding 10 year Euro Area benchmark bond yield (*EAint*). From that, we can construct interest rate differential (intDiff). The terms of trade (*ToT*) is the ratio of the domestic export unit value relative to the import unit value relative to the equivalent effective Euro Area ratio. The source of the data is Czech Statistical Office and Eurostat. The Balassa-Samuelsson effect (*Bal_Sam*), or traded to non-traded goods ratio in Czech Republic relative to the Euro Area, is calculated from the data of Czech Statistical Office and Eurostat. The Czech government spending to Euro Area countries governments spending ratio (*ShareGOV_EA_CZ*), taken in logarithms, relative to the ratio of the GDP of the Czech Republic and Euro Area, in logarithms, taken from Czech Statistical Office and Eurostat. The capital account (*CZKA*) of the Czech Republic is given in millions of CZK, in logarithms, data is taken from Czech Statistical Office. Average labour productivity (*CZProd*) in the industry is computed as industrial production over industrial employment in Czech Republic, data is given by Czech

Statistical Office. The European Area Labour productivity is given in analogous way, data are given by Eurostat (*EUProd*). The weight of the Czech labour productivity relative to the European Area productivity is variable *Prod*. Net foreign assets of the Czech Republic are published by the Czech National Bank. Net foreign assets are then weighed to nominal GDP (in logarithms, *CZNF_GDP*). The similar operation is made with European Area data, which are taken from Eurostat. The weight of the Czech Net foreign assets relative to Euro Area Net foreign assets (both given as weights of GDP´s of the relative area) is variable *Share_NF_EA_CZ*. Aggregate demand of the Czech Republic is variable *DD*, data are given by Czech Statistical Office, we use it in logarithms. Similarly, the government debt relative to the GDP.

For extended models, we will use *For_Ex_Res* variable, which is representing the Foreign exchange reserves, held by the Czech National Bank at the end of the each month. For *Intervention* and *Spot_trades* as flow variables, we will use data gathered from the Czech National Bank database. The whole analysis and distinction of the two is made according to Lízal (2013).

Variables for own proposed extended BEER model determined solely by Forward rates of the Czech koruna relative to the Euro. The final rates are taken as quarterly averages of the forward rates lagged by the respective period of forward. For example, 3 month forward rate of first quarter in 2010 is used for adjusted rate of second quarter in the same year. This method is used for all gathered data of the forward rates, thus for 3 month, 6 month, 9 month and 12 month forward rates. The adjusted variable names are *3MForw_adj*, *6MForw_adj*, *9MForw_adj, 12MForw_adj*, respectively. Data are gathered from Bloomberg terminal and are weighted by inflation.

3.3 Stationarity

For stationarity test of the residuals (ε_t), we will use augmented Dickey-Fuller (ADF) and Phillips – Perron (PP) unit root tests. The equation used for the ADF test is:

$$\Delta\varepsilon_t = a_1\varepsilon_{t-1} + \sum_{i=1}^{n} a_{i+1}\,\Delta\varepsilon_{t-i} + v_t \tag{21}$$

Where ε_i is tested variable with its lags until n. The Phillips - Perron test uses Newey – West standard errors to account for serial correlation, but it is built on Dickey and Fuller (1979) and its null hypothesis.

Both tests have null hypothesis that variable contains unit root with alternative that variable follows stationary process. The results of the stationarity tests are reported in the table below. First stationarity test is ADF, second reported number is PP test. We put variables to logarithms to make working with them easier. All variables are set to represent stationary process, hence most of them are taken as a return of their original:

$$lY_t = \log(Y_t) \tag{22}$$

This type of variable has prefix "l". The *Intervention* and *Spot_trades* variables are not used in logarithms, since they are flow variables. Test p- values are reported below:

Table 1 - Stationarity tests

Variable	**p-value (ADF)**	**p-value (PP)**	**Variable**	**p-value (ADF)**	**p-value (PP)**
lCZEUR	20.9%	20.6%	lProd	12.3%	11.8%
lCZEURPPI	43.5%	39.7%	lShare_Govdbt	10.3%	9.5%
lCZGDP	43.9%	55.1%	lint_Diff	94.7%	93.0%
lEAGDP	53.1%	34.8%	lCZDemand	7.3%	9.4%
lCZKA	40.1%	37.5%	lCZExReal	52.1%	55.9%
lCZCurr_acc	100%	100%	lCZImpReal	53.4%	54.4%
lCZEint	96.8%	97.95%	lEAImReal	56.3%	54.6%
lEAint	93.6%	91.7%	L3MForw_adj	6.6%	7.6%
lToT	24.3%	12.6%	L6MForw_adj	6.2%	6.5%
lShareGOV_EA_CZ	46.8%	44.1%	L9MForw_adj	3.7%	3.3%
lBal_Sam	8.3%	8.9%	l12MForw_adj	10.3%	10.5%
lBrent	26.3%	20.3%	lFor_Ex_Res	99.6%	99.6%
lShareNF_EA_CZ	50.5%	46.1%			

Source: author's computations.

As we can see on the table above, most of the variables are non-stationary. But if we want to adress VAR model in VECM structure, we need satisfy integration of first degree. Hence variables are differentiated of their original variable:

$$\log(Y_t) - \log(Y_{t-1}) = \log(\frac{Y_t}{Y_{t-1}}), \tag{23}$$

This represents also returns, or changes, of the variables. Results of differentiated variables is reported below. Since we are using *Intervention* and *Spot_trades* as flow variables, we are not differentiating them in the analysis.

Table 2 - Stationarity tests - log variables

Variable (differentiated)	**p-value (ADF)**	**p-value (PP)**	**Variable**	**p-value (ADF)**	**p-value (PP)**
lCZEUR	0	0	lProd	0	0
lCZEURPPI	0	0	lint_Diff	0	0
lCZGDP	0.2%	0.2%	lShare_Govdbt	0	0
lEAGDP	3.3%	2.6%	lCZDemand	0	0
lCZKA	0	0	lCZExReal	0	0
lCZCurr_acc	0	0	lCZImpReal	0	0
lCZEint	0	0	lEAImReal	0	0
lEAint	0	0	L3MForw_adj	0	0
lToT	0	0	L6MForw_adj	0	0
lShareGOV_EA_CZ	0	0	L9MForw_adj	0	0
lBal_Sam	0	0	l12MForw_adj	0	0
lBrent	0	0	lFor_Ex_Res	0	0
lShareNF_EA_CZ	0	0			

Source: author's computations.

3.4 Heteroskedasticity

For heteroskedasticity test of the residuals the White test is used. The null hypothesis is that there is no heteroskedasticity against heteroskedasticity of any general form. The equation tested for the hypothesis is:

$$\varepsilon_t{}^2 = a_1 + \sum_{i=1}^{n} a_{i+1}\, x_i + \sum_{j=1}^{n} b_j\, x_j * \sum_{k=1}^{n} c_k\, x_k + v_t, \tag{24}$$

where the test is that squared error is uncorrelated with all independent variables (x_j), squares of all independent variables (x_j^2) and all cross products ($x_j * x_h$, $for\ j \neq h$). This was proposed by White (1980). The extension of the test for the VAR models is stated by Doornik (1996). If p-value is low, we can reject that there is no homoskedasticity. If the p-value is high, we do not reject the null hypothesis.

3.5 Normality

For testing normality of residuals, we will use Shapiro – Wilk and Shapiro – Francia tests, based on Shapiro and Wilk (1965), Shapiro and Francia (1972) respectively. The null hypothesis is that the residuals ε_t are normally distributed (not significantly different than normal population). The opposite is that residuals are not normally distributed.

3.6 Hodrick – Prescott filter

For smoothing variables, we will use Hodrick – Prescott, which separate time series data in trend and cyclical components. Formally, the filter is defined as the solution to the following optimization problem for τ_t:

$$min_{\tau_t}\left[\sum_{t=1}^{T}(\, y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1}\{(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})\}^2\right], \tag{25}$$

Where λ is set. If $\lambda = 0$, solution generates $\tau_t = y_t$ and otherwise if $\lambda \rightarrow \infty$, we will get fit to regression of the line $\tau_t = \beta_0 + \beta_1 t$. We set $\lambda = 1600$, since we work with quarterly reported variables.

3.7 Choosing lags and rank in the models

Before estimating the parameters of the VECM models, we must choose number of lags in the underlying VAR and choose number of the cointegrating vectors.

To choose the underlying lags in the model, we need the log likelihood for VAR (p)

$$LL = \left(\frac{T}{2}\right)\left\{ln\left|\hat{\Sigma}\right|^{-1} - Kln(2\pi) - K\right\} \tag{26}$$

Where T is number of observations and K is the number of equation $\hat{\Sigma}$ is the maximum likelihood estimate of $E\left[u_t u_t^{'}\right]$, where u_t is the $K \, x \, 1$ vector of disturbances. Letting the Log likelihood with j lags letting to be LR statistics for lag order j we can write the function as

$$LR(j) = 2\{LL(j) - LL(j-1)\} \tag{27}$$

(Hamilton, 1994 p. 295 – 296)

The Akaike information criteria, which is the main lag order static used in this thesis. The criteria includes constant term from the log likelihood. That being:

$$AIC = -2\left(\frac{LL}{T}\right) + \frac{2t_p}{T} \tag{28}$$

Where t_p is the total number of parameters in the model. (Akaike, 1973)

For the correct number of cointegrating equations, where the are $0 \leq r \leq K$ cointegrating equations. The two models, unrestricted and restricted model according to Johansen (1995) are put in the LR test trace statistic. The comparison is:

$$LR_{trace} = -T \sum_{i=r+1}^{K} \ln(1 - \hat{\lambda}_i) \tag{29}$$

Where $\hat{\lambda}_i$ are eigenvalues of the model in the eigenvalue problem of the Johansen specification. The statistic is pu into the maximum eigenvalue value, which compares the null model, containing r cointegrating relations with alternate model of r+1 cointegrating relations. Test hypothesis is:

$$LR_{max} = -T * \ln\left(1 - \widehat{\lambda_{r+1}}\right) \tag{30}$$

As the trace statistic, because this test involves restrictions on the coefficients on a vector I(1) variables, test statistic distribution is nonstandard. (Statacorp, 2013)

3.8 Lagrange-multiplier test for no autocorrelation of residuals

For our presented model, we should check autocorrelation in the residuals. That is tested by Lagrange-multiplier (Rao´s score) test. We will follow the procedure described by Johansen (1995). If we set vector r x 1 of estimated cointegrating relations as:

$$\widehat{E_t} = \hat{\beta} y_t \tag{31}$$

Thus, our VECM model can be rewritten as :

$$\Delta y_t = \alpha \widehat{E_t} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \epsilon_t \tag{32}$$

Which is just VAR with p-1 lags where the endogenous variables have been first differenced and augmented by exogeneous variables $\widehat{E_t}$. Then the Lagrange-multiplier test is performed.

3.9 Eigenvalue stability condition

After VAR or VECM models, we need to check the stability condition. Therefore, we need to obtain eigenvalues and if they are stable, also our model has stable results, as is shown in Lutkepohl (2005). The companion matrix A is specified as:

$$\begin{pmatrix} A_1 & A_2 & \cdots & A_{p-1} & A_p \\ I & 0 & \cdots & 0 & 0 \\ 0 & I & \cdots & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \cdots & I & 0 \end{pmatrix} \tag{33}$$

The modulus of the complex eigenvalues $r+ci$ are $\sqrt{r^2 + c^2}$. The VECM and VAR models are stable if eigenvalue of A is strictly less than 1. However, the exact number, which is strictly smaller than 1 is not stated, we will take every eigenvalue smaller than 0.95 as strictly smaller than 1.

3.10 Principal components analysis

For comparison and computation of one "average" model from the analysis, we will use principal component analysis to gain this goal. Formally, if *M* is correlation or covariance matrix, which is being analysed. The special decomposition in eigenvalues of *M* is:

$$M = V\Lambda V' = \sum_{i=1}^{p} \lambda_i v_i v_i' \tag{34}$$

$$\lambda_1 \geq \lambda_2 \geq \lambda_3 \geq \cdots \lambda_p \geq 0 \tag{35}$$

The eigenvectors v_i are knows as principal components, direction of principal components is not defined. In STATA function returns principal components signed that $1'v_i > 0$. Total variance of principal components equals $trace(M) = \sum \lambda_j$

4 Results

In this part, we will conduct analysis of the presented Equilibrium exchange rate models, which than will be extended with new variables, which has been not tested for the Czech economy. Model estimations are performed in the STATA 14 program. Code is available upon request. All estimation results are available in the appendix.

4.1 Fundamental Equilibrium Exchange Rate models

For the FEER model, two types are stated, according to Clark and MacDonald (1999); Komárek and Motl (2012). The sample used is from 2000 until 2016. When fitting the variables to the long-term fitted model, we use HP – filtered variables, to show long-term relationships. For determining trend current account balance, we use HP – filtered variables as well.

$$RERCZEURPPI = f(lCZGDP, lEAGDP, lCZKAin, lCZKAout), \tag{36}$$

estimated with VECM, with lags of the variables determined by AIC.

$$lExport = f(lMEMU, lRERCZEURPPI, lProd), \tag{37}$$

$$lImport = f(lDemand, lRERCZEURPPI, lExport), \tag{38}$$

After conducting all BEER and FEER models, we create simple principal components analysis and reggression to combine presented models.

We also predict possible effects of the dependent variables on the long-term real exchange rate, also stated in previous literature.

$$RERCZEURPPI = f(\overbrace{lCZGDP}^{-}, \overbrace{lEAGDP}^{+}, \overbrace{lCZKAin}^{+}, \overbrace{lCZKAout}^{-}), \tag{39}$$

$$lExport = f\left(\overbrace{lMEMU}^{+}, \overbrace{lRERCZEURPPI}^{+}, \overbrace{lProd}^{-}\right), \tag{40}$$

$$lImport = f(\overbrace{lDemand}^{-}, \overbrace{lRERCZEURPPI}^{-}, \overbrace{lExport}^{+}), \tag{41}$$

Firstly, we will start with analysis of the oldest proposed model, proposed by Clark and MacDonald. For estimation, we estimate all models without interventions of the Czech National Bank, thus our models are computed with sample from 2000 until third quarter of 2013. Then the prediction of the model is used for full sample from 2000 until 2016.

Firstly, we estimate the FEER model with methods according to Clark and MacDonald (1998). Akaike information criteria shows that 2 lags are appropriate to use in our model. The Johansen identification restrictions shows that rank of 2 cointegrating vectors should be used. Model without constant results in to best fit of the variables. Capital account is used as two variables, Capital inflow and outflow to the economy, since both current and capital account are positive and negative at times. The results are stated below. The long run relationship is computed as follows:

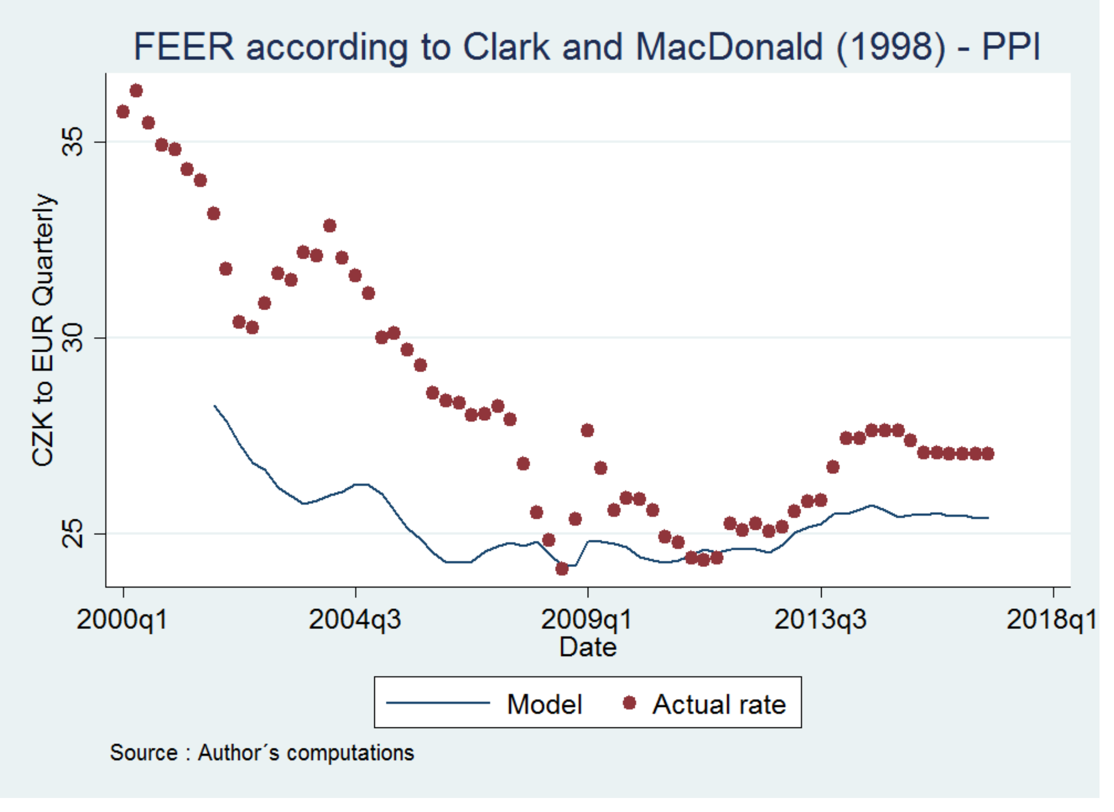
$$lCZEURPPI = -0.045 * CZKAout^{**} - 0.592 * lCZGDP^{*} + 0.719 * lEAGDP^{**}$$

For long-term effects, results show that growth of the Czech GDP results into appreciation of the real exchange rate roughly, similarly growth of the Capital account outflows in Czech economy results in appreciation of the exchange rate relative to the euro. On the other hand, growth of the European Area GDP results in real exchange rate depreciation. Two out of three variables are significant on 95 % significance level. If we look at short run effects, we can see there are no significant variables, which affect real exchange rate in the short run, except its own lagged variable and both cointegrating vectors on significance level higher than 90 %. This shows sense of the FEER models, which are built more on the long run fundamentals, which are not really affecting exchange rate in quarter to quarter change of the real exchange rate.

Regarding good specification of the model, we are unable to reject no autocorrelation and normality of the residuals. For cointegration vectors, we are unable to reject zero average mean and Eigenvalue stability seems to be met as well.

If we fit long-term relationship of the HP – filtered values of the variables of the FEER model and then put real exchange rate back to the nominal values, we will get the following result. We adjust for the current account balance change, which is predicted to behave according to the trend given by Hodrick-Prescott filter.

Figure 6 - FEER Clark and MacDonald



As we can see, the equilibrium exchange rate is moving in the Area around 24 – 25 CZK to EUR from the end of the year 2004 until the start of the interventions by CNB. After start of the interventions, Czech koruna depreciates relative to the euro and slowly moves to the value at the end of the year 2016, which is 25.39 CZK to EUR.

Secondly, we conduct models according Komárek and Motl (2012). We have conducted two models. After that, we get two long run relationships, which we set according the paper by Komárek and Motl. First part of the model is builded around the real Imports in Czech economy, second model is presented for real Exports of the Czech economy. The long-term relationships are then put to the equation of Net exports and the whole equilibrium is equal to current account. After that, the Real exchange rate equilibrium is estimated from the equation. Long run relationships are as follows:

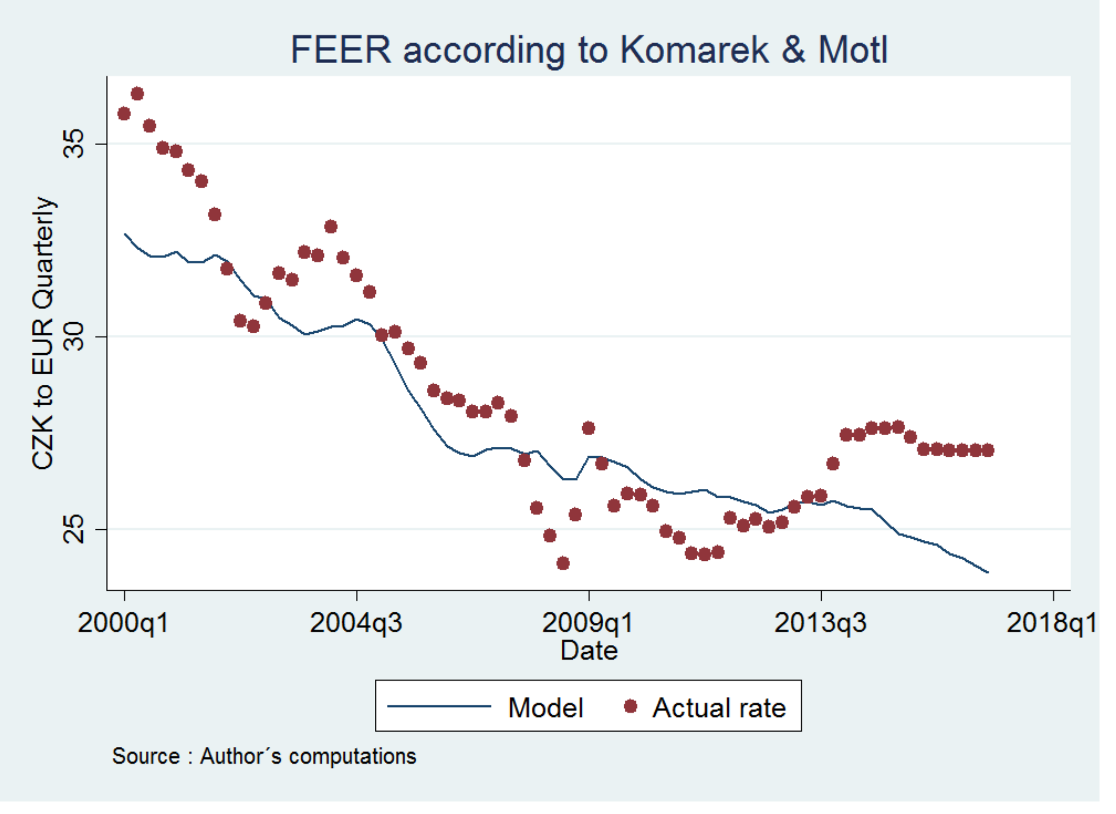
$$lCZExReal = 0.956 * lCZEURPPI^{*} + 0.719 * lEAImReal^{***} - 3.303 * lProd^{**} + 3.414$$

$$lCZImpReal = -0.368 * lCZEURPPI^{***} - 0.152 * lCZDemand^{*} + 0.835 * lCZExReal^{***} + 8.948$$

Results show again, that there is not so many significant variables for short run relationships to Real exchange rate, as it is expected in the FEER models. For the long-term effects, we see that imports of Euro area are logically connected significantly with Exports of Czech Republic. Productivity growth of the Czech Republic relative to the Euro area have opposite effect on domestic exports. As we see the Real exchange rate growth has positive effect on the Real exports. On the other hand, logically, the Real exchange rate has negative effect on the domestic imports, however it is 3 times smaller than effect on the exports. The Czech household demand has a little, although significant effect on the real imports. What is interesting, that Exports are also stimulating imports in the model. Since we are computing cointegrating vectors, we can compute effects for Real exchange rate of Czech koruna, relative to the Euro, if we put Real exchange rate to the left-hand side. All variables are significant at least on the 90 % significance interval. Regarding good specification of the model, we see that our cointegration vectors are stable. We are unable to reject normality and no normality of the residuals.

For the short-term effects, we see that change in the growth of the exports has positive effect on the appreciation of the Czech koruna. Similarly, Imports have depreciative effect on the dynamics of the Czech koruna. Both variables are significant on the 90 % significance interval. No other variables are significant on the dynamics of the model.

Figure 7 - FEER Komárek and Motl



The model, which we fit to the trend variables, we see that Czech koruna is overvalued during the years after crisis until the start of the interventions by the the Czech National Bank. After the start of the interventions, we see that real exchange rate is moving around 26 CZK for Euro until the end of 2014, after that, we see continuing appreciation of the Czech koruna relative to the Euro to the value of 23.8 CZK to EUR at the end of 2016.

4.2 Behavioral Equilibrium Exchange Rate models

In the following part of the thesis, four types of BEER model are recreated, according to Clark and MacDonald (1999); Babetski and Égert (2005); Pošta (2010). The sample used is from 2000 until 2016. When fitting the variables to the long-term fitted model, we use HP – filtered variables, to show long-term relationships. We compose models for both FEER and BEER models for Real exchange rate returns, where real exchange rate has its weights with Production price index (PPI).

Following equations are assumed, with respective method of measuring.

$$RERCZEURPPI = f(CZK10Y\_CPI, ToT, Bal\_Sam, ShareGOV\_EA\_CZ, EAint), \tag{42}$$

estimated with Vector error correction (VEC) method, with lags determined by Akaike information criteria.

$$RERCZEURPPI = f(Bal\_Sam, ShareNF\_EA\_CZ, ShareGOV\_DBT, Brent, lint\_diff), \tag{43}$$

estimated with VECM, with lags determined by AIC.

$$RERCZEURPPI = f(Prod, ShareNF\_EA\_CZ), \tag{44}$$

estimated with autoregressive distributed lag (ARDL) method, lags are minimised by AIC.

We also predict possible effects of the dependent variables on the long-term real exchange rate, also according previous studies.

$$RERCZEURPPI = f(\overbrace{CZK10Y\_CPI}^{-}, \overbrace{ToT}^{-}, \overbrace{Bal\_Sam}^{-}, \overbrace{ShareGOV\_EA\_CZ}^{+}, \overbrace{lEAint}^{+}), \tag{45}$$

$$RERCZEURPPI = f(\overbrace{Bal\_Sam}^{-}, \overbrace{ShareNF\_EA\_CZ}^{-}, \overbrace{ShareGOV\_DBT}^{-}, \overbrace{Brent}^{+}, \overbrace{lint\_diff}^{+}), \tag{46}$$

$$RERCZEURPPI = f(\overbrace{Prod}^{-}, \overbrace{ShareNF\_EA\_CZ}^{+}), \tag{47}$$

Firstly, we estimate the BEER model. In this model, we are working with smaller sample, from 2004 until 2016, since the data for *Terms of trade* in Euro Area are given by the statisticians from this period. Thus, our model has only 31 observations. Akaike information criteria shows that using of 4 lags in the model is appropriate, the Johanson identification restrictions suggest that rank of 2 cointegrating vectors should be appropriate to use in our model. Long run relationship from the model:

$$lCZEURPPI = -0.107 * lCZEint^{***} + 0.277 * lEAint^{***} - 2.366 * lBal\_Sam^{***} + 0.369 * lShareGov\_EA\_CZ^{***} + 4.288$$

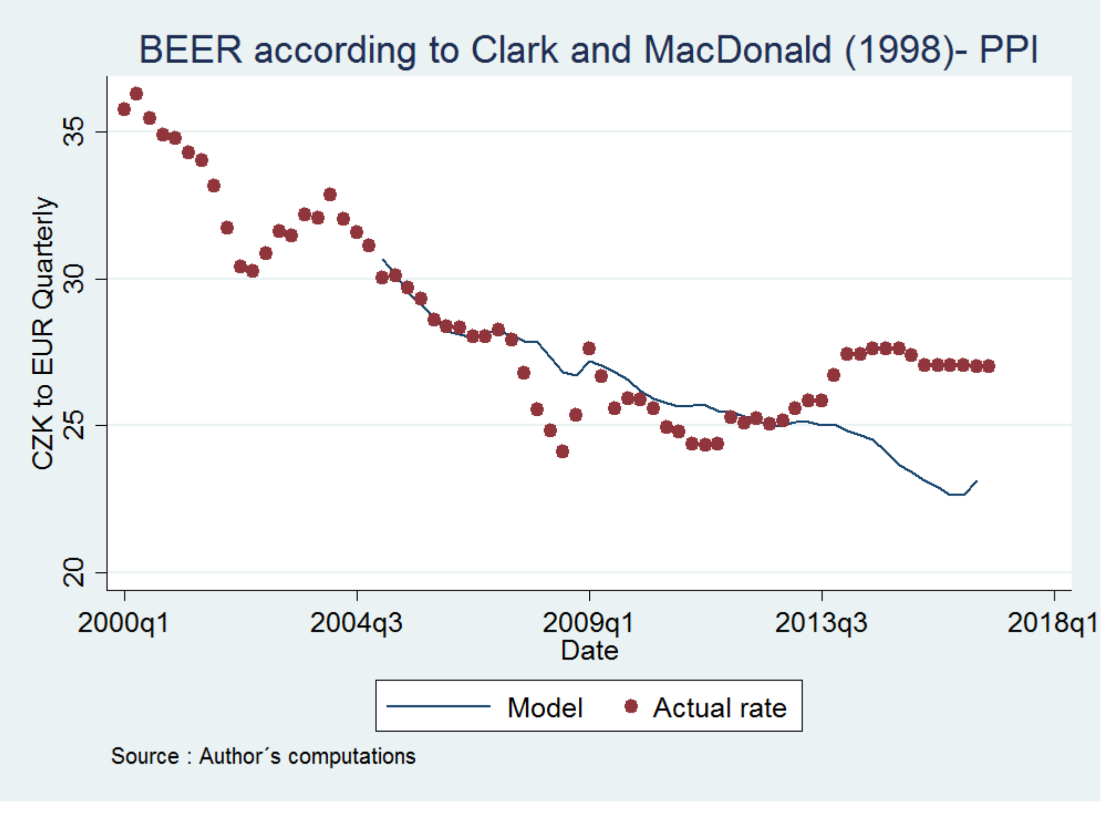
Our predicted value line is shorter than in the FEER model, since data for *Terms of trade* are available from Eurostat just from the 2004 for the Euro Area. For the long run, results shows that growth in the Czech long-term interest rates results in to currency appreciation. Similarly, growth in relative ratio traded to non-traded goods in Czech economy relative to the Euro Area (known as Balassa-Samuelson effect) has huge appreciation effect on the Czech koruna. On the other hand, growth in Share of government spending of the Czech government relative to the Euro Area has depreciative impact on Czech koruna in the long run. Growth of the long-term interest rates in the Euro Area has depreciative effect on the Czech koruna. All long-term variables are significant on 99 % significance level.

Short-term effects on the change of the real exchange rate are often significant for presented variables, which is more likely for BEER than FEER models. The Czech long-term interest rates and their changes has significant effect on the Real exchange rate for over two previous quarters. *Terms of Trade* and Balassa-Samuelson effect affect change of the real exchange rate, with depreciative effect on the Czech koruna in the short-term. This is interesting for Balassa-Samuelson effect, which has opposite effect in short run and long run. European Area interest rates has short-term effect with 2 quarter-lagged variable on 90% significance level.

Regarding of the specification of the model, we can reject normality of the residuals by both Shapiro-Wilk and Shapiro-Francia tests. For the cointegrated vectors, we are unable to reject hypothesis of the zero-average mean, but the predicted cointegrated equation results into peak after start of the interventions, with eigenvalues resulting in possible instability of the model.

If we fit the long-term trend variables to the long-term equation model, we get different fit as it was in the FEER model, according to Clark and MacDonald(1998). We see that after interventions made by CNB, the equilibrium exchange rate is going in opposing direction to the real direction of the nominal rate on the market. The rate stops at 23.2 CZK to EUR at the end of the 2016.

Figure 8 - BEER Clark and MacDonald



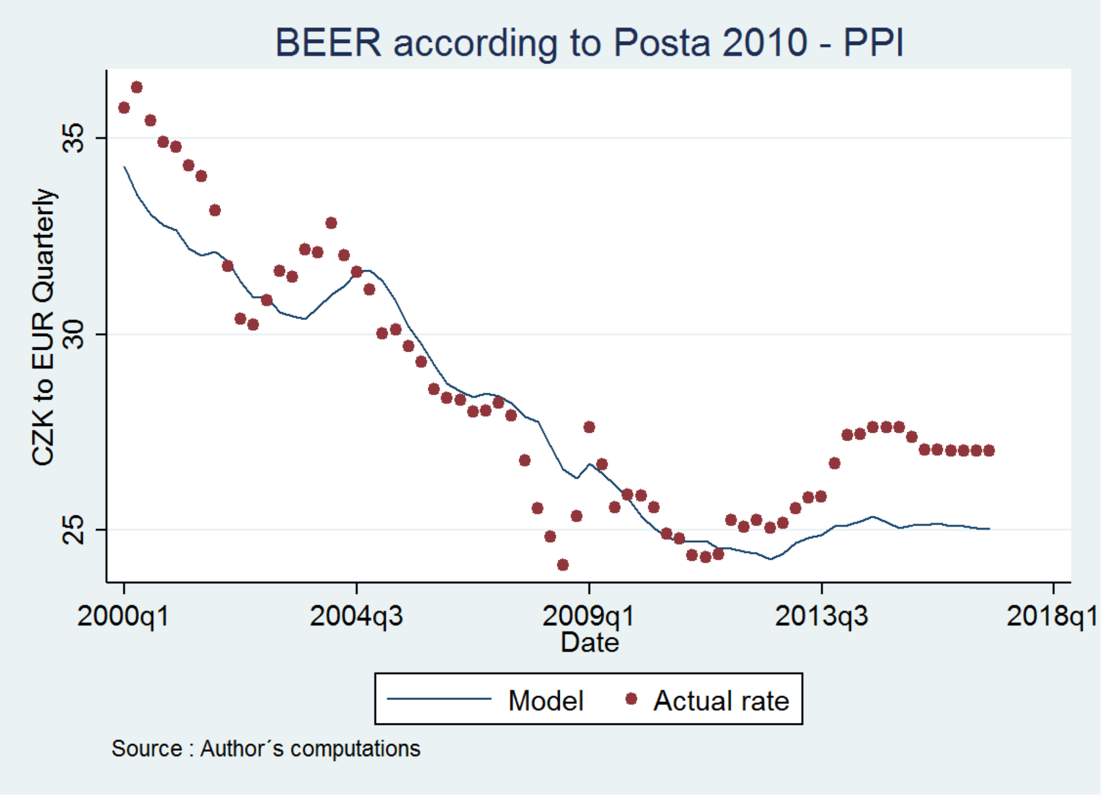
Next, we have conducted models according to Pošta (2010). Performed model is weighted by PPI. Again, our sample for building the model is from 2000 until third quarter of 2013. 4 lags and 2 cointegrating vector are appropriate to use in the estimation. The long-term relationship is as follows:

$$lCZEURPPI = -0.050 * lShareNF\_EA\_CZ \ - 0.661 * lShare\_Govdbt^{***} - 3.923 * Bal\_Sam^{***} - 0.069 * lintDiff + 3.091$$

For the long run relationships, we see that growth in all variables has positive effect on the Czech koruna and should yield in apreciation of the currency. Two of the variables are significant on 99 % significance interval. The one puzzling effect is effect of the interest rate differential, which has insignificant, but appreciative effect on the Czech koruna, although it should have opposite effect. For the short run effects, we see that Brent price, Ballassa-Samuelson effect and interest rate differentials have significant short-term effect on the real exchange rate of the Czech koruna, relative to the Euro.

Regarding the fit of the model, we can reject normality, but we are unable to reject no autocorrelation of the residuals. On the other hand, the eigenvalue stability condition is met, together with stability of the cointegrating vectors.

If we see the fit of the model, we see that Czech koruna equilibrium is very close to the Real exchange rate during whole period from 2004 until the end of 2012. Since 2013, the equilibrium exchange rate is moving near to the 25 CZK to EUR, but exchange rate in the economy moves the intervention regime values.



Finally, Babetski and Égert have proposed BEER model. We are rebuilding this model with sample ranging from 2000 until third quarter of 2013, fitting the predicted long-term values until the end of 2016. The Akaike information criteria results in respective short-term effects of the model. As we see the long run relationship is:

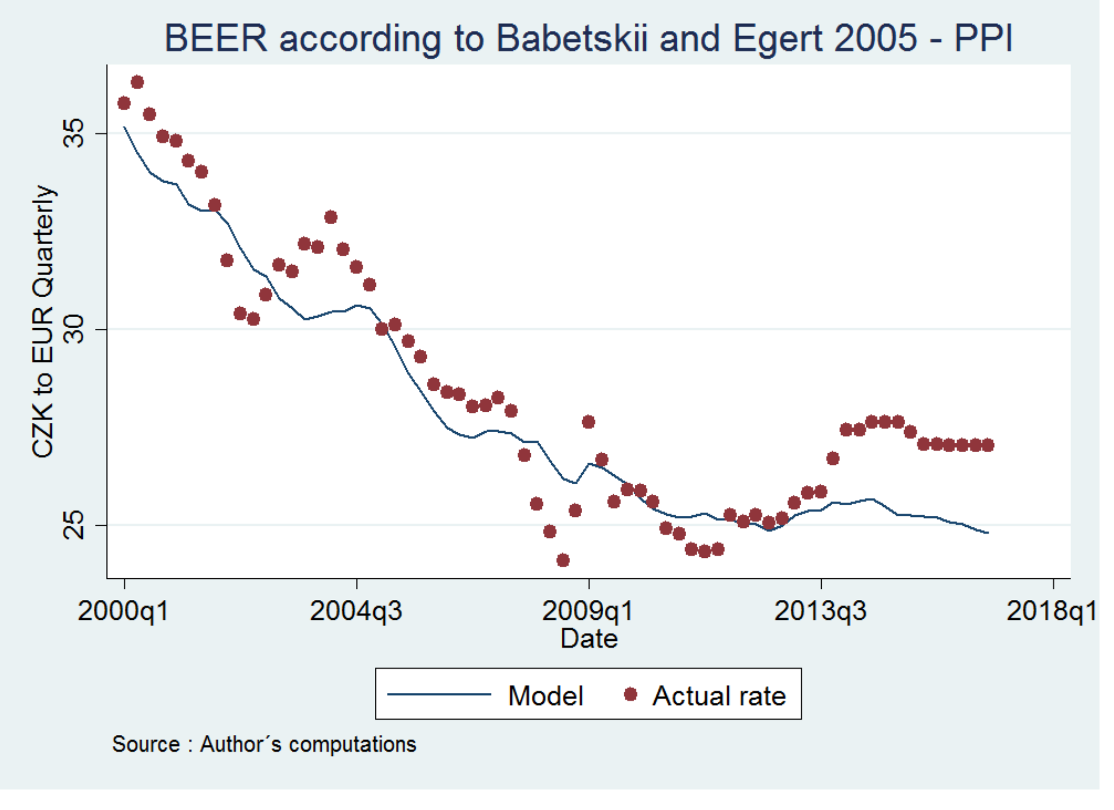
$$lCZEURPPI = -0.678 * lProd^{***} + 0.101 * lShareNF\_EA\_CZ^{**} + 3.071^{***}$$

Results shows that all variables used in the model are significant at least on 95% significance interval. Long-term relationship shows that growth in Czech labour productivity relative to the Euro Area productivity by 1 % results in appreciation of the Czech koruna. The 1 % growth of share Net foreign assets of Czech Republic relative to the Euro Area results in currency depreciation in the long run. For the short run analysis, change of the labour productivity results in the depreciation of the Czech koruna in the short run. Also lagged variable of the real exchange rate has effect on the change in present period. The second short-term effect is showing persistence of the effects on the real exchange rate from previous quarter. All variables are significant on 95 % significant level.

Shapiro-Wilk and Shapiro-Francia tests performed result in p-values higher than 0.79 in both cases, we are unable to reject the null hypothesis of normality. There is no evidence of autocorrelation of the residuals.

If we look at the fit of the predicted long-term model, we see that model is showing undervalued Czech koruna during period from 2003 until 2004 and slightly overvalued crown during recession times from 2008. During the start of the interventions, Czech koruna seems to be at its equilibrium state. After start of the interventions, equilibrium exchange rate seems to go up a little at first, until it arrives at 24.9 CZK to EUR at the end of 2016.

Figure 9 - BEER Babetskii and Égert



4.3 Comparision of the presented models

In the comparison, we conduct Principal component analysis. We therefore pool 5 models in to the analysis. We get 2 principal components, which are cumulatively covering 95 % of the total structure of the variables. We put this variables to the simple regression model.

Table 3 - Principal component analysis – original models

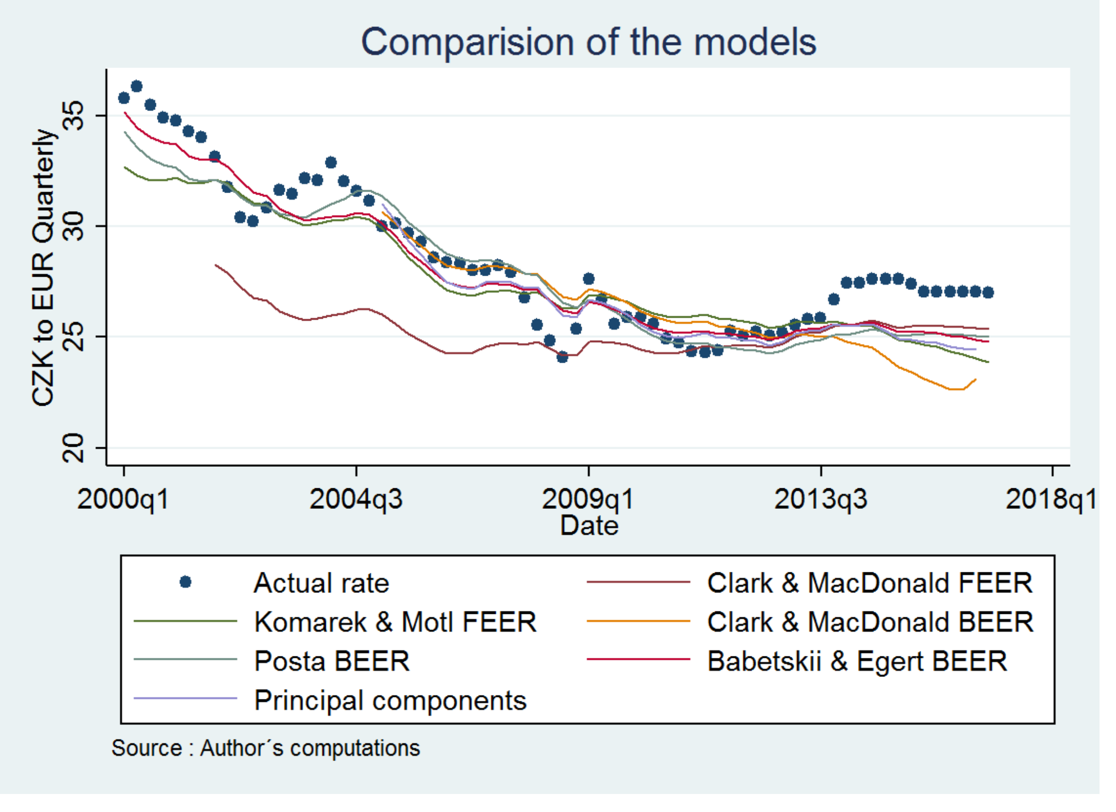
VARIABLES	(1) CZK_EUR
pc1	0.775***
	(0.0958)
pc2	0.304
	(0.202)
Constant	26.11***
	(0.187)
Observations	35
R-squared	0.813

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As we can see on the results, only first principal component is significant for the regression, with R-squared high as 81.3 %. We fit the predicted variables and see that the implied equilibrium exchange rate is oscillating around 25 CZK to EUR from the end of the 2010, until the end of the 2015. After that, the equilibrium exchange rate is slightly decreasing until the end of the sampling period. The equilibrium exchange rate at the end of 2016 is 24.43 CZK to EUR. We are unable to reject homoscedasticity and normality of the residuals.

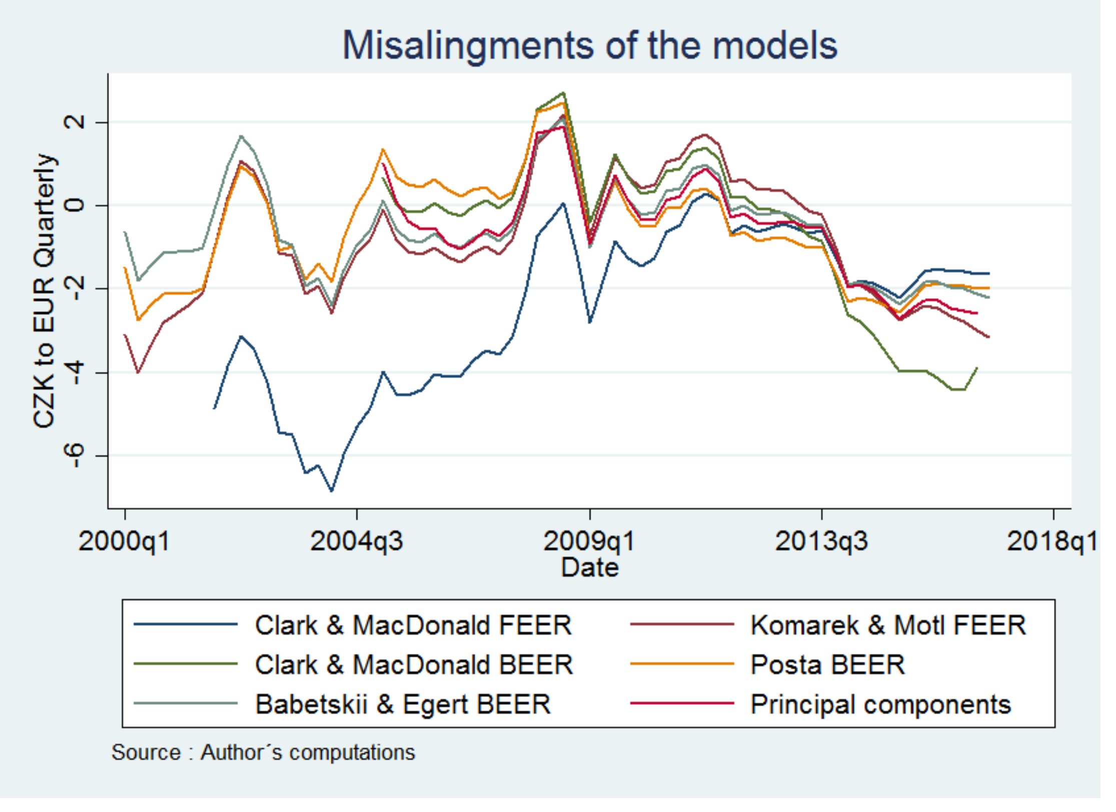
If we look at the comparison of the presented models, we can reflect on two important trends of the models. Firstly we have two models which are not similar to the others. FEER model, which was presented by Clark and MacDonald (1998) is showing very stable predicted values during the whole analysis. This is understandable for the fundamental analysis, which yields for long-term equilibrium. Also this model can be used as solid argument for stable equilibrium exchange rate, not affected by interventions. On the other hand, the FEER model presented by Komárek and Motl (2012) has not that similar dynamics, at least until the end of 2010. The second inconsistency in the presented models are dynamics after the start of the interventions of the Clark and MacDonald (1998) BEER model, which predicted variables are yielding much sharper downward slope in this period. This can be caused by the intervention measures in the economy by the Czech National Bank, together with very low long-term interest rates, near to zero.

Figure 10 - Comparision Original models



If we compare our model of Czech koruna with FEER model presented by Komárek and Motl (2012), the results are similar. The Czech koruna seems to be undervalued during the years from 2000 until 2008 for both analyses, with overvaluation of the Czech koruna during the 2008. Finally in the period from 2009 until 2012, both models seems to move just slightly above the exchange rate on the market. The similarity of the predicted results in the sample can be agreed also with BEER model presented by Babetski and Egert (2005), where the overlapping periods are between 2000 and 2004. The Czech koruna seems to be overvalued in both models during 2002, with undervaluation in following years. In 2004, original models are showing overvaluation of the Czech koruna, our model is showing, even though small, undervaluation.

Figure 11 - Misalingments Original models



Similarly, the results can be seen also at the misalignments of the models, relative to the actual exchange rate. The dynamics presented are similar for all the models. The Czech koruna seems to be very near to its equilibrium during the 2004, until the start of the interventions, in the third quarter of 2013. After that, the misalignment is clear due to the start of the intervention regime. The misalignment at the end of 2016 is between 2 and 4 Czech korunas per Euro, or 7 to 14 % undervaluation.

4.4 Extended BEER models

We will conduct three types of extended models. Firstly, we will perform all BEER models presented with interventions presented by the Czech National Bank as aimed to affect the Czech koruna on the market. To this model, we will also add spot trades conducted by the Czech National Bank, with no aim on changing the strength od Czech koruna. For our VECM models, we will use DOLS methodology, presented by Levy-Yeyati et. al. (2013), where the VECM cointegrated vectors are taken and are used on short-term measurement. Since we also conduct one ARDL model (Babetski and Égert, 2005) , we will add this variables to the short-term effects in the model. The expected effect of the *Intervention* variable is to have short-term depreciative effect on the Czech koruna. On the other hand, the *Spot_trades* variable is expected to have none or appreciative effect on the Czech koruna. *X* is representing the matrix of the all explanatory variables in the original models.

$$\Delta RERCZEURPPI = f(\Delta X, Intervention, Spot\_trades) \tag{48}$$

$$RERCZEURPPI = f(Prod, ShareNF\_EA\_CZ, Intervention, Spot\_trades), \tag{49}$$

Secondly, we will conduct extended models with *For_Ex_Res* variable, which is monitoring the total Foreign exchange reserves kept by the Czech National Bank. We will test the long-term relationship and from that resulting omitted variable bias in the models presented before. We will conduct two VECM models, with one ARDL model. For VECM models, we will not take short-term effect in to the account, since there should be no effect for cointegration vectors. For ARDL model, we will still hold short-term effects of the Interventions and Spot trades.

$$RERCZEURPPI = f(X, lFor\_Ex\_Res) \tag{50}$$

$$\begin{aligned} &RERCZEURPPI \\ &= f(Prod, ShareNF\_EA\_CZ, lFor\_Ex\_Res, Intervention, Spot\_trades), \end{aligned} \tag{51}$$

Thirdly, we will use again methodology presented by Levy-Yeyati et. al. (2013) for adressing the Forward rates as the market driver in the economy. We will use 3,6,9 and 12 month forward predicted rates of Czech koruna to Euro to see what is the effect on the Exchange rate. For ARDL model, we will use the existing model. The cointegration vector taken will be from the extended model with the Foreign exchange reserves variable.

$$\Delta RERCZEURPPI = f(\Delta X, \Delta lFor\_Ex\_Res, Intervention, Spot\_trades, \Delta lForward) \quad (52)$$

$$RERCZEURPPI = f(Prod, ShareNF\_EA\_CZ, lFor\_Ex\_Res, Intervention, Spot\_trades, \Delta lForward) \quad (53)$$

4.5 BEER model with Interventions and Spot trades – short run

In this part, we look at the short-term effect of the variables, together with added variables of the *Intervention* and *Spot trades*, made by the Czech National Bank. For the sample length, we took full sample from 2000 until 2016. As we see on the graph below, there are two main periods, when the Czech National Bank was signalling the Market trades as Interventions in our sample, from 2000 until the end of 2002 and then from the start of the intervention regime in third quarter of 2013. On the other hand, the Czech National Bank was selling their Foreign exchange currencies, from 2004 until 2012. This selling of the currency earnings, as the Czech National Bank states, has no aim to affect the exchange rate of the market in any manner. As it is also noticeable, there were much bigger transactions within one quarter from 2013, than in the rest of the sample. The distinction is made according to Lízal (2013).

Figure 12 - CNB Market activity

Firstly, we took analysis of the BEER model presented by Clark and MacDonald (1998). The method is simple to estimate, with Dynamic OLS procedure.

Table 4 - BEER with interventions / Spot trades Clark and MacDonald

VARIABLES	(1) D.lCZEURPPI
LD.lCZEURPPI	0.333
	(0.255)
L.ce	-0.0483
	(0.0599)
Intervention	1.04e-06
	(7.77e-07)
Spot_trades	-6.19e-06
	(2.27e-05)
D.lCZEint	-0.0263
	(0.0158)
D.lEAint	0.0318
	(0.0225)
D.lToT	0.771*
	(0.452)
D.lBal_Sam	-0.107
	(0.513)
D.lShareGoV_EA_CZ	-0.0444
	(0.0577)
Constant	0.00651
	(0.0112)
Observations	47
R-squared	0.309

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As we can see on the results, there is just one significant variable, which has effect on the change of the real exchange rate. Growth of the terms of trade variable should yield in the depreciation of the Real exchange rate dynamics. We fail to yield significance of the Interventions or spot trades in the short run. We have robust results, hence no heteroskedasticity occurs in our model. We reject normality of the results on 90 % significance level. There is no autocorrelation of the residuals. R-squared is just under 31 %.

Secondly, we conduct short-term analysis provided by Pošta (2010) extended by the short-term effects made by the Czech National Bank.

Table 5 - BEER with interventions / Spot trades Pošta

VARIABLES	(1) D.lCZEURPPI
LD.lCZEURPPI	0.419***
	(0.137)
L.ce	-0.0968**
	(0.0473)
Intervention	1.17e-06
	(1.26e-06)
Spot_trades	-6.85e-06
	(2.35e-05)
D.lBal_Sam	-0.0680
	(0.289)
D.lBrent	-0.0549**
	(0.0225)
D.lShareNF_EA_CZ	0.0173
	(0.0379)
D.lShare_Govdbt	-0.285**
	(0.116)
D.lintDiff	-0.0123
	(0.0216)
Constant	0.00421
	(0.00582)
Observations	47
R-squared	0.414

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As we see on the results, there are 4 significant variables. The lagged real exchange rate, error correction variable, Change of Brent price and Change of the relative share of the debt in Czech Republic to GDP, relative to the Euro Area. Both changes in these two significant variables results in the appreciation of the real exchange rate. Again, we fail to justify our claims regarding interventions and Spot trades, made by the Czech National Bank. Again, we have robust results regarding homoscedasticity. We fail to reject normality, and no autocorrelation of the residuals. R squared is well over 41 %.

Thirdly, we conduct new analysis of the ARDL model, presented by Babetski and Egert (2005).

Table 6 - BEER with Interventions and Spot trades, Babetski and Egert

VARIABLES	(1) ADJ	(2) LR	(3) SR
lProd		-0.479***	
		(0.105)	
lShareNF_EA_CZ		0.0864**	
		(0.0422)	
L.lCZEURPPI	-0.275***		
	(0.0683)		
LD.lCZEURPPI			0.426***
			(0.119)
D.lProd			0.134***
			(0.0501)
Intervention			5.52e-07
			(1.27e-06)
Spot_trades			-5.22e-05**
			(2.07e-05)
Constant		3.154***	
		(0.0774)	
Observations	64	64	64
R-squared	0.387	0.387	0.387

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

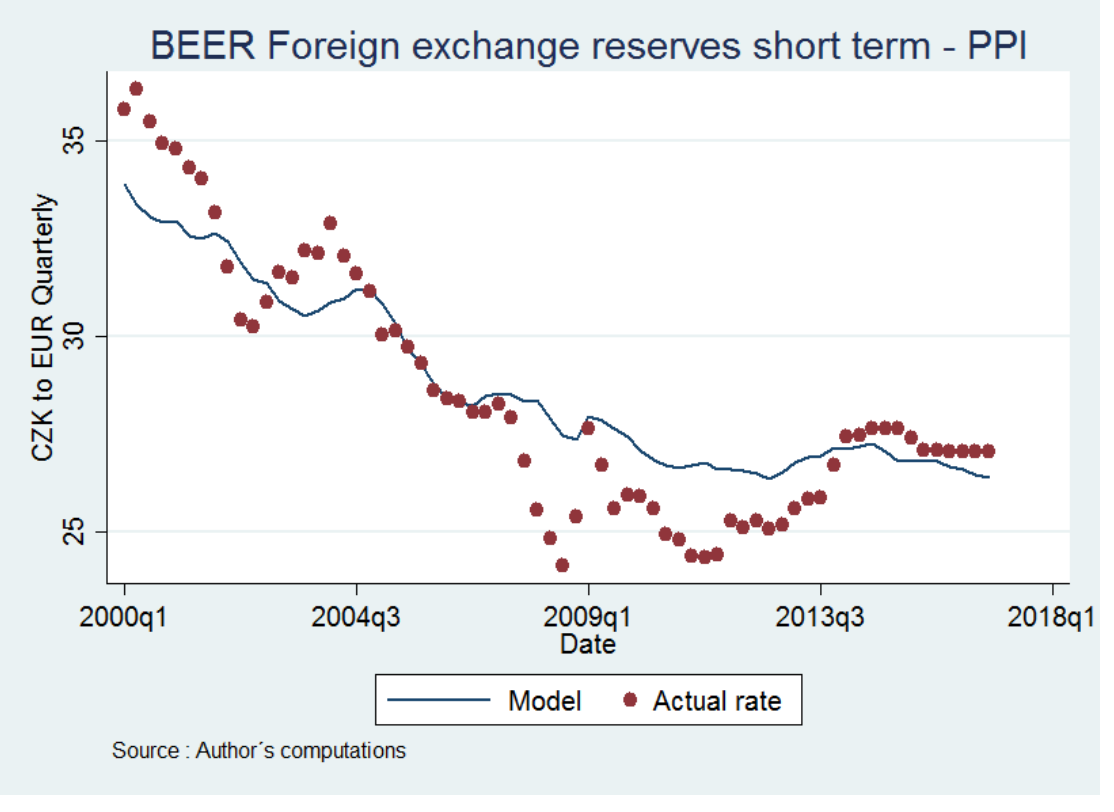
If we look at the results, we see that we have 3 out of 4 variables significant for the short run. *Prod* variable yields opposite effect in the short run, in comparison for long run. Similarly, the cahnge of the real exchange rate is significant for the model. More interestingly, we see that Spot trades of the Czech koruna have significant effect on the exchange rate, with appreciative effect. This is against the Czech National Bank notion, which states that these sales should have no effect at all on the Exchange rate of the Czech koruna. *Intervention* variable fails to meet the notion for the short-term effect. We are unable to reject normality and no autocorrelation of the residuals.

In this part, we also present the changed Long run relationship of the Equilibrium Exchange rate, on top of the short run. We take just presented ARDL model. The long run relationship changes to:

$$lCZEURPPI = -0.479 * lProd^{***} + 0.0864 * lShareNF\_EA\_CZ^{**} + 3.154^{***}$$

When we compare this model, with same long run relationship in the original one, we see that effect of the relative productivity fell almost by 0.2 in absolute values. The effect of Net foreign assets fell as well, this time by 0.02 by absolute values. The constant is higher. The fell of the absolute values is the result of more short term controls in the model.

Figure 13 - BEER Forex reserves - short term effect



When we fit the model, we see that the Czech koruna was overvalued from 2008, until the start of the interventions, in 2013. When we compare the fitted values with the original ones, we see that model shifted in to weaker Czech koruna at mean, from the 2008. The actual equilibrium rate at the end of 2016 is 26.7 CZK to EUR.

After the analysis, we are unable to asses *Intervention* as significant variable in any model. On the other hand, *Spot_trades* variable is in one model significant on the 95 % significance interval, with appreciative effect on the Czech koruna. When we recompute one long term relationship, we see that there is shift in the equilibrium to the values near to the market rates at the end of 2016.

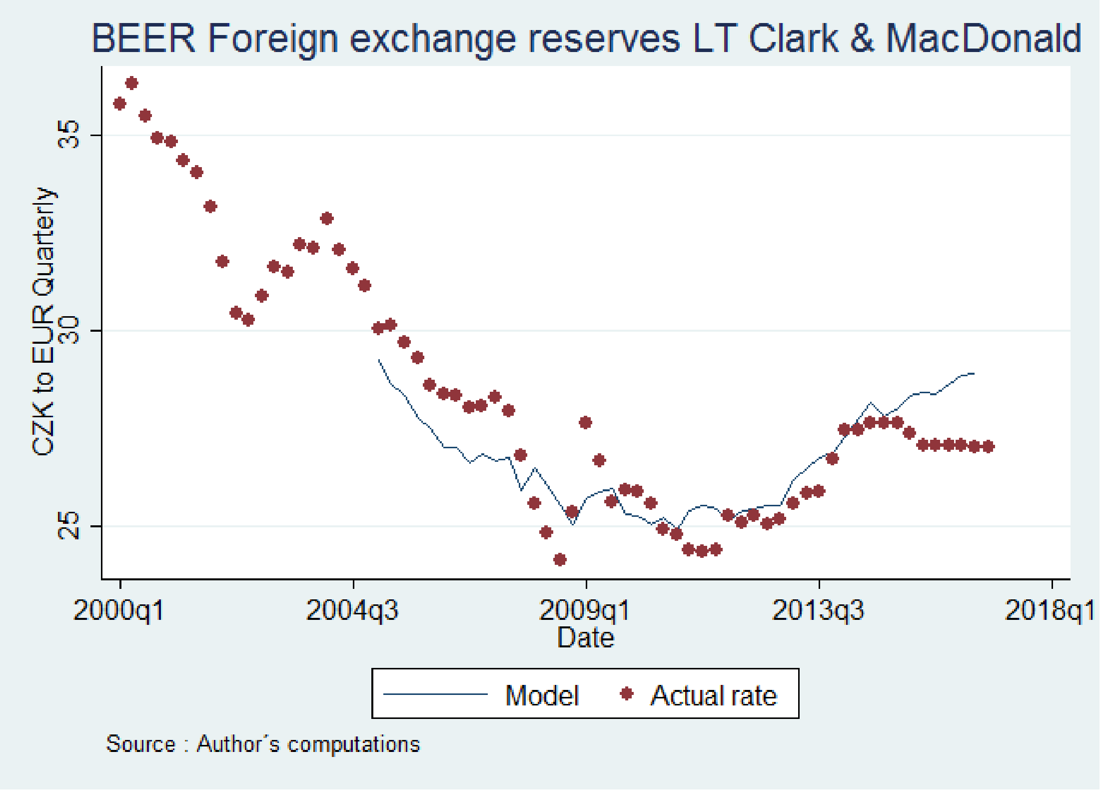
4.6 BEER model with Foreign exchange reserves – long run

Firstly, we took analysis of the BEER model presented by Clark and MacDonald (1998), with extension by Foreign exchange reserve as long-term variable. Three cointegration vectors are appropriate for the model, with 4 lags of the variables, chosen by AIC. The long-term relationship is as follows:

$$lCZEURPPI = -0.191 * lToT - 0.626 * lBal\_Sam^{*} + 0.782 * lShareGov\_EA\_CZ^{***} + 0.507 * lFor\_Ex\_Res^{***} + 6.123$$

If we look at the results, we see that we have two variables significant on the 99% confidence interval, which are Foreign exchange reserves and Share of the government spending in Czech Republic versus the Euro Area. Both variables have depreciative effect on the Czech koruna, in the long-term. Regarding the fitness of the model, we are unable to reject no autocorrelation of the variables and normality. The stability condition of the error correction vectors is unfortunately not met.

Figure 14 - BEER Clark and MacDonald Forex reserves long term



If we look at the predicted results of the equilibrium exchange rate, we see that after the start of the interventions, the predicted variables shifted to overvaluation of the Czech koruna, rather than undervaluation, which is predicted by original BEER model. The predicted value of the exchange rate at the end of 2016 is 28.9 CZK to EUR.

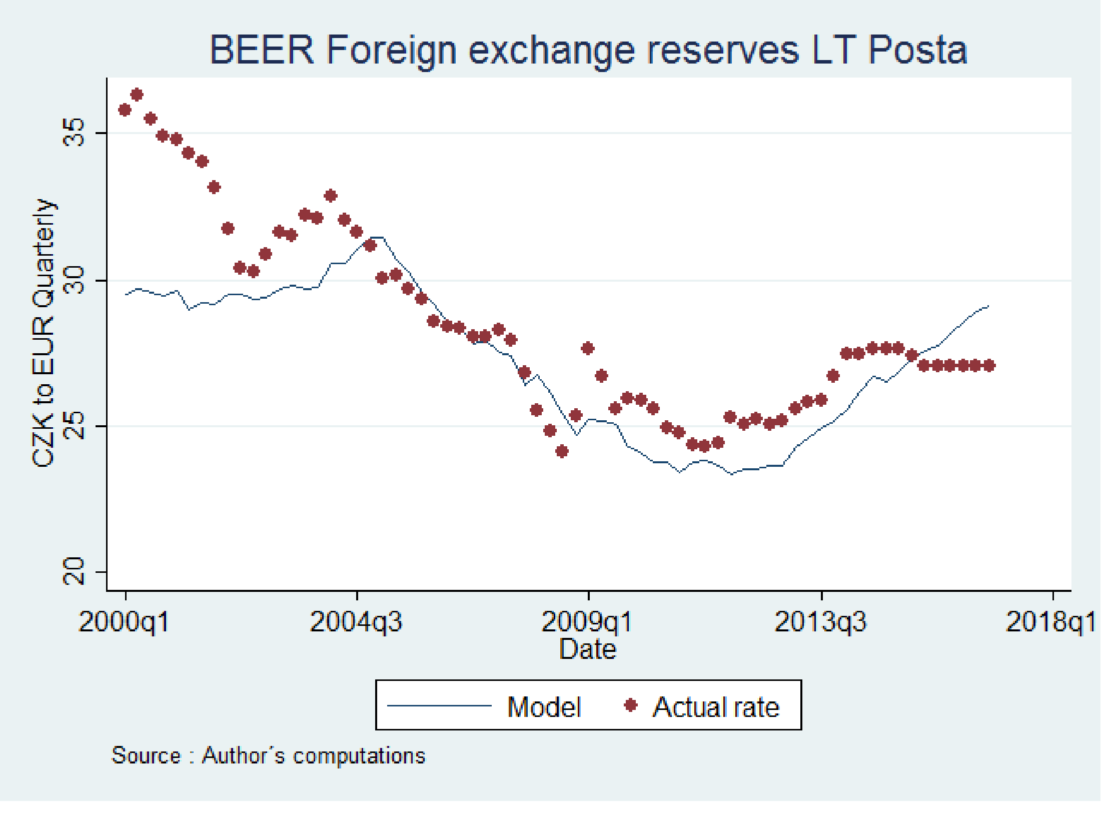
Secondly, we conduct short-term analysis provided by Pošta (2010) extended by the short-term effects made by the Czech National Bank. The two cointegrating vectors are appropriate to choose in the model, with 4 lags, chosen by AIC. The long-term relationship is as follows:

$$
\begin{aligned}
lCZEURPPI = {} & -0.182 * lShareNF\_EA\_CZ^{**} - 1.215 * lShare\_Govdbt^{***} \\
& - 4.944 * Bal\_Sam^{***} - 0.169 * lintDiff^{***} + 0.488 \\
& * lFor\_Ex\_Res^{***} + 5.000
\end{aligned}
$$

If we look at the results, we see that all explenatory long-term variables are significant at least on 95 % significance interval. The effects of the variables, which were used in the original model, remain roughly unchanged. The depreciative effect of the Foreign reserves is present in the model, with similar effect as in previous extended model presented by Clark and MacDonald (1998). We fail to reject normality and no autocorrelation of the variables. Model is also stable, which is represented by the stability condition.

We look at the predicted values of the model. The model behaves differently than models presented before, with slight undervaluation of the Czech koruna from 2009 until the third quarter of 2015. After that, the equilibrium moves to the values higher than actual rate. The equilibrium exchange rate is at the end of 2016 is 29 CZK to EUR.

Figure 15 - BEER Pošta Forex reserves long term



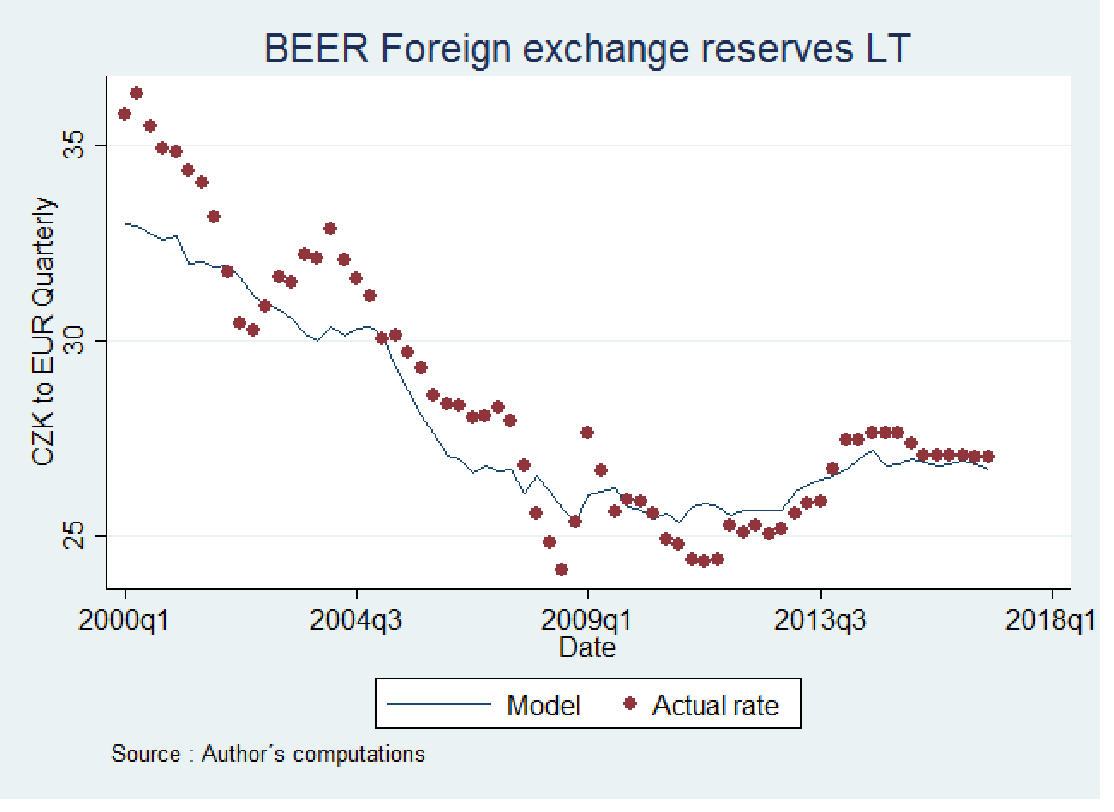
Thirdly, we conduct new analysis of the ARDL model, presented by Babetski and Egert (2005). As we see the long run relationship is:

$$lCZEURPPI = -1.093 * lProd^{***} - 0.0474 * lShareNF\_EA\_CZ + 0.361 * lFor\_Ex\_Res^{***} + 4.835^{***}$$

The following can be said regarding the long-term function of the model. Firstly, the growth of Prod variable yields in to appreciation of the Czech koruna. Similarly, the Share of net foreign assets have insignificant appreciative effect on the currency. On the other hand, the Foreign exchange reserves have deprecetiative effect on the Czech koruna. The effect is although smaller than in the previous 2 models. Moreover, the short-term differentiated effects of the significant variables have opposite sign than the long-term signs of the effects. Model has R-squared high as 48.5 %. We are unable to reject normality and no autocorrelation of the residuals.

Predicted variables of the model are until 2013 very similar to the variables predicted by the original model. After 2013, extended model yields value very near to the actual rate. The rate, which is predicted at the end of 2016 is 26.72 CZK to EUR.

Figure 16 - BEER Babetskii and Egert Forex reserves long term



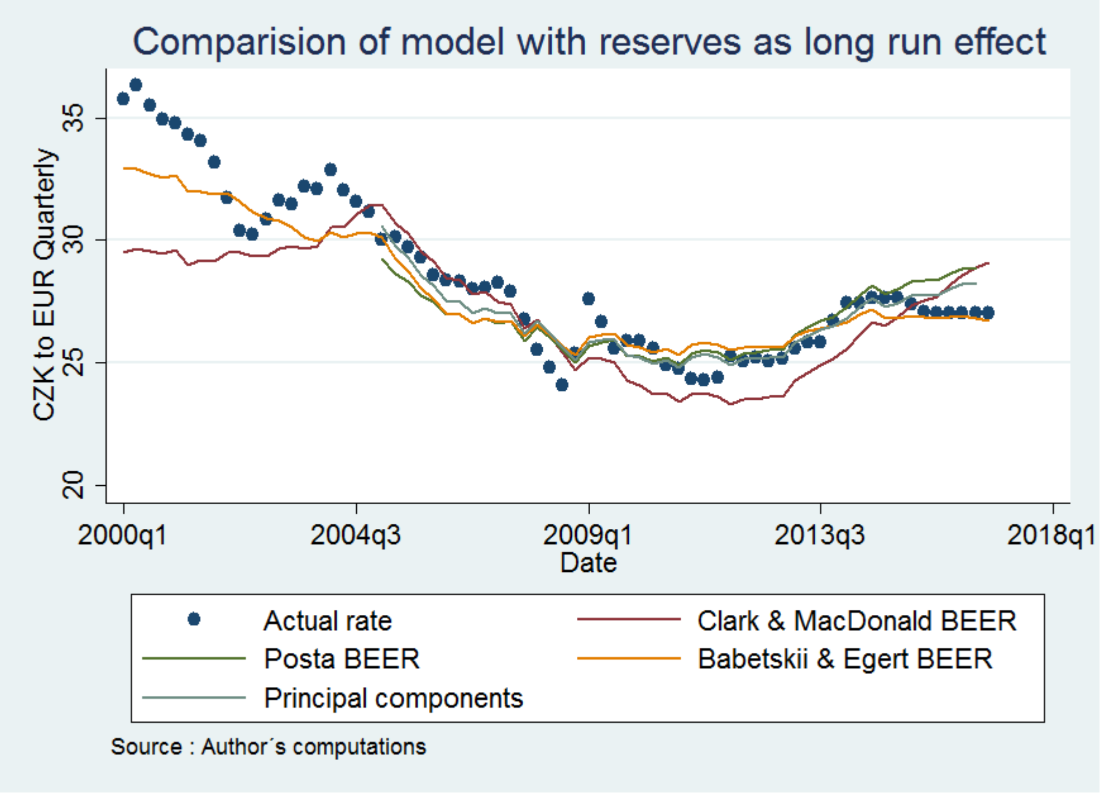
In further analysis, we will conduct principal component analysis on the presented extended models. After the analysis, we see that we have one principal component, which is explaining more than 90 % of the variance. We are unable to reject homoscedasticity, normality and no autocorrelation of the residuals. R-squared in the model is 77 %. The principal component model yields comparable results as in previous principal component analysis until end of the 2013, when model moves to the values over the actual rate in the market. The final equilibrium exchange rate at the end of 2016 is 28.2 CZK to EUR.

Table 7 -Principal component analysis extended models

VARIABLES	(1) CZK_EUR
pc11	0.844***
	(0.0685)
Constant	26.67***
	(0.112)
Observations	47
R-squared	0.771

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

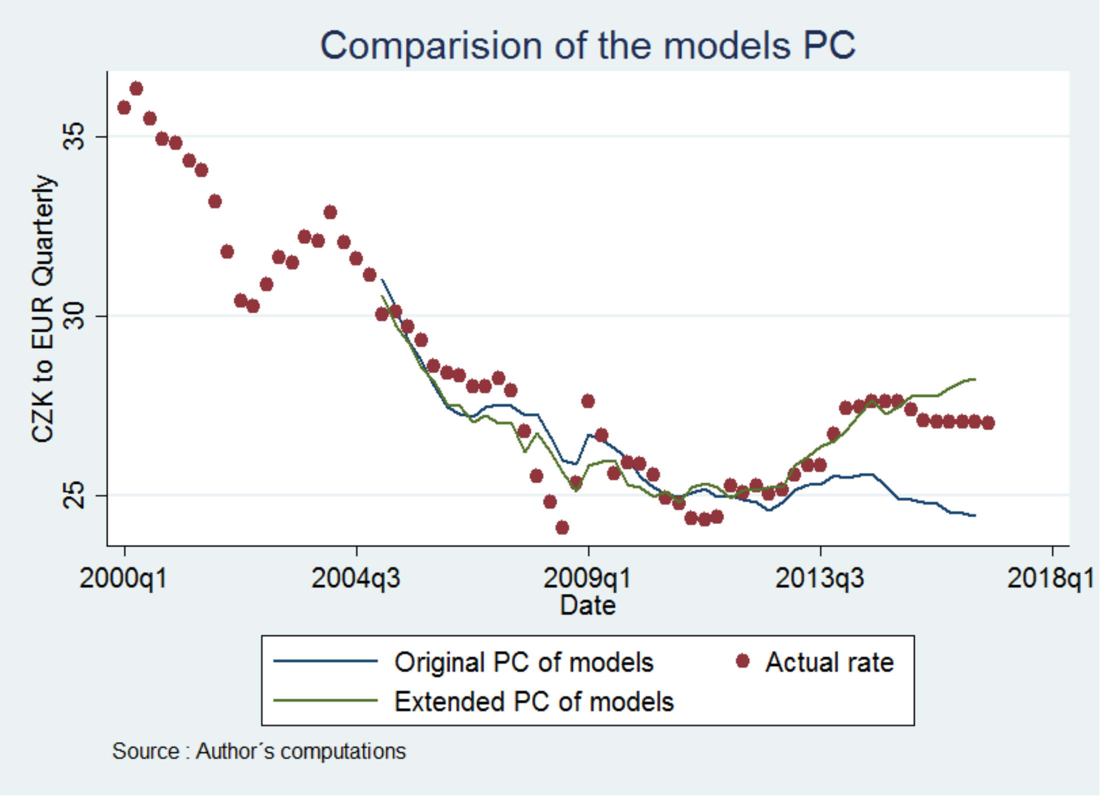
Figure 17 - Comparision of the Extended models



We have compared both principal components models. As we can see on the graph, the same dynamics of the models are present from the start of the analysis, during 2012. The principal component analysis of the original models moves to stronger Czech koruna to area around 24.5 CZK to EUR. On the other hand, the principal component analysis of the extended model moves to the equilibrium exchange rate around 28.2 CZK to EUR. This difference at the end of the sample is fairly big, around 15 %.

There is still possibility, that the model moves more to the short-term equilibrium in this section, since the variable added is identified as short-term in the economic literature. Thus, the possibility of the disappearance of the fereign exchange reserves effect is possible in a few quarters after the end of intervention regime. That would also adress the misalingnement of the models.

Figure 18 - Comparision of the principal component analysis



4.7 BEER model with Forward rates – short run

In this section, we consider Forward exchange rates as variables, which are affecting the equilibrium exchange rate in short-term. As in the section with interventions, we will use DOLS model twice, and once we will extend the ARDL model. For the ARDL models, we conduct also the long term relationship approximations.

Firstly, we took analysis of the BEER models presented by Clark and MacDonald (1998). We use DOLS methodology on all explanatory variables from the model, together with changes of the forward rates.

Table 8 - BEER Forex reserves, interventions and forwards Clark and MacDonald

	(1)	(2)	(3)	(4)
VARIABLES	D.lCZEURPPI	D.lCZEURPPI	D.lCZEURPPI	D.lCZEURPPI
LD.lCZEURPPI	0.814***	0.380***	0.457***	0.353***
	(0.297)	(0.120)	(0.151)	(0.127)
L.ce1	-0.162***	-0.137***	-0.159***	-0.146***
	(0.0512)	(0.0474)	(0.0523)	(0.0497)
Intervention	-1.77e-07	5.49e-07	-4.89e-07	2.11e-07
	(1.28e-06)	(1.20e-06)	(1.31e-06)	(1.25e-06)
Spot_Trades	5.79e-06	2.81e-06	3.72e-06	8.37e-06
	(1.98e-05)	(1.79e-05)	(2.01e-05)	(1.90e-05)
D.lCZEint	-0.00889	-0.0134	-0.00952	0.00131
	(0.0206)	(0.0187)	(0.0210)	(0.0205)
D.lEAint	0.0162	0.00664	0.0271	0.00672
	(0.0318)	(0.0291)	(0.0318)	(0.0311)
D.lToT	0.955***	0.731**	1.156***	1.146***
	(0.315)	(0.299)	(0.310)	(0.290)
D.lBal_Sam	0.201	-0.0536	0.280	0.0608
	(0.369)	(0.349)	(0.375)	(0.362)
D.lShareGoV_EA_CZ	0.000560	0.00605	-0.0133	0.0206
	(0.0486)	(0.0443)	(0.0496)	(0.0478)
D.l3MForw_adj1	-0.407			
	(0.250)			
D.l6MForw_adj1		-0.256***		
		(0.0794)		
D.l9MForw_adj1			0.0797	
			(0.0734)	
D.l12MForw_adj1				0.140**
				(0.0579)
Constant	0.000488	-0.000719	0.00176	0.000847
	(0.00484)	(0.00444)	(0.00491)	(0.00463)
Observations	47	47	47	47
R-squared	0.480	0.567	0.460	0.520

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As it seems among the models, the Forward exchange rates effects are moving slightly from negative effect to positive effect on the equilibrium exchange rate. Results shows that 6 month forwards have significant negative effect on the equilibrium exchange rate. On the other hand, the 12 month forward exchange rates change have significant depreciative effect, which is according to theory. The terms of trade variable have significant effect on the equilibrium exchange rate change in all estimations.

Secondly, we conduct short-term analysis provided by Pošta (2010) extended by the short-term effects made by the Czech National Bank.

Table 9 - BEER with forex reserves, interventions and forwards Pošta

	(1)	(2)	(3)	(4)
VARIABLES	D.lCZEURPPI	D.lCZEURPPI	D.lCZEURPPI	D.lCZEURPPI
LD.lCZEURPPI	0.704***	0.373***	0.376***	0.369***
	(0.247)	(0.112)	(0.125)	(0.123)
L.ce2	-0.0405	-0.0434*	-0.0387	-0.0407
	(0.0269)	(0.0256)	(0.0283)	(0.0277)
Intervention	9.10e-07	1.11e-06	5.29e-07	6.52e-07
	(1.33e-06)	(1.28e-06)	(1.37e-06)	(1.38e-06)
Spot_trades	1.35e-06	6.62e-08	-8.77e-06	-6.75e-06
	(1.94e-05)	(1.86e-05)	(2.01e-05)	(2.00e-05)
D.lBal_Sam	-0.181	-0.179	-0.164	-0.195
	(0.268)	(0.256)	(0.277)	(0.277)
D.lBrent	-0.0286	-0.0276	-0.0326	-0.0376
	(0.0226)	(0.0211)	(0.0228)	(0.0230)
D.lShareNF_EA_CZ	0.0127	0.0310	0.00240	0.00826
	(0.0395)	(0.0381)	(0.0427)	(0.0412)
D.lShare_Govdbt	-0.0642	-0.0331	-0.0694	-0.0566
	(0.0910)	(0.0878)	(0.0951)	(0.0958)
D.lintDiff	-0.01000	-0.00619	-0.00315	0.00382
	(0.0235)	(0.0224)	(0.0242)	(0.0247)
D.l3MForw_adj1	-0.369*			
	(0.217)			
D.l6MForw_adj1		-0.226***		
		(0.0778)		
D.l9MForw_adj1			0.0543	
			(0.0530)	
D.l12MForw_adj1				0.0852
				(0.0568)
Constant	-0.00118	-0.00153	0.00165	0.00185
	(0.00441)	(0.00433)	(0.00466)	(0.00467)
R-squared	0.265	0.339	0.246	0.262

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In the second model, we see that only 3 and 6 month Forward rates are significant variables on 90 % significance level. Both should result to appreciation of the Czech koruna. Any other variables are not significant in the short run.

Thirdly, we conduct new analysis of the ARDL models, presented by Babetski and Egert (2005). The adjustment factors and long run relationship are omitted, although they are significant, but it is not important for the analysis. The lags and other short-term vectors are chosen by AIC. The full model is in the appendix.

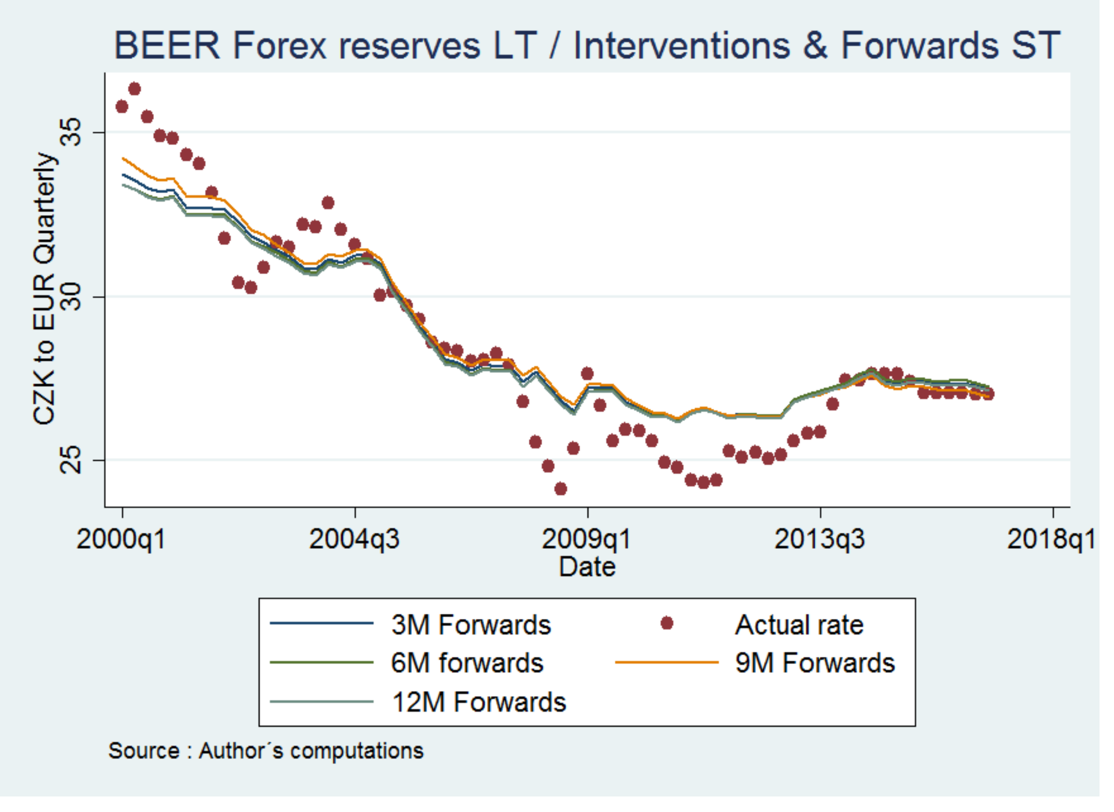
Table 10 - BEER with reserves, interventions and Forwards, Babetskii and Egert

VARIABLES	(1) SR	(2) SR	(3) SR	(4) SR
LD.lCZEURPPI	0.493**	0.179	0.341***	0.269**
	(0.214)	(0.109)	(0.111)	(0.112)
D.lProd	0.318***	0.268***	0.362***	0.474***
	(0.0769)	(0.0743)	(0.0734)	(0.106)
LD.lProd	0.239***	0.190**	0.269***	0.409***
	(0.0880)	(0.0847)	(0.0854)	(0.118)
L2D.lProd	0.142**	0.125*	0.147**	0.292**
	(0.0682)	(0.0645)	(0.0669)	(0.110)
D.lShareNF_EA_CZ	0.0401	0.0593*		
	(0.0316)	(0.0306)		
D.lFor_Ex_Res	-0.157***	-0.150***	-0.143***	-0.179***
	(0.0423)	(0.0396)	(0.0411)	(0.0443)
LD.lFor_Ex_Res	-0.133***	-0.124***	-0.156***	-0.146***
	(0.0477)	(0.0449)	(0.0471)	(0.0465)
Intervention	1.17e-06	1.17e-06	1.48e-06	1.53e-06
	(1.22e-06)	(1.15e-06)	(1.18e-06)	(1.21e-06)
Spot_trades	-6.39e-05***	-5.64e-05***	-7.26e-05***	-7.87e-05***
	(1.99e-05)	(1.88e-05)	(1.91e-05)	(2.11e-05)
L2D.lCZEURPPI		0.258*		
		(0.147)		
L3D.lProd				0.141
				(0.0908)
L2D.lFor_Ex_Res				-0.0656
				(0.0463)
D.l3MForw_adj1	-0.231			
	(0.187)			
D.l6MForw_adj1		-0.285***		
		(0.0948)		
D.l9MForw_adj1			0.0877**	
			(0.0435)	
D.l12MForw_adj1				0.0645
				(0.0459)
Observations	64	64	64	63
R-squared	0.600	0.654	0.609	0.615

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

As we see on the models, the 6 and 9 month Forward rate changes are significant. The 6 month forward rate change should have appreciative effect on the equilibrium exchange rate, and 9 month forward rate change should have slight depreciative effect on the short-term equilibrium. As we see the Spot_trades are still significant under this type of model. Also, we can see that Long run relationships are stable among all forward rates.

Figure 19 - BEER Forex reserves, nterventions and forwards Babetskii and Egert



For the long run relationships, we see that there is slight upward shift in the predicted values. The Czech koruna is overvalued from 2008 until 2013, but much less than in the model stated in chapter 4.5. On the other hand, the model with the Foreign exchange reserves as long term effect has fitted values much closer to the actual values in period. The equilibrium seems to be met by the intervention regime, the predicted value of the equilibrium is in 27 to 27.2 CZK to EUR.

5 Conclusion

The objective of this thesis was to find equilibrium exchange rate of the Czech koruna relative to the Euro. We have conducted Fundamental and Behavioral equilibrium exchange rate models, where fundamental models aim for long-term equilibrium, while behavioural models are focusing on shorter equilibriums in the economy. After conducting the first analyses, we extended our models with flow variables which are determining interventions on the market by the Czech National Bank and spot trades made by the bank. We have also extended models with Foreign exchange reserves variable owned by the bank. Finally, we have added exchange rates forwards given by the 3, 6, 9 and 12 month rates, respectively. The original models were estimated with sample from 2000 until the start of intervention period, which is third quarter of 2013. Then, all models were fit for the full period. The extended models were estimated with full sample from 2000 until the end of 2016.

The equilibrium exchange rate is equal to 24.42 CZK to EUR at the end of 2016 in the original models. This is the outcome of the principal components model constructed with predicted variables from all 6 models. We argue that this equilibrium imlplies too strong Czech koruna, since intervention effect is not taken in to the consideration. Omission of the interventions can yield not only omitted variable bias, but also interventions boosted a few variables after the introduction of them. We took this effect to the consideration, since interventions were main policy tool used by the Czech National Bank to weaken currency and therefore to accelerate inflation.

The good measure of the long-term equilibrium exchange rate seems to be Fundamental equilibrium exchange rate model, presented by Clark and MacDonald (1998), which is relatively stable during the full sample and is resulting in to the long-term equilibrium worth around 25.39 CZK to EUR. In our models, we have arrived to many significant variables, which have effect on the equilibrium exchange rate. The GDP, export and import effect in the Czech economy has direct effect on the equilibrium and often also on the nominal exchange rate in the economy. Since Czech Republic is much smaller than Euro Area, the effect of the variables introduced in the Euro Area is much bigger for the equilibrium exchange rate. This feature was strongly stated in both FEER models and in the BEER models as well. The import effect in Czech economy is much smaller than export effect. In the FEER models, there are no short-term relationships, which should have effect on the equilibrium.

In the BEER models, we have found a significant evidence of Balassa-Samuelson effect in determination of equlibrium exchange rate in all models. This effect was expected and was shown in the previous papers. The higher the ratio is in the Czech Republic relative to the Euro Area, the stronger the Czech koruna is. Even though that this effect has no significant effects in the short-term, the higher number of the traded goods in the economy results in to the stronger currency. Although that Net foreign assets ratio growth should have depreciative effect on the currency, we have found out that just in 1 out of 3 models is this effect present, on the 95 % significance interval. For the Czech National Bank and European Central Bank, there are strong policy tools already. BEER models are quantifying these measures, with European Area interest rates having larger effect on the bilateral exchange rate than the Czech counterpart. The changing interest rates have also higher short-term effect. The relative labour productivity of the Czech economy and its growth has also appreciative effect on the Czech koruna. Lastly, the Foreign exchange reserves and their level held by the Czech National Bank has significant depreciative effect on the Czech koruna.

The policy implications for the Czech National Bank are mixed with general and more surprising implications. First of all, the interest rates have the known effect on the Czech koruna. Secondly what is more interesting, the Interventions presented by central bank as such have no significancant effect among the models. This is definitely because small number of observations and interventions in a sample. While the Czech National Bank was intervening, the incentive of the market was to apprecitiate the currency, hence in opposite direction. That resulted mostly in to no change in the exchange rate, which translates to no significant effect on the currency. Even more surprising is the fact that spot trades from 2004 until 2012 have significant effect on the currency. The long period of the ongoing spot trades seems to have appreciative effect on the Czech koruna, even though that bank was not expecting and was signalling this trades without any intent to affect the exchange rate. On the other hand, this effect coincides with long term appreciation of the Czech koruna. Finally, the long-term effect of the Foreign exchange reserves seems to be significant in the model. This can be due to the very specific strategy of the bank regarding the reserves. The foreign exchange reserves are held mostly consistently with growing tendency almost during the whole short life of the Czech koruna. Even though that our models yields no significance of the interventions, the equilibrium exchange rate moves up to the value near to the 27 CZK to EUR.

The Foreign exchange reserves (weighted by M2 amount of money supply to avoid endogeneity) held by the Czech National Bank were assumed as for long-term effect on the equilibrium exchange rate, we will come to the significant effect on the currency. All extended models result in to equilibrium exchange rate higher than in the original models, with enlarging misalingment from the start of the intervention period. The principal components analysis on the extended model results in to the equilibrium exchange rate of 28.2 CZK to EUR.

In the next part of the analysis, we have analysed possible short-term effect of the forward exchange rates on the market. The implications of the forward rates remain ambigous. The most frequently significant forward rates were 6 month and 9 month forwards changes, although with opposite effects on the currency. We argue that the depreciation of the Forward rates can indeed result in stronger Czech koruna. If the Forward rates are increasing, it creates incentive to the traders to exchange less on the Forward market and move more market players to the spot market where they believe to get better exchange rate, which at the end results to the Czech koruna appreciation. On the other hand, the 9 month Forward rate change shows depreciative significant effect on the Czech koruna in 2 out of 3 models. The 12 month Forward rate change has deprecitiative although not significant effect on the currency. The insignificance can be yield from very uncertain and unstable currency market, which is difficult to predict in 12 month advance. Over all, the results shows that effect of the forwards changes from appreciative to depreciative over the longer holding period of the contract. For the policy perspective and forecasting, both 6 and 9 month forward rate change is sowing slight possibility to foresee the future exchange rate, even though the 6 month forward change effect is not supported in the literature yet.

We can see that there are similar dynamics in all presented models until 2008. After that, there are two main states of the Czech koruna. First one, presented by the majority of the models, is showing that Czech koruna is near to its equilibrium until the start of the interventions. On the other hand, the model with Interventions as short-term effect on the equilibrium shows that Czech koruna is overvalued by 1.5 CZK to EUR, until the start of the interventions. After the start, we have, again two different dynamics. Original models are showing stable equilibrium just around 25 CZK to EUR, but extended models are showing move of the equilibrium to the “intervention” rate.

What is the equilibrium exchange rate of the Czech koruna? For the equilibrium, which should be met or converged in the medium term, we take in to account the BEER models. If we take also into mind that Foreign exchange reserves held by the Czech National Bank have long-term effect in the economy, we can argue that the original BEER models are suffering omitted variable bias. When we conduct models with short term effect of the interventions and spot rates, the long term equilibrium moves to 26.7 CZK to EUR. Because of the possible bias, the equilibrium exchange rate should be in the line with the extended BEER models and somewhere between 26.7 – 28.2 CZK to EUR. These values are closer to the short-term equilibrium, by the selection of the variables. If we talk about long-term equilibrium, which will be converging in the following decade, we can talk about the values near to the original FEER models, where the equilibrium is moving steadily around 25.3 CZK to EUR.

There is one big “IF” concerning the results. The case of the Czech Republic and its interventions is very specific. There has been very little research focused on the Foreign exchange reserves held by the Czech National Bank and there still was not enough time to get all the data from the intervention period, which has ended in April 2017. We definetely move to more short-term equilibrium in our models by adding the Foreign exchange reserves to our models. There is huge uncertainty how the interventions affected the equilibrium at the end of regime set by the Czech National Bank and if they affect Czech koruna equilibrium in short or long term. It will be interesting to see how nominal Czech koruna will behave few quarters after the end of the regime, which will tell us more about this effect.

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Appendix: Estimation results

Table 11 - FEER according to Clark & MacDonald

	(1)	(2)	(3)	(4)	(5)
VARIABLES	D_lCZEURPPI	D_lCZKAin	D_lCZKAout	D_lCZGDP	D_lEAGDP
L._ce1	-0.135***	-4.622*	-4.962*	0.0396	0.0282**
	(0.0409)	(2.783)	(2.854)	(0.0270)	(0.0134)
L._ce2	-0.00675*	-0.718***	0.744***	0.000780	0.00156
	(0.00372)	(0.253)	(0.259)	(0.00245)	(0.00122)
LD.lCZEURPPI	0.330**	-4.997	0.638	-0.0938	-0.0627
	(0.131)	(8.931)	(9.157)	(0.0866)	(0.0430)
LD.lCZKAin	0.00220	-0.0360	-0.466**	-0.00119	-0.00114
	(0.00281)	(0.191)	(0.196)	(0.00185)	(0.000920)
LD.lCZKAout	0.000243	-0.184	-0.182	-0.00105	0.000274
	(0.00223)	(0.152)	(0.156)	(0.00147)	(0.000730)
LD.lCZGDP	0.0158	3.923	37.79**	0.00119	0.231***
	(0.249)	(16.96)	(17.39)	(0.164)	(0.0816)
LD.lEAGDP	0.532	44.02	19.82	0.537*	-0.150
	(0.451)	(30.69)	(31.47)	(0.297)	(0.148)
Observations	53	53	53	53	53
r2_1	0.324	0.324	0.324	0.324	0.324

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 12 - FEER PPI according to Clark & MacDonald Import equation

VARIABLES	(1) D_lCZEURPPI	(2) D_lCZImpReal	(3) D_lCZDemand	(4) D_lCZExReal
L._ce1	-0.0765	-0.216	0.119***	-0.0264
	(0.0869)	(0.174)	(0.0247)	(0.158)
LD.lCZEURPPI	0.380**	0.305	-0.0685	0.206
	(0.164)	(0.328)	(0.0466)	(0.298)
L2D.lCZEURPPI	-0.156	0.0406	-0.153***	0.0816
	(0.170)	(0.339)	(0.0482)	(0.308)
L3D.lCZEURPPI	-0.127	0.549	-0.0758	0.500
	(0.167)	(0.335)	(0.0476)	(0.304)
LD.lCZImpReal	0.428*	0.254	0.00707	0.188
	(0.248)	(0.495)	(0.0703)	(0.450)
L2D.lCZImpReal	0.000774	0.207	-0.0896	0.0394
	(0.242)	(0.485)	(0.0689)	(0.440)
L3D.lCZImpReal	0.0805	-0.297	-0.0448	-0.358
	(0.228)	(0.456)	(0.0648)	(0.414)
LD.lCZDemand	-0.428	1.470	-0.00340	1.580*
	(0.511)	(1.023)	(0.145)	(0.928)
L2D.lCZDemand	0.153	0.141	-0.0205	-0.643
	(0.459)	(0.917)	(0.130)	(0.833)
L3D.lCZDemand	0.0580	-0.769	-0.254*	-1.077
	(0.487)	(0.974)	(0.138)	(0.884)
LD.lCZExReal	-0.439*	0.0419	0.0245	0.0601
	(0.250)	(0.500)	(0.0710)	(0.454)
L2D.lCZExReal	0.0634	-0.195	0.0772	-0.0784
	(0.245)	(0.490)	(0.0696)	(0.445)
L3D.lCZExReal	-0.153	0.403	-0.0214	0.424
	(0.224)	(0.449)	(0.0638)	(0.408)
Constant	-0.00184	0.00443	0.0105***	0.0163
	(0.00746)	(0.0149)	(0.00212)	(0.0136)
Observations	51	51	51	51
r2_1	0.401	0.401	0.401	0.401

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 13 - FEER according to Komarek & Motl Export equation

	(1)	(2)	(3)	(4)
VARIABLES	D_lCZEURPPI	D_lCZExReal	D_lEAImReal	D_lProd
L._ce1	-0.00318	-0.00575	-0.0875	0.0601***
	(0.00978)	(0.0168)	(0.0580)	(0.00955)
LD.lCZEURPPI	0.444***	0.645**	-0.695	0.180
	(0.169)	(0.290)	(1.004)	(0.165)
L2D.lCZEURPPI	-0.226	-0.0452	0.118	-0.310*
	(0.185)	(0.317)	(1.096)	(0.180)
L3D.lCZEURPPI	-0.0563	0.521*	-1.034	0.272*
	(0.164)	(0.282)	(0.973)	(0.160)
LD.lCZExReal	-0.0195	0.258*	0.0588	0.301***
	(0.0881)	(0.151)	(0.523)	(0.0860)
L2D.lCZExReal	-0.00959	0.00368	-0.349	-0.163*
	(0.0942)	(0.162)	(0.558)	(0.0919)
L3D.lCZExReal	-0.133	-0.0594	2.525***	-0.0120
	(0.0847)	(0.145)	(0.502)	(0.0826)
LD.lEAImReal	0.0373*	0.107***	-0.0556	0.0286
	(0.0222)	(0.0380)	(0.131)	(0.0216)
L2D.lEAImReal	0.00563	0.0200	0.0271	-0.0879***
	(0.0238)	(0.0409)	(0.141)	(0.0233)
L3D.lEAImReal	-0.00886	-0.0154	0.0386	0.0603***
	(0.0238)	(0.0408)	(0.141)	(0.0232)
LD.lProd	-0.142	-0.0549	-0.366	-0.616***
	(0.0940)	(0.161)	(0.558)	(0.0918)
L2D.lProd	-0.00418	0.367*	-0.384	-0.456***
	(0.118)	(0.202)	(0.697)	(0.115)
L3D.lProd	0.00858	0.279*	0.0921	-0.684***
	(0.0968)	(0.166)	(0.574)	(0.0944)
Constant	-0.00208	0.0108	0.00489	0.00803*
	(0.00425)	(0.00730)	(0.0252)	(0.00415)
Observations	51	51	51	51
r2_1	0.369	0.369	0.369	0.369

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 14 - BEER according to Clark & MacDonald

VARIABLES	(1) D_lCZEURPPI	(2) D_lToT	(3) D_lShareGoV_EA_CZ	(4) D_lCZEint	(5) D_lEAint	(6) D_lBal_Sam
L._ce1	-0.0315	0.518***	0.142	-0.527	0.469	-0.180
	(0.347)	(0.186)	(0.485)	(1.772)	(2.137)	(0.150)
L._ce2	-1.493	-1.928***	-0.530	4.477	3.386	0.508
	(1.131)	(0.606)	(1.578)	(5.766)	(6.953)	(0.489)
LD.lCZEURPPI	0.835***	-0.125	-0.0677	-0.175	-1.370	0.0332
	(0.283)	(0.152)	(0.396)	(1.446)	(1.743)	(0.123)
L2D.lCZEURPPI	-0.680*	-0.345*	0.227	-1.221	-2.696	0.190
	(0.373)	(0.200)	(0.520)	(1.900)	(2.291)	(0.161)
L3D.lCZEURPPI	1.240***	0.455**	0.222	-1.325	-1.011	-0.185
	(0.420)	(0.225)	(0.586)	(2.143)	(2.584)	(0.182)
LD.lToT	0.791	1.213***	0.430	0.699	-0.365	-0.312
	(0.708)	(0.379)	(0.987)	(3.609)	(4.351)	(0.306)
L2D.lToT	0.220	1.017*	-0.409	2.322	0.506	-0.266
	(1.065)	(0.571)	(1.486)	(5.431)	(6.549)	(0.461)
L3D.lToT	1.535***	0.761**	-0.924	-3.248	-2.926	-0.129
	(0.592)	(0.317)	(0.825)	(3.017)	(3.638)	(0.256)
LD.lShareGoV_EA_CZ	0.770	1.413***	-0.549	-3.721	-2.099	-0.501
	(0.882)	(0.473)	(1.231)	(4.499)	(5.425)	(0.382)
L2D.lShareGoV_EA_CZ	0.402	0.890***	-0.614	-2.211	-1.489	-0.287
	(0.541)	(0.290)	(0.755)	(2.761)	(3.329)	(0.234)
L3D.lShareGoV_EA_CZ	-0.00440	0.365**	-0.677	-1.186	-0.703	-0.104
	(0.313)	(0.168)	(0.437)	(1.597)	(1.925)	(0.135)
LD.lCZEint	-0.389**	-0.268***	-0.0177	1.029	0.964	0.0463
	(0.189)	(0.101)	(0.264)	(0.965)	(1.163)	(0.0818)
L2D.lCZEint	-0.365***	-0.216***	-0.0815	0.0240	-0.0787	0.103*
	(0.136)	(0.0728)	(0.189)	(0.692)	(0.835)	(0.0587)
L3D.lCZEint	-0.0261	-0.113**	0.0991	-0.157	-0.107	0.0373
	(0.0955)	(0.0512)	(0.133)	(0.487)	(0.587)	(0.0413)
LD.lEAint	0.287	0.317***	0.165	-0.784	-0.648	-0.0550
	(0.209)	(0.112)	(0.292)	(1.068)	(1.288)	(0.0906)
L2D.lEAint	0.401*	0.364***	0.0589	0.195	0.0155	-0.138
	(0.205)	(0.110)	(0.286)	(1.047)	(1.263)	(0.0888)
L3D.lEAint	0.134	0.250***	-0.160	-0.424	-0.188	-0.0801
	(0.161)	(0.0864)	(0.225)	(0.822)	(0.991)	(0.0697)
LD.lBal_Sam	1.540	1.235**	-0.135	2.000	-2.062	-0.0544
	(0.956)	(0.513)	(1.334)	(4.877)	(5.881)	(0.414)
L2D.lBal_Sam	-0.602	0.0766	-0.481	-4.725	-3.722	0.476
	(1.051)	(0.564)	(1.466)	(5.359)	(6.462)	(0.454)
L3D.lBal_Sam	2.954***	1.326***	-0.736	-0.204	-1.630	-0.822**
	(0.813)	(0.436)	(1.134)	(4.147)	(5.000)	(0.352)
Constant	-0.0193***	-0.00937***	-0.00825	-0.0115	-0.000346	0.00276
	(0.00677)	(0.00363)	(0.00945)	(0.0345)	(0.0417)	(0.00293)
Observations	31	31	31	31	31	31
r2_1	0.833	0.833	0.833	0.833	0.833	0.833

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 15 - BEER according Pošta

VARIABLES	(1) D_lCZEURPPI	(2) D_lBrent	(3) D_lShareNF_EA_CZ	(4) D_lShare_Govdbt	(5) D_lBal_Sam	(6) D_lintDiff
L._ce1	-0.0794	0.0896	0.0436	0.105	-0.150***	-0.205
	(0.0797)	(0.525)	(0.317)	(0.160)	(0.0331)	(0.286)
L._ce2	-0.0723***	-0.160	-0.0929	-0.0204	-0.0114	-0.214**
	(0.0245)	(0.162)	(0.0976)	(0.0492)	(0.0102)	(0.0880)
LD.lCZEURPPI	0.473***	-1.411	0.0925	-0.163	0.0730	-0.341
	(0.164)	(1.082)	(0.653)	(0.329)	(0.0681)	(0.589)
L2D.lCZEURPPI	-0.156	0.433	-0.387	0.0467	0.0678	1.707***
	(0.151)	(0.993)	(0.600)	(0.302)	(0.0625)	(0.541)
L3D.lCZEURPPI	0.01000	0.140	0.703	-0.202	0.0651	-1.004*
	(0.160)	(1.058)	(0.639)	(0.322)	(0.0666)	(0.576)
LD.lBrent	0.0108	0.112	-0.0925	0.0344	0.0177	0.187*
	(0.0314)	(0.207)	(0.125)	(0.0630)	(0.0130)	(0.113)
L2D.lBrent	0.110***	-0.476**	-0.158	-0.0978	0.00384	-0.0648
	(0.0302)	(0.199)	(0.120)	(0.0605)	(0.0125)	(0.108)
L3D.lBrent	-0.0333	0.287	-0.177	0.00639	-0.00604	0.111
	(0.0328)	(0.216)	(0.130)	(0.0658)	(0.0136)	(0.118)
LD.lShareNF_EA_CZ	-0.0769	-0.0638	0.108	0.0760	0.0105	-0.130
	(0.0545)	(0.359)	(0.217)	(0.109)	(0.0226)	(0.196)
L2D.lShareNF_EA_CZ	0.0361	0.421	0.170	0.0912	-0.0144	0.176
	(0.0516)	(0.340)	(0.205)	(0.103)	(0.0214)	(0.185)
L3D.lShareNF_EA_CZ	-0.0533	-0.135	0.141	0.0906	0.0667***	-0.244
	(0.0455)	(0.300)	(0.181)	(0.0913)	(0.0189)	(0.163)
LD.lShare_Govdbt	0.105	-0.641	0.674	-0.246	0.113**	-0.0650
	(0.129)	(0.852)	(0.514)	(0.259)	(0.0536)	(0.464)
L2D.lShare_Govdbt	0.173	-0.390	-0.453	-0.154	0.0687	0.324
	(0.139)	(0.917)	(0.554)	(0.279)	(0.0577)	(0.499)
L3D.lShare_Govdbt	-0.139	-1.772**	-0.672	-0.227	0.144***	-0.147
	(0.126)	(0.831)	(0.502)	(0.253)	(0.0523)	(0.453)
LD.lBal_Sam	0.377	0.418	0.209	0.467	0.161	2.303*
	(0.340)	(2.240)	(1.353)	(0.682)	(0.141)	(1.220)
L2D.lBal_Sam	0.591*	1.000	-0.328	0.808	0.641***	1.672
	(0.345)	(2.275)	(1.374)	(0.692)	(0.143)	(1.239)
L3D.lBal_Sam	0.804**	-4.411*	-0.609	0.0106	-0.0577	1.446
	(0.404)	(2.661)	(1.607)	(0.810)	(0.168)	(1.450)
LD.lintDiff	-0.0681	0.0415	-0.175	0.0740	-0.00883	0.300
	(0.0546)	(0.360)	(0.217)	(0.110)	(0.0227)	(0.196)
L2D.lintDiff	0.00687	0.199	0.125	0.111	0.0194	-0.0289
	(0.0459)	(0.303)	(0.183)	(0.0921)	(0.0191)	(0.165)
L3D.lintDiff	0.113**	0.226	0.166	0.0633	0.0198	0.281
	(0.0485)	(0.320)	(0.193)	(0.0973)	(0.0201)	(0.174)
Constant	-0.00499	0.0121	-0.00565	0.00219	0.0182***	-0.00615
	(0.00931)	(0.0614)	(0.0371)	(0.0187)	(0.00386)	(0.0334)
Observations	51	51	51	51	51	51
r2_1	0.682	0.682	0.682	0.682	0.682	0.682

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 16 - BEER according Babetski & Egert

VARIABLES	(1) ADJ	(2) LR	(3) SR
lProd		-0.678***	
		(0.101)	
lShareNF_EA_CZ		0.101**	
		(0.0388)	
L.lCZEURPPI	-0.320***		
	(0.0870)		
LD.lCZEURPPI			0.506***
			(0.135)
D.lProd			0.207***
			(0.0642)
Constant		3.071***	
		(0.0640)	
Observations	51	51	51
R-squared	0.361	0.361	0.361

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 17 - BEER with foreign exchange reserves long term Clark and MacDonald

VARIABLES	(1) D_lCZEURPPI	(2) D_CZEint	(3) D_EAint	(4) D_lToT	(5) D_lShareGoV_EA_CZ	(6) D_lBal_Sam	(7) D_lFor_Ex_Res
L._ce1	-0.327	-0.0192	-0.0788*	0.190	-0.751**	-0.175	1.143
	(0.328)	(0.0462)	(0.0470)	(0.145)	(0.381)	(0.108)	(0.825)
L._ce2	3.931	-0.148	0.478	3.091***	8.448***	0.530	8.976
	(2.686)	(0.378)	(0.384)	(1.187)	(3.119)	(0.887)	(6.743)
L._ce3	-4.979	0.129	-0.895	-3.268*	-12.46***	-1.242	-8.182
	(4.080)	(0.574)	(0.584)	(1.803)	(4.736)	(1.347)	(10.24)
LD.lCZEURPPI	0.441	0.00645	0.0333	-0.188	0.495	0.170*	-0.265
	(0.311)	(0.0438)	(0.0446)	(0.138)	(0.361)	(0.103)	(0.782)
L2D.lCZEURPPI	-0.153	-0.0136	-0.0204	-0.0107	0.707*	0.0617	-1.066
	(0.335)	(0.0471)	(0.0480)	(0.148)	(0.389)	(0.111)	(0.841)
L3D.lCZEURPPI	0.398	-0.00173	0.0155	-0.0711	0.0899	-0.0445	0.673
	(0.280)	(0.0394)	(0.0401)	(0.124)	(0.325)	(0.0924)	(0.703)
LD.CZEint	-7.040**	-0.0269	-0.418	-1.647	-3.903	0.281	3.869
	(3.027)	(0.426)	(0.433)	(1.338)	(3.514)	(0.999)	(7.599)
L2D.CZEint	-2.793	-0.331	-0.718**	-0.456	-4.390*	1.342*	1.551
	(2.117)	(0.298)	(0.303)	(0.936)	(2.458)	(0.699)	(5.315)
L3D.CZEint	0.0172	-0.0746	-0.0947	-0.469	2.290	0.0557	-6.156
	(2.079)	(0.292)	(0.298)	(0.919)	(2.413)	(0.686)	(5.218)
LD.EAint	6.976**	0.0981	0.373	2.499*	9.980**	0.697	5.416
	(3.406)	(0.479)	(0.488)	(1.506)	(3.955)	(1.125)	(8.551)
L2D.EAint	6.469**	0.467	0.756*	3.639***	5.054	-2.042**	9.361
	(2.983)	(0.419)	(0.427)	(1.319)	(3.463)	(0.985)	(7.488)
L3D.EAint	3.321	-0.299	0.0295	3.314**	-0.684	-0.301	8.798
	(2.928)	(0.412)	(0.419)	(1.294)	(3.399)	(0.967)	(7.350)
LD.lToT	0.666	0.0348	-0.0406	0.559**	0.212	-0.218	-0.0158
	(0.562)	(0.0790)	(0.0804)	(0.248)	(0.652)	(0.185)	(1.410)
L2D.lToT	0.231	0.150*	0.0491	0.0790	-0.194	-0.0371	3.729**
	(0.621)	(0.0873)	(0.0888)	(0.274)	(0.721)	(0.205)	(1.558)
L3D.lToT	0.926*	-0.0415	0.00729	0.318	-0.0651	-0.0807	-2.121
	(0.560)	(0.0787)	(0.0801)	(0.247)	(0.650)	(0.185)	(1.405)
LD.lShareGoV_EA_CZ	0.0322	-0.0492	-0.0798	0.429***	-1.179***	-0.285**	1.869**
	(0.355)	(0.0499)	(0.0508)	(0.157)	(0.412)	(0.117)	(0.891)
L2D.lShareGoV_EA_CZ	-0.0528	-0.0373	-0.0837**	0.255**	-1.128***	-0.123	1.262*
	(0.271)	(0.0380)	(0.0387)	(0.120)	(0.314)	(0.0893)	(0.679)
L3D.lShareGoV_EA_CZ	-0.0868	-0.0111	-0.0407	0.0393	-0.966***	-0.0637	0.859*
	(0.186)	(0.0262)	(0.0267)	(0.0824)	(0.216)	(0.0615)	(0.468)
LD.lBal_Sam	0.555	0.0168	-0.137	0.235	-0.196	0.384	1.055
	(0.713)	(0.100)	(0.102)	(0.315)	(0.828)	(0.236)	(1.791)
L2D.lBal_Sam	0.0331	0.0608	0.0528	-0.296	0.0622	0.101	1.105
	(0.803)	(0.113)	(0.115)	(0.355)	(0.933)	(0.265)	(2.016)
L3D.lBal_Sam	0.964	0.0475	0.124	0.702**	0.135	-0.440*	-1.677
	(0.681)	(0.0957)	(0.0975)	(0.301)	(0.791)	(0.225)	(1.709)
LD.lFor_Ex_Res	-0.229**	0.0170	0.0137	-0.135***	-0.0808	0.00736	0.280
	(0.113)	(0.0158)	(0.0161)	(0.0498)	(0.131)	(0.0372)	(0.283)
L2D.lFor_Ex_Res	-0.140	-0.0175	-0.00980	0.00638	-0.193*	-0.0340	-0.345
	(0.0986)	(0.0139)	(0.0141)	(0.0436)	(0.114)	(0.0326)	(0.248)
L3D.lFor_Ex_Res	-0.125	0.000376	-0.00887	-0.0428	-0.0910	0.0276	0.242
	(0.113)	(0.0159)	(0.0162)	(0.0499)	(0.131)	(0.0373)	(0.284)
Constant	0.000519	-0.000897	-0.000898	-0.00199	-0.000275	0.00250	0.000604
	(0.00469)	(0.000659)	(0.000671)	(0.00207)	(0.00545)	(0.00155)	(0.0118)
Observations	44	44	44	44	44	44	44
r2_1	0.660	0.660	0.660	0.660	0.660	0.660	0.660

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 18 - BEER with foreign exchange reserves long term Pošta

VARIABLES	(1) D_lCZEURPPI	(2) D_lBrent	(3) D_lShareNF_EA_CZ	(4) D_lShare_Govdbt	(5) D_lBal_Sam	(6) D_lintDiff	(7) D_lFor_Ex_Res
L._ce1	0.121	0.253	0.257	0.0986	-0.132***	-1.203**	-0.586***
	(0.0842)	(0.683)	(0.312)	(0.148)	(0.0370)	(0.528)	(0.171)
L._ce2	0.0178	0.0918	0.0237	-0.00218	-0.0106**	-0.121*	-0.132***
	(0.0113)	(0.0917)	(0.0419)	(0.0199)	(0.00498)	(0.0709)	(0.0230)
LD.lCZEURPPI	0.156	-0.821	0.118	-0.162	0.0911	1.296	0.613*
	(0.166)	(1.349)	(0.616)	(0.293)	(0.0732)	(1.043)	(0.338)
L2D.lCZEURPPI	-0.188	-0.0331	-0.496	0.0318	0.0303	2.562***	0.0232
	(0.156)	(1.268)	(0.579)	(0.275)	(0.0688)	(0.980)	(0.318)
L3D.lCZEURPPI	-0.141	0.292	0.173	-0.158	0.0275	0.251	0.542*
	(0.145)	(1.176)	(0.537)	(0.255)	(0.0638)	(0.909)	(0.295)
LD.lBrent	-0.0755***	-0.229	-0.128	0.0467	0.0191	0.281	0.208***
	(0.0291)	(0.236)	(0.108)	(0.0512)	(0.0128)	(0.182)	(0.0592)
L2D.lBrent	-0.00793	-0.301	-0.141	-0.0321	0.0138	0.00826	0.0551
	(0.0300)	(0.243)	(0.111)	(0.0527)	(0.0132)	(0.188)	(0.0609)
L3D.lBrent	-0.00559	0.0623	-0.0693	0.0474	0.00411	0.218	0.0623
	(0.0293)	(0.237)	(0.108)	(0.0515)	(0.0129)	(0.183)	(0.0595)
LD.lShareNF_EA_CZ	0.0169	0.325	0.188	0.0740	0.00577	-0.185	-0.0650
	(0.0514)	(0.417)	(0.190)	(0.0904)	(0.0226)	(0.322)	(0.104)
L2D.lShareNF_EA_CZ	0.0765	0.00612	0.139	-0.0360	-0.0179	0.0916	-0.120
	(0.0474)	(0.385)	(0.176)	(0.0834)	(0.0209)	(0.297)	(0.0964)
L3D.lShareNF_EA_CZ	-0.0626	0.00545	-0.0257	-0.0117	0.0456**	-0.421	-0.0667
	(0.0417)	(0.338)	(0.154)	(0.0734)	(0.0184)	(0.262)	(0.0848)
LD.lShare_Govdbt	0.0466	0.0357	0.540	-0.196	0.0737	0.921	-0.304
	(0.132)	(1.067)	(0.487)	(0.231)	(0.0579)	(0.825)	(0.268)
L2D.lShare_Govdbt	-0.0684	0.156	-0.482	-0.130	0.0388	0.924	-0.995***
	(0.128)	(1.038)	(0.474)	(0.225)	(0.0563)	(0.802)	(0.260)
L3D.lShare_Govdbt	-0.269*	0.563	-0.435	-0.134	0.0964	0.714	-0.185
	(0.138)	(1.122)	(0.512)	(0.243)	(0.0609)	(0.867)	(0.281)
LD.lBal_Sam	-0.155	1.060	-1.189	0.188	0.0386	0.856	-0.707
	(0.291)	(2.358)	(1.076)	(0.511)	(0.128)	(1.822)	(0.591)
L2D.lBal_Sam	-0.0806	-1.356	-1.632*	0.420	0.519***	1.009	0.444
	(0.259)	(2.103)	(0.960)	(0.456)	(0.114)	(1.626)	(0.527)
L3D.lBal_Sam	0.0391	-4.000	-0.939	-0.338	-0.172	1.765	0.417
	(0.303)	(2.458)	(1.122)	(0.533)	(0.133)	(1.900)	(0.616)
LD.lintDiff	-0.0299	-0.152	-0.00152	0.0306	0.00908	-0.0271	0.216***
	(0.0288)	(0.234)	(0.107)	(0.0507)	(0.0127)	(0.181)	(0.0586)
L2D.lintDiff	-0.0375	-0.182	-0.00427	0.0413	0.0240*	-0.141	0.158***
	(0.0286)	(0.231)	(0.106)	(0.0502)	(0.0126)	(0.179)	(0.0580)
L3D.lintDiff	-0.0425	-0.0982	-0.0240	0.0221	0.0248**	0.160	0.158***
	(0.0271)	(0.220)	(0.100)	(0.0477)	(0.0119)	(0.170)	(0.0552)
LD.lFor_Ex_Res	-0.0462	0.444	0.254	0.0327	0.00921	0.502	0.371***
	(0.0580)	(0.471)	(0.215)	(0.102)	(0.0255)	(0.364)	(0.118)
L2D.lFor_Ex_Res	0.0770	-0.0821	-0.0364	-0.158*	-0.0358*	-0.230	-0.0822
	(0.0492)	(0.399)	(0.182)	(0.0866)	(0.0217)	(0.309)	(0.100)
L3D.lFor_Ex_Res	0.116**	-0.131	-0.155	0.0775	-0.00972	-0.0707	0.177*
	(0.0497)	(0.403)	(0.184)	(0.0875)	(0.0219)	(0.312)	(0.101)
Constant	-0.00538*	0.00986	-0.00580	0.00326	0.00444***	-0.00399	0.00832
	(0.00313)	(0.0254)	(0.0116)	(0.00551)	(0.00138)	(0.0196)	(0.00637)
Observations	64	64	64	64	64	64	64
r2_1	0.560	0.560	0.560	0.560	0.560	0.560	0.560

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 19 - BEER with foreign exchange reserves long term Babetski and Egert

VARIABLES	(1) ADJ	(2) LR	(3) SR
LD.lCZEURPPI			0.254**
			(0.123)
D.lProd			0.224**
			(0.0875)
LD.lProd			0.0943
			(0.0731)
D.lShareNF_EA_CZ			0.0566
			(0.0349)
D.lFor_Ex_Res			-0.125***
			(0.0463)
LD.lFor_Ex_Res			-0.0524
			(0.0488)
L2D.lFor_Ex_Res			0.00594
			(0.0454)
L3D.lFor_Ex_Res			0.0959**
			(0.0471)
lProd		-1.093***	
		(0.308)	
lShareNF_EA_CZ		-0.0474	
		(0.0954)	
lFor_Ex_Res		0.361**	
		(0.175)	
L.lCZEURPPI	-0.192**		
	(0.0721)		
Constant		4.835***	
		(0.841)	
Observations	64	64	64
R-squared	0.485	0.485	0.485

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 20 - BEER with foreign exchange reserves, interventions and forwards Babetskii and Egert

VARIABLES	(1) ADJ	(2) LR	(3) SR	(4) ADJ	(5) LR	(6) SR	(7) ADJ	(8) LR	(9) SR	(10) ADJ	(11) LR	(12) SR
LD.lCZEURPPI			0.493**			0.179			0.341***			0.269**
			(0.214)			(0.109)			(0.111)			(0.112)
D.lProd			0.318***			0.268***			0.362***			0.474***
			(0.0769)			(0.0743)			(0.0734)			(0.106)
LD.lProd			0.239***			0.190**			0.269***			0.409***
			(0.0880)			(0.0847)			(0.0854)			(0.118)
L2D.lProd			0.142**			0.125*			0.147**			0.292**
			(0.0682)			(0.0645)			(0.0669)			(0.110)
D.lShareNF_EA_CZ			0.0401			0.0593*						
			(0.0316)			(0.0306)						
D.lFor_Ex_Res			-0.157***			-0.150***			-0.143***			-0.179***
			(0.0423)			(0.0396)			(0.0411)			(0.0443)
LD.lFor_Ex_Res			-0.133***			-0.124***			-0.156***			-0.146***
			(0.0477)			(0.0449)			(0.0471)			(0.0465)
For_Ex_ResS			1.17e-06			1.17e-06			1.48e-06			1.53e-06
			(1.22e-06)			(1.15e-06)			(1.18e-06)			(1.21e-06)
For_Ex_ResS2			-6.39e-05***			-5.64e-05***			-7.26e-05***			-7.87e-05***
			(1.99e-05)			(1.88e-05)			(1.91e-05)			(2.11e-05)
D.l3MForw_adj1			-0.231									
			(0.187)									
lProd		-0.869***			-0.893***			-0.824***			-0.871***	
		(0.148)			(0.155)			(0.126)			(0.130)	
lShareNF_EA_CZ		0.00674			-0.00369			0.0266			0.00188	
		(0.0425)			(0.0470)			(0.0356)			(0.0382)	
lFor_Ex_Res		0.239***			0.266***			0.192***			0.248***	
		(0.0839)			(0.0928)			(0.0695)			(0.0707)	
L.lCZEURPPI	-0.360***			-0.329***			-0.398***			-0.436***		
	(0.0712)			(0.0718)			(0.0659)			(0.0790)		
L2D.lCZEURPPI						0.258*						
						(0.147)						
D.l6MForw_adj1						-0.285***						
						(0.0948)						
D.l9MForw_adj1									0.0877**			
									(0.0435)			
L3D.lProd												0.141
												(0.0908)
L2D.lFor_Ex_Res												-0.0656
												(0.0463)
D.l12MForw_adj1												0.0645
												(0.0459)
Constant		4.275***			4.402***			4.046***			4.317***	
		(0.401)			(0.447)			(0.331)			(0.340)	
Observations	64	64	64	64	64	64	64	64	64	63	63	63
R-squared	0.600	0.600	0.600	0.654	0.654	0.654	0.609	0.609	0.609	0.615	0.615	0.615

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1