# Exchange rate modelling for Lithuania and Switzerland

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# EXCHANGE RATE MODELLING FOR LITHUANIA AND SWITZERLAND

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Abstract

In this research, the equilibrium real exchange rate as well as exchange rate misalignment in Switzerland and Lithuania is estimated based on behavioural equilibrium exchange rate and structural vector autoregression models. Moreover, driving forces of the real effective exchange rate are identified based on these methods for both countries. For estimation purposes data from various sources, such as Reuters, Eurostat, Swiss National Bank, Bank of Lithuania, Datastream, World Bank, IMF and others, is used. The results indicate that openness differential, net foreign assets, commodity terms of trade, productivity differential and fiscal balance to gross domestic product differential are significant determinants of the real effective exchange rate in Switzerland, and the latter three variables are significant in determining the real effective exchange rate in Lithuania. Results also give evidence that real effective exchange rate is mainly driven by demand shocks in both countries. Several periods of significant misalignment are detected for both Switzerland and Lithuania. The Thesis supports the exchange rate policy implemented by the Swiss National Bank and the internal adjustment strategy pursued by the Lithuanian government.

Declaration

"I declare in lieu of an oath that I have written this master thesis by myself, and that I did not use other sources or resources than stated for its preparation. I declare that I have clearly indicated all direct and indirect quotations, and that this thesis has not been submitted elsewhere for examination purposes or publication."

3 September, 2012 Ramune Rimgailaite

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# 1. Introduction

In this part of the study the study's background, central research questions and hypotheses, as well as aims and objectives are provided.

## 1.1. Background

The exchange rate is very important economic variable especially for small and open economies. If, for example, country's currency is overvalued, it implies that domestic goods are more expensive than foreign goods. Thus, this leads to a fall in exports, a rise in imports in the country and at the end a loss in competitiveness in the international trade. Otherwise, if the exchange rate is undervalued, country's exports are likely to increase significantly; however, there is also inflation risk due to high prices of imported goods. The concept of equilibrium exchange rate (EER) is very helpful on this issue. Equilibrium exchange rate is defined in terms of the real exchange rate, that combines measures of domestic and foreign prices with the nominal exchange rate. Equilibrium exchange rate can be thought of as a weak, however steady attractor for the actual exchange rate, that pulls the actual exchange rate towards it. Taking into account that equilibrium exchange rate is not directly observable, it is necessary to estimate the equilibrium exchange rate with appropriate models.

From the economic policy-makers point of view, calculation of the equilibrium exchange rates is crucial for several reasons. First, many countries that have acceded to the European Union need to know the appropriate exchange rate for entering the Euro zone (Kim, Korhonen, 2005). Second, sharp falls and increases in the values of certain currencies, for example Swiss franc's recent appreciation, generated a debate about the correct pricing of the currencies (Reynard, 2008). More precisely, the question is whether the appreciation of the currency implies that there is a movement in an underlying equilibrium, and, thus, the currency is correctly priced, or the currency appreciation rather represents currency misalignment. The exchange rate misalignment is defined as the difference between the current real effective exchange rate (REER) and equilibrium exchange rate.[1] Third, the behavior of some currencies, such as euro depreciation in 1999 or sterling appreciation in late 1990s, has raised among researchers a question: "Do these movements represent changes in the underlying equilibriums, and, thus, imply that the currencies are correctly priced, or rather indicate misalignments?" (MacDonald and Dias, 2007).[2] In order to answer all these questions equilibrium exchange rate needs to be estimated.

The growing amount of empirical and theoretical literature devoted to estimation of equilibrium exchange rates has most often applied two methods: fundamental equilibrium exchange rates (FEERs) and behavioral equilibrium exchange rates (BEERs). The FEER is defined as a level of real exchange rate, which is consistent with attaining internal and external equilibrium simultaneously. Most of the researches define the external

[1] REER is defined as the weighted average of the country's currency relative to a basket of its main trading partners' currencies adjusted for the effects of inflation.

[2] In this Master thesis not bilateral, but real effective exchange rate is used in analysis and estimations.

equilibrium as the current account equal to its exogenously set target. At the same time they define the internal equilibrium as closed output gap (successful policy of inflation targeting) (Hallet, Richter, 2004). The FEER is typically estimated using a complete macroeconomic model or a partial equilibrium model. The BEER is described in the following section.

The Master thesis will focus on Lithuania and Switzerland. Regarding Lithuania, it has already joined the Exchange Rate Mechanism II (ERM II),[3] it has a currency board with a tight peg to the euro as exchange rate policy, and is on the verge of adopting the euro. Given that Lithuania still has to undergo the catching-up process, getting the rate wrong could have very serious negative implications, as it was mentioned before. Thus, it is very important to estimate the equilibrium exchange rate for this country. With regards to Switzerland, it is also a small open economy. Reynard (2008) argues that some factors, such as a relative increase in Swiss domestic productivity, higher oil prices and the launch of the euro project in 1999 have modified the Swiss franc's behavior. Moreover, Switzerland's case is special in a sense that after a strong Swiss franc's appreciation in 2011 the Swiss National Bank unprecedentedly announced that it would do everything within its power to defend a minimum exchange rate of 1.20 Swiss francs to the euro. While there is a great uncertainty regarding the franc's equilibrium exchange rate, the current exchange rate floor may be too high. In case the exchange rate floor would appear to be too high, it would bring significant costs for the economy. The Swiss National Bank may need to significantly increase money supply in order to meet increasing demand for the franc. As a result, adjustment of the real exchange rate towards equilibrium would happen via adjustment in prices, which could involve significant macroeconomic costs, including the harm for the inflation stability. Thus, it is necessary to correctly estimate the equilibrium exchange rate for the Swiss franc and to indicate the suggestions for macroeconomic policy makers.

The thesis is structured as follows. In section 2 the literature review is presented. In section 3 the semi-structural model and its results are presented and discussed. In section 4 behavioural equilibrium exchange rate method is applied, the cointegration relationship is estimated and results are discussed. In section 5 equilibrium exchange rate based on SVAR model is estimated and the results are examined. Finally, in section 6 conclusions are provided.

### 1.2. Central research questions and hypotheses

The Master Thesis tries to find an answer to a number of questions about exchange rates for the countries under consideration.[4]

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[3] Participation in the ERM II is a prerequisite for joining the euro area. The ERM II requirement is to keep the exchange rate against the euro within a corridor of +/-15%.

[4] Separate research questions are formulated for the countries under consideration due to the diferences in formulation of hypotheses and their implications, because Switzerland has floating exchange rate regime and Lithuania has fixed exchange rate regime. Moreover, the countries have different historical experiences in economic developments over time spans under consideration.

1) Research question for Switzerland: Are empirical observations in line with theory of floating exchange rate regime in Switzerland? Research question for Lithuania: Are empirical observations in line with theory of fixed exchange rate regime in Lithuania?
2) Research question for Switzerland: Do all of the variables, comprising productivity differential, openness to trade differential, commodity terms of trade, net foreign assets and fiscal balance to GDP differential, have impact on the equilibrium exchange rate in Switzerland? Research question for Lithuania: Do all of the variables, comprising productivity differential, openness to trade differential, commodity terms of trade, net foreign assets and fiscal balance to GDP differential, have impact on the equilibrium exchange rate in Lithuania?
3) Research question for Switzerland: Is the real exchange rate overvalued, undervalued or at the equilibrium in 2009 in Switzerland? Research question for Lithuania: Is the real exchange rate overvalued, undervalued or at the equilibrium in 2009 in Lithuania?
4) Research question for Switzerland: Is the REER affected by the demand shock, nominal shock or supply shock in Switzerland in the long run? Research question for Lithuania: Is the REER affected by the demand shock, nominal shock or supply shock in Lithuania in the long run?

Based on the research questions the following null and alternative hypotheses are formulated.

1) Null hypothesis for Switzerland: Empirical observations are in line with theory of floating exchange rate regime in Switzerland. Alternative hypothesis for Switzerland: Empirical observations are not in line with theory of floating exchange rate regime in Switzerland. Null hypothesis for Lithuania: Empirical observations are in line with theory of fixed exchange rate regime in Lithuania. Alternative hypothesis for Lithuania: Empirical observations are not in line with theory of fixed exchange rate regime in Lithuania.
2) Null hypothesis for Switzerland: All of the variables, comprising productivity differential, openness to trade differential, commodity terms of trade, net foreign assets and fiscal balance to GDP differential, have impact on the equilibrium exchange rate in Switzerland.[5] Alternative hypothesis for Switzerland: Not all of the variables, comprising productivity differential, openness to trade differential, commodity terms of trade, net foreign assets and fiscal balance to GDP differential, have impact on the equilibrium exchange rate in Switzerland. Null hypothesis for Lithuania: All of the variables, comprising productivity differential, openness to trade differential, commodity terms of trade, net foreign assets and fiscal balance to GDP differential, have impact on the equilibrium exchange rate in Lithuania. Alternative hypothesis for Lithuania: Not all of the variables, comprising productivity differential, openness to trade differential, commodity terms of trade, net foreign assets and fiscal balance to GDP differential, have impact on the equilibrium exchange rate in Lithuania.

[5] The statistical significance of the regression coefficients implies that there is a relationship between the variables under consideration.

3) Null hypothesis for Switzerland: Real exchange rate is overvalued in 2009 in Switzerland. Alternative hypothesis for Switzerland: Real exchange rate is undervalued or at the equilibrium in 2009 in Switzerland. Null hypothesis for Lithuania: Real exchange rate is overvalued in 2009 in Lithuania. Alternative hypothesis for Lithuania: Real exchange rate is undervalued or at the equilibrium in 2009 in Lithuania.
4) Null hypothesis for Switzerland: The REER is affected by the nominal shock in Switzerland in the long run. Alternative hypothesis for Switzerland: The REER is affected by the demand shock or supply shock in Switzerland in the long run. Null hypothesis for Lithuania: The REER is affected by the demand shock in Lithuania in the long run. Alternative hypothesis for Lithuania: The REER is affected by the nominal shock or supply shock in Lithuania in the long run.

### 1.3. Aims and objectives

This section shortly explains the aims and objectives of the Master Thesis with respect to the methodologies chosen. Quantitative research methodology is applied in the Master Thesis in order to answer the research questions and check the hypotheses by employing econometric models. In order to answer the first research question and to investigate the relationship between major macroeconomic variables, the semi-structural econometric model is estimated for Lithuania and Switzerland. A semi-structural econometric model, that includes the Phillips curve, the IS curve and the equation for changes in the nominal effective exchange rate, is based on regression analysis. The standard backward-looking Phillips curve is estimated and shows whether output gap, REER or inflation's value in the previous period is the main determinant of inflation. The IS curve is estimated and shows whether output gap's value in the previous period, REER, real interest rate or the growth rate of Euro area imports is the main determinant of the changes in output gap. The equation for changes in the nominal effective exchange rate is estimated and shows if the NEER's value in the previous period, inflation or output gap is the main determinant of NEER. The main determinants of the variables considered are determined according to statistical significance of their coefficients in the econometric model. Estimations of these three equations enable comparing the macrodynamics of the main macroeconomic variables in Switzerland, a representative of the floating exchange rate regime, and Lithuania, a representative of the fixed exchange rate regime.

In order to answer the second and the third research questions, the BEER methodology, proposed by Clark and MacDonald (1998), is used in this Master Thesis. The BEER method is seen as statistical way to estimate the equilibrium real exchange rate's behavior. In comparison to the other methods, the quantitative BEER method imposes no certain conditions on the structure of the relationship, usually uses cointegration econometric technique to find long run relationships, and, thus, provides direct estimations of the equilibrium exchange rate and exchange rate misalignment.

In order to answer the fourth research question, structural vector autoregression (SVAR) model is constructed using real exchange rate, GDP deflator and output relative to the main trading partners. SVAR model enables

finding which shock is the main driving force for the movements in the REER. Moreover, this method helps to see the impulse responses of the variables considered to the demand, nominal and supply shocks (Sims, 1980). In addition, SVAR model provides with the estimate of the EER, represented as accumulated demand and supply shocks. The data is taken from the Swiss National Bank, Bank of Lithuania and Eurostat.

## 2. Literature review

In this section, a number of models describing the behaviour of exchange rate at different time horizons are considered. Namely, monetary models, capital enhanced equilibrium exchange rates, intermediate-term model-based equilibrium exchange rates, as well as BEERs have been developed for looking at the short-run exchange rate movements. FEERs and desired equilibrium exchange rates are intended for discussing the medium-run exchange rate movements. Finally, permanent equilibrium exchange rates and natural real exchange rates are used for explaining the long-run exchange rate movements.

### 2.1. Short-run exchange rate movements

Short run equilibrium exchange rate is the exchange rate, whose fundamental determinants are at their current settings after the impact of random disturbances is abstracted.[6] Equation 1 illustrates the short run equilibrium exchange rate:

$$e_t^s = ß * Z_t + \varphi * T_t, \quad (1)$$

where $e_t^s$ is a short run equilibrium exchange rate at time t, ß is a vector of coefficients, $Z_t$ is a vector of economic fundamentals at time t, $\varphi$ is a vector of coefficients, and $T_t$ is a vector of transitory factors which have an effect on exchange rate in the short term. Short run exchange rate relates to the actual value of fundamentals, not their equilibrium values (for example, trend output), thus, in case the economy is not in equilibrium in the short run, the exchange rate moves to enable the markets to deal with this. Williamson (1983) calls the short run equilibrium exchange rate as the current equilibrium exchange rate.

#### 2.1.1. Monetary models

Monetary method to determine exchange rates is a direct extension of purchasing power parity (PPP). PPP states that the law of one price for prices of the goods holds across countries. PPP exchange rates, which are defined as the exchange rates at which domestic purchasing powers of countries are the same, are not very good measures of exchange rates due to the fact that non-traded and traded goods' prices can be very different across countries. In its relative version PPP requires that inflation differentials between two countries are equal to changes in the nominal exchange rates. The underlying notion is that deviations from parity create profitable commodity arbitrage opportunities, which, if exploited, bring the exchange rate towards parity. Nevertheless, most of the studies find that the movement of the exchange rate to the PPP equilibrium is very slow (Rogoff, 1996).

Monetary method establishes a theoretical link between the nominal exchange rate and a set of monetary fundamentals. The main notion is that nominal exchange rate is influenced by both assets and goods markets.

[6] Changes in fundamental variables (determinants) are defined as macroeconomic variables, which determine changes in the exchange rate.

Monetary method builds on a number of theoretical concepts, namely perfect capital substitutability and uncovered interest parity (UIP).

Uncovered interest parity condition equalizes the predictable risk-adjusted nominal rate of return on the foreign and domestic currency assets. It is also possible to express the UIP condition in real terms. Equation 2 illustrates this:

$$e_t=E_te_{t+1}+r_t-r_t^*+\delta_t, \quad (2)$$

where $e_t$ is the real exchange rate indicating how many units of foreign currency can be bought with one unit of domestic currency at time t, $E_t$ is the expectations operator showing the expectated value of a variable taken at time t, $e_{t+1}$ is the real exchange rate for one period, $r_t$ is domestic ex-ante real interest rate at time t, $r_t^*$ is foreign ex-ante real interest rate at time t, $\delta_t$ is the foreign currency risk premium, potentially time varying, at time t. If the risk premium is assumed to be zero and domestic interest rates are higher than foreign interest rates, it is expected that the domestic exchange rate will depreciate against the foreign exchange rate so that investors would be indifferent between holding domestic and foreign assets. However, UIP condition ties down only the rate of change of the real exchange rate, not the level of the real exchange rate. In addition, risk premia is not observable. Moreover, general expectations about the exchange rates in the future are not available, and their measures are not sufficiently accurate to be matched to real time interest rate differentials. For example, Lewis (1995) shows that interest rate differentials often do not explain ex-post changes in the exchange rates.

While both perfect capital substitutability and UIP have to hold, the exact model depends on the assumptions about the price adjustment. According to Frenkel (1976), monetarist model assumes that prices are flexible and PPP holds continuously. At the same time, overshooting model assumes that prices are sticky and PPP holds only in the long run (Dornbusch, 1976). Portfolio balance method assumes that there is imperfect substitutability of capital, thus UIP condition holds only when the risk premium is added.

The monetary method states that the movement of nominal exchange rate is driven by the excess supply of money, output and nominal interest rate in the local economy relative to the foreign economy. Equation 3 illustrates this:

$$e_t=(m_t-m_t^*)-\alpha_1(y_t-y_t^*)-\alpha_2(i_t-i_t^*), \quad (3)$$

where $e_t$ is the nominal exchange rate, $m_t$ is domestic money supply, $m_t$* is foreign money supply, $\alpha_1$ is a coefficient that is expected to be bigger than zero, $y_t$ is domestic real income, $y_t$* is foreign real income, $\alpha_2$ is a coefficient that is expected to be bigger than zero, $i_t$ is domestic nominal interest rate and $i_t$* is foreign nominal interest rate. All variables except for the interest rates are in natural logarithms. Within this framework an increase in domestic interest rates leads to a decrease in the exchange rate (depreciation of domestic currency), even though domestic assets become more attractive. This happens because a hike in the interest rates decreases demand for domestic currency, in such a way, generating excess supply of money. As a consequence, in order to restore money market equilibrium prices must rise, and depreciation is needed for PPP to hold. Still, the assumption that PPP holds continuously implies that the monetary model of exchange rate setting cannot

generate or explain changes in the real exchange rates if, for example, there is a sustained relative productivity shock. Moreover, monetary model does not take into account the dynamics of assets accumulation. The same also applies to the long-run behavior of the overshooting model.

At the same time portfolio balance method considers the dynamics of the asset accumulation in determining the equilibrium exchange rate. The exchange rate is determined by the supply and demand of financial assets.

2.1.2. Capital enhanced equilibrium exchange rates

CHEERs method to calculation of the equilibrium exchange rate is based on the combination of PPP theory with the UIP condition. MacDonald (2000) uses the PPP theory with UIP condition to calculate the equilibrium exchange rate. This equilibrium exchange rate is called CHEER. CHEER method uses UIP condition, but excludes risk premia by assuming that, if PPP holds, the expected value of the nominal exchange rate can be predicted by the use of relative prices. According to the CHEER method the cointegrating relationship between nominal interest rate differentials, nominal exchange rate and relative prices is estimated.

2.1.3. Intermediate-term model-based equilibrium exchange rates

Wadhwani (1999) suggests ITMEER, which is based on the UIP condition. UIP condition includes risk premium and the risk premium consists of two components. The first component is included in the model by assuming that risk is a function of the deviation in the real exchange rate from the equilibrium level. Equilibrium is assumed to be a function of the relative net foreign assets, relative current accounts and relative unemployment to GDP ratios, as well as relative ratio of wholesale to retail prices. The second component is included in the model by assuming that it is made up of returns on stocks and bonds in order to help to explain the exchange rate movements. All assets should be priced off the same combination of the underlying risks in such a way enabling to predict excess currency returns. Both the first and the second components employ the actual levels of the variables. However, unless the equilibrium related to these variables is constant, actual levels of the variables are an imperfect proxy of disequilibrium. Moreover, in contrast to other methods to estimate equilibrium exchange rates, ITMEER method does not apply cointegration analysis. However, while the method mainly tries to predict nominal rather than real exchange rate changes, it has been relatively successful.

2.1.4. Behavioral equilibrium exchange rates

Clark and MacDonald (1998) proposed a new methodology for estimating EER. This method is called BEER. BEER method is based on employing a modeling technique that captures the fluctuations in real exchange rates over time, not only the moves in long run or medium run equilibrium exchange rate level. In addition, the BEER method is empirical and allows capturing the short run equilibrium exchange rate concepts. BEER method is based on the UIP condition and is adjusted for the time varying risk premium. Risk premium is usually proxied as the ratio of outstanding domestic government debt as a percentage of domestic GDP to outstanding foreign government debt as a percentage of foreign GDP. Nevertheless, UIP condition lacks observed expectations of the levels of the real exchange rates in the future and, thus, Clark and MacDonald (1998) assume that expected exchange rates in the future are connected to the long run fundamentals,

represented by these variables: net foreign assets as a ratio of gross national product, ratio of the unit value of exports to the unit value of imports, the relative price of traded to non-traded goods. All of these variables are estimated relative to their foreign counterparts. Thus, BEER method estimates the relationship between the real exchange rate and the following variables: function of real interest rate differentials, ratio of the unit value of exports to the unit value of imports, the relative price of traded to non-traded goods and the net foreign assets as a ratio of gross national product (GNP). The functional forms or links are determined not by economic theory, but by data.

2.2. Medium-run exchange rate movements

The medium run equilibrium exchange rate is the exchange rate, which holds when the economy is both at internal and external balance.

The internal balance is achieved when the economy is running at normal capacity and demand is at the level of supply potential. The external balance occurs when the rest of the world from the point of view of domestic economy is at the internal balance. Nevertheless, it must be taken into consideration that not the current account of each economy in the world has to be equal to zero, but rather the current account of the balance of payments of each economy in the world has to be at sustainable level in a sense that it is consistent with eventual convergence to the stock-flow equilibrium. It is important to note that, as the real exchange rate is converging to the long run stock flow equilibrium, domestic real interest rates are converging to the world levels. Thus, the medium run exchange rate equilibrium is in particular important in the models with real inflexibilities.

Taking into account that the nominal inertia is depleted from the system, medium run equilibrium exchange rate can be considered as a flexible price equilibrium that is independent of monetary policy. The reason for this is that the equilibrium is defined in real terms of the variables, which the monetary policy is not able to affect, if assumption of superneutrality holds.

Equation 4 illustrates the medium run equilibrium exchange rate:

$$e_t^m = ß * Y_t, \quad (4)$$

where $e_t^m$ is a medium term equilibrium exchange rate at time t, ß is a vector of coefficients, $Y_t$ is a vector of economic fundamentals being at their trend values at time t. Thus, the medium term equilibrium exchange rate is consistent with fundamentals being at their trend values, but fundamentals may be moving towards long run steady state.

2.2.1. Fundamental equilibrium exchange rates

A straightforward way to determine the equilibrium exchange rate for a small and open economy is in terms of the sustainability of its current account which prevents an explosion of external debt. While the Balassa-Samuelson framework recognizes the external sustainability issue by emphasizing that appreciation of the real exchange rate should go in line with according productivity gains to maintain the competitiveness of exports, it is straightforward to show that other factors, such as fiscal policy, determinants of the savings and investment or real interest rate, also play a significant role in external debt and current account sustainability.

The theory of equilibrium real exchange rate based on external sustainability was first mentioned by Nurkse (1949), then it was extended by Artus (1978), and finally it was popularized by Williamson (1994). Williamson (1994) defined the FEER as the real effective exchange rate that secures external and internal balance for a country, or even for a number of countries, at the same time. Internal balance is achieved when the economy operates at the full capacity output and the inflation is low. At the same time, the external balance is achieved when the balance of payments is in a sustainable position over the medium term, in such a way ensuring sustainability of the external debt.

There are two important factors that have to be addressed when measuring the FEER, namely determination of potential output growth in line with low inflation, and the sustainability of the current account position.

Regarding the determination of potential output growth in line with low inflation, historical GDP growth can be decomposed statistically into cyclical and trend components by using, for instance, the Beveridge-Nelson decomposition or the Hodrick-Prescott filter. Otherwise, economic theory can be used in order to determine the magnitude of the potential growth.

Regarding the sustainability of the current account position, it can be looked at the current account imbalance and analyzed if it is covered by the opposite and equal capital account imbalance. This enables to conclude whether sustainability of external debt is ensured. Otherwise, it can be looked at the current account in terms of the investment and saving balances. Econometric models are estimated by regressing the current account on a number of explanatory variables, such as the fiscal position, openness, population growth and others. All the fitted values for the current account are then used for interpreting the medium term values of the current account.

FEER can be estimated by using macroeconomic model, imposing the internal and external balance, and solving for the FEER. FEER also can be estimated by focusing on the estimated current account equation and setting it equal to the sustainable capital account. First, the targeted current account position has to be determined. Second, the elasticities of the trade account with respect to the real effective exchange rate, foreign output and domestic output have to be estimated. Third, the change in the REER, which would achieve the targeted current account and place foreign and domestic output on their potential path, has to be estimated. Nevertheless, as it is hardly possible to achieve all the three aims simultaneously, researchers usually assume that internal balance in both foreign and domestic countries is achieved without any aid of the REER. Fourth, the change in the REER, that makes the current account prevailing at the potential output move towards targeted current account, has to be determined. Fifth, the nominal effective equilibrium exchange rate from the equilibrium REER has to be calculated.

Still, in spite of its analytical elegance, the FEER method has some drawbacks.

The first drawback is related to the determination of the appropriate current account, capital account or external debt level. Bussiere and Fratzscher (2004) argue that the estimation of a sustainable current account, capital account or external debt level is surrounded by great uncertainty.

The second drawback is related to the fact that changes in productivity are sometimes not accounted for in this method, but the Balassa-Samuelson hypothesis and the catching up effect is central behind the argument of the equilibrium exchange rate appreciation of transition countries', including Lithuania's, currencies.

The third drawback is related to the estimation of trade elasticities. Often estimated trade elasticities turn out to be equal to zero (Goldstein, Khan, 1985). In addition, Driver and Westaway (2005) note that considering interest payments on the net foreign asset term when estimating the FEER is likely to create a hysteresis. For example, in the initial period the internal and external balance is obtained and the current exchange rate is at the FEER level. If the actual real exchange rate depreciates in the following period, it improves both the country's net foreign assets position and the current account balance. This implies that in the future the real exchange rate, which is consistent with the medium-run capital accumulation, will not be the FEER anymore. Namely, FEER should appreciate in order to squeeze out the net foreign assets' accumulation effects. While the hysteresis effect is a compulsory consequence of looking at the exchange rate as at the medium run concept, taking a stock measure of equilibrium is likely to eliminate this effect.

The fourth drawback is related to the fact that the FEER method does not take into account the theory of exchange rate determination. Barell and Wren-Lewis (1989) show that it is crucial to allow for the revaluation effects through the net foreign asset term in the FEER estimation. It is assumed that a divergence of the actual real exchange rate from the FEER sets in motion forces that eliminate the divergence, however, as the FEER method characterizes the equilibrium position only; the nature of adjustment forces remains unexplained.

2.2.2. Desired equilibrium exchange rates

Bryant (1983) suggests that the equilibrium real effective exchange rate derived from the FEER method can be called desired equilibrium exchange rate, because economy's internal and external balance is captured by the size of targeted sustainable current account.

The calculation of the DEER methodically follows that of the FEER method, and all three estimates of the current account elasticities (with respect to foreign output, domestic output and real exchange rate) have to be calculated. While constructing the DEER its estimates can differ depending on the choices of assumptions regarding the positions of external and internal balances, which impact the underlying elasticities. For example, Bayoumi et al (1994) calculates the DEER by assumption that targeted current account surplus is equal to one percent of GDP. Different assumptions on currency preference shifts can also affect the trade balance and estimates of the key elasticities. In addition, in case trade balance instead of the current account balance is used in the estimation, underlying elasticities also are affected. To sum up, the selections of policy targets or assumptions lead to changes in the level of the DEER eventually.

Still the DEER method can be useful. For instance, various estimates of the DEER are frequently calculated with the aim to generate a number of equilibrium exchange rates under different policy choices and economic circumstances. Thus, this method has proved to be useful in particular in estimating different equilibrium exchange rates under differing sets of hypothetical current account balance or external balance targets.

2.3. Long-run exchange rate movements

A long run equilibrium exchange rate is the exchange rate when stock-flow equilibrium is achieved for all agents in the economy. This can happen in years or even decades. The long run exchange rate equilibrium is achieved when the net wealth is in full stock-flow equilibrium and changes in asset stocks as a percentage of GDP are equal to zero. Milgate (1987) argues that this equilibrium occurs when the economy has reached the point from which there is no endogenous tendency to change. Equation 5 illustrates this:

$$e_t^l = ß * X_t, \quad (5)$$

where $e_t^l$ is a long run equilibrium exchange rate at time t, ß is a vector of coefficients, $X_t$ is a vector of economic fundamentals at their long run values at time t.

2.3.1. Permanent equilibrium exchange rates

When analyzing the BEER, the equilibrium exchange rate is derived based on the prevailing levels of the economic fundamentals and the misalignment is frequently seen as the current misalignment rate. Nevertheless, taking into account that the levels of economic fundamentals can deviate significantly from the sustainable level or long run level, some researchers extend the BEER analysis by estimating the equilibrium level of the exchange rate that is driven by long run sustainable levels of the identified economic fundamentals. This exchange rate is called the PEER. At the same time the difference between the PEER and the actual real exchange rate is called total misalignment.

Decomposing each variable into its permanent and temporary components is a critical step in generating the PEER and researchers apply different techniques in order to generate the PEER. Beveridge-Nelson decompositions, structured vector autoregression estimates and cointegration based PEER estimates are discussed below.

With regards to the Beveridge-Nelson decompositions, decompositions of multivariate and univariate forms have been used by some researchers in order to decompose real exchange rates into temporary and permanent components. For instance, Huizinga (1987) uses univariate Beveridge-Nelson decompositions to extract the permanent components of certain currencies. He concludes that on average around 90% of real exchange rate movements are permanent. Moreover, Cumby and Huizinga (1990) use a multivariate Beveridge-Nelson decomposition based on a small vector autoregression model of the real exchange rate and inflation differential and show that permanent components of certain real exchange rates exhibit significant time variability, however are more stable than the actual real exchange rates at the same time. They argue that sustained and large deviations of real exchange rates from their permanent values are driven by the business cycles. Finally, Clarida and Gali (1994) use both univariate and multivariate Beveridge-Nelson decompositions of the Germany's, Japan's, the Great Britain's and Canada's real exchange rates. They find that on the basis of the univariate results, on average 0.2 percent of the variance in the real exchange rate is transitory and 0.8 percent of the variance in the real exchange rate is permanent. Moreover, they indicate that univariate decompositions can create a very different picture of misalignment in comparison to the multivariate decompositions. This is in

favor of using multivariate methods. Thus, in case the exchange rate model shows that certain fundamentals are potentially important, they must be tested and, if they are statistically significant, used for assessment purposes.

Regarding the structured vector autoregression estimates, Clarida and Gali (1994) use a quite sophisticated way to decompose real exchange rates into temporary and permanent components. More precisely, they suggest decomposing real exchange rates into demand, supply, and nominal components and evaluating which of those components are the most crucial in explaining the variability of real exchange rates. The components denote three shocks in the model: a nominal shock, a demand shock and a supply shock. The identifying restrictions are based on a modified version of the Mundell-Fleming-Dornbusch model. Only supply shock impacts relative output in the long run. Both supply and demand shocks influence the real exchange rate in the long run. And, finally, nominal shock does not influence the relative output and the real exchange rate in the long run. The key finding of the study is that supply shocks explain only a very small share of real exchange rate movements in Canada, Germany, the Great Britain and Japan.

With regards to the cointegration based PEER estimates, contrasting the total misalignment of the PEER and the current misalignment of the BEER helps to identify various sources of misalignments. Policymakers find it crucial to understand if the misalignment has been mainly driven by permanent or temporary shocks from one or more of the determinants. Clark and MacDonald (2000) suggest improving the BEER analysis by constructing the PEER, as PEER method explicitly takes account of possible cointegrating relationships among the relevant variables. They measure PEERs and BEERs for the real effective exchange rates in the United States, Canada and the United Kingdom. According to them, the BEER and the PEER move very closely together for the United States dollar and for the Canadian dollar, while the volatility of the United Kingdom's pound is driven by fluctuations of the permanent component of the real interest rate differential. They conclude that supplementing the BEER method with the PEER decomposition can be of great use for assessment purposes, in particular if the driving fundamentals include crucial transitory elements. In addition, Maseo-Fernandez et al (2002) apply both the PEER and the BEER, and evaluate the equilibrium effective exchange rate of the euro in 1975-1998. They find that the PEER is less volatile than the BEER.

2.3.2. Natural real exchange rates

The concept of the natural real exchange rate was built up by Stein (1994). Similarly to the FEER, sustainable capital account term is assumed to be equal to the social saving less planned investment and speculative capital flows are excluded from the measure of the capital account. As in the FEER method, external balance is synonymous with sustainable current account in the NATREX method. Equation 6 illustrates this:

$$CA(q, k, n)-(S(t, n)-I(w, q, k))=0, \quad (6)$$

where CA is current account, S is saving, I is investment, q is Tobin's ratio, k is capital stock, n is net foreign assets, t is rate of time preference, and w is productivity. Current account is determined by the Tobin's ratio, capital stock, and net foreign assets. Saving is determined by the rate of time preference and net foreign assets. Finally, investment is determined by the productivity, Tobin's ratio and capital stock.

In contrast to the FEER method, NATREX method distinguishes equilibrium exchange rates in the medium run and long run. While external equilibrium is defined in the same way as in the FEER method, internal equilibrium is defined in terms of full capacity utilization.

While both in the long run equilibrium and medium run equilibrium internal balance is assumed to hold, different criterions need to be satisfied for the medium and long run exchange rates to be in equilibrium. With regards to long run equilibrium, a number of criterions have to be satisfied. First, there are neither changes in reserves, nor speculative capital movements. Second, net foreign assets have to be constant and the current account has to be equal to zero in a non-growing economy. Third, the rate of capacity utilization has to be at its stationary mean and the capital stock has to be constant. The main difference between the long run equilibrium exchange rate and the medium run equilibrium exchange rate is related to the development of the capital stock and net foreign assets. While in the medium run the current account can be non-zero if the difference between forecasted savings and forecasted investment is non-zero, this is not the case in the long run. With regards to the long run equilibrium, those imbalances are integrated into the stocks. Stocks drive the whole system to the long run equilibrium and the satisfying of the intertemporal budget constraints.

Stein (1995) shows two cases, which help to understand the difference between medium run real exchange rate and long run real exchange rate. More precisely, he analyzes the case of a decrease in the propensity to save and the case of a rise in productivity.

If there is a decrease in the propensity to save, this leads to a fall in savings and an increase in consumption. As a result, current account balance worsens and foreign debt rises. This results in capital inflows, which cause an appreciation of the real exchange rate, as well as enable to achieve internal and external balance in medium term. However, in long term real exchange rate is expected to depreciate, as higher foreign debt raises interest payments. As a consequence, real exchange rate depreciates and improves the trade balance until net foreign assets stabilize.

If there is a rise in productivity, real exchange rate appreciates in the medium run and this produces a bigger current account deficit and higher foreign debt. However, in contrast to the decrease in the propensity to save, higher productivity implies real exchange rate appreciation in the long run, as capital stock also rises in the medium term. As a result, productivity increases even more and raises the gross domestic product's and, thus, savings' growth. Then foreign debt decreases and the real exchange rate appreciates in the long run in order to counterbalance the improving current account balance. Nevertheless, higher capital stock leads to higher imports, which can offset some of the real exchange rate's appreciation.

What regards the estimation of the NATREX, two issues need to be considered. First, it is essential to select the fundamentals that are able to capture the shocks in productivity and time preference. Second, it is important to choose the most appropriate testing procedure.

In relation to the first issue, some researchers use productivity of labor, which is measured as a ratio of gross domestic product to employment, and other researchers use total factor productivity in order to capture productivity. At the same time household and government consumption over gross domestic product is used in

order to find the time preference. However, taking into consideration that household consumption is very often stationary over a long time period for some countries, some researchers, including Stein and Paladino (1999), as well as Rajan and Siregar (2002) consider only the government consumption over gross domestic product as a proxy for time preference. Other variables that can influence the evolution of debt and capital are chosen by taking into account whether the economy is developed or developing.

In relation to the second issue, there are basically two ways how to test procedures. Many researchers use a single reduced form equation and some of the researchers conduct structural estimations of the NATREX.

# 3. Semistructural economic model of business cycles

In order to answer the first research question for Switzerland and Lithuania in this section semistructural economic models of business cycles is estimated and discussion of results is provided.

## 3.1. Motivation for the semistructural economic model of business cycles

In order to understand the effects of the monetary policy strategy of Swiss National Bank and Bank of Lithuania, simple semi-structural model is estimated for both economies. This model is advantageous over the VAR model, as it enables interpreting the estimated equations. Moreover, nature of the differences between the two economies can be understood. Thus, in order to explore the relationship and causality between main macroeconomic variables, the Philips curve, the IS curve and the equation for changes in the NEER are estimated. To deal with the problem of simultaneity, all regressions are estimated with 2SLS.

## 3.2. Description of the semistructural economic model of business cycles

First, the standard backward-looking open economy's Phillips curve is estimated. Inflation depends on its own lagged value, output gap and real effective exchange rate. Moreover, taking into account that a rise in output gap implies growth in input costs for producers, and, thus, higher inflation, it is also included in the equation 7. REER depreciation (it is defined so that depreciation means a decrease in the exchange rate) is expected to increase prices of imported goods, and, thus, inflation.

While estimating the two-stage least squares regression, the current regressors, except for inflation, are instrumented with their own once-lagged values as well as current euro area inflation rate and 3-month EURIBOR rate.

Second, the standard backward-looking open economy's IS curve is estimated. Output gap depends on its first lag, REER, real interest rate and growth rate of euro area's total imports. To investigate how REER affects output gap, REER is included in the specification. Real interest rate is incorporated in the equation 8, as its increase typically leads to lower investment, and, as a result, contraction in the economy. Growth rate of euro area's total imports enables understanding the changes in the foreign demand for domestic goods, thus Swiss and Lithuanian exports, and, consequently, output gap.

Similarly to Equation 7, current euro area inflation rate, 3-month EURIBOR rate, and once-lagged values of all regressors, except for output gap, are used as instrumental variables.

Third, in order to evaluate changes in the NEER, the third regression is estimated. NEER depends on its first lag, inflation and output gap. Following Gerlach and Gerlach-Kristen (2006) inflation is also included in equation 9. Output gap is included in the model in order to see how it affects the value of domestic currency in Switzerland and Lithuania.

3-month EURIBOR rate, current EU27 inflation rate as well as once-lagged values of current regressors, except for NEER, are used as instrumental variables while estimating the 2SLS regression.

Taking into consideration that not many coefficients appeared to be significant in the initially identified equations, those coefficients, whose signs are in line with theory were selected. In case there were a few more variables with such coefficients, the ones, which had bigger probability of being insignificant, were removed from the TSLS equations.

3.3. Description of the data for the semistructural economic model of business cycles

Quarterly data from the first quarter of 1997 to the third quarter of 2011 for Switzerland and from the first quarter of 1997 to the second quarter of 2011 for Lithuania is used. Precise definitions of variables are given in Table 1.

Table 1. Description of the data for the semistructural economic model of business cycles

| Variable name | Definition | Source |
|---|---|---|
| gap | Detrended logarithm of seasonally adjusted real gross domestic product* | Eurostat |
| inflt | Logarithm of seasonally adjusted annual rate of change of harmonized index of consumer prices (2005=100) in Lithuania | Eurostat |
| infch | Logarithm of seasonally adjusted annual rate of change of inflation in Switzerland | Datastream |
| infea | Logarithm of seasonally adjusted annual rate of change of harmonized index of consumer prices (2005=100) in euro area | Eurostat |
| reer | Detrended logarithm of real effective exchange rate index (1973Q1=100 for Switzerland and 1993Q2=100 for Lithuania) measured against currencies of main trade partners | Bank of Lithuania, Swiss National bank |
| neer | Quarter-on-quarter change in logarithm of nominal effective exchange rate index (1973Q1=100 for Switzerland and 1993Q2=100 for Lithuania) measured against currencies of main trade partners | Bank of Lithuania, Swiss National bank |
| imp | Euro area's total imports quarter-on-quarter growth rate based on seasonally and working day adjusted volume indices (2000=100) | Eurostat |
| realint | Detrended difference between 3-month VILIBOR rate and inflation for Lithuania and detrended difference between 3-month LIBOR rate and inflation for Switzerland* | Datastream, Bank of Lithuania, Eurostat |
| eurib | 3-month EURIBOR rate | Reuters |

Note: *Detrended variables are calculated as the difference between the variable itself and its value calculated by Hodrick-Prescott filter with a smoothing parameter of 1600

3.4. Discussion of results for the semistructural economic model of business cycles

As it is shown in Table 2 and Table 3, results seem plausible for both the first and second specifications both in Switzerland and Lithuania respectively.

Table 2. Two-stage least squares regression results for Switzerland

| | Specification 1 | Specification 2 |
|---|---|---|
| Equation 7 | $infch_t=ß_0+ß_1*infch_{t-1}+ß_2*gap_t+ß_3*reer_t+z_t$ | - |
| $ß_0$ | 0.002 (0.004) | - |
| $ß_1$ | 0.792 (0.438)* | - |
| $ß_2$ | 0.079 (0.187) | - |
| $ß_3$ | -0.008 (0.037) | - |
| $R^2$ | 0.626 | - |
| | Specification 1 | Specification 2 |
| Equation 8 | $gap_t=\alpha_0+\alpha_1*gap_{t-1}+\alpha_2*reer_t+\alpha_3*realint_t+\alpha_4*imp_t+u_t$ | $gap_t=\alpha_0+\alpha_1*gap_{t-1}+\alpha_2*reer_t+\alpha_4*imp_t+u_t$ |
| $\alpha_0$ | -0.002 (0.001) | -0.002 (0.001) |
| $\alpha_1$ | 1.001 (0.090) | 1.005 (0.090)*** |
| $\alpha_2$ | -0.012 (0.057)*** | -0.035 (0.043) |
| $\alpha_3$ | 0.121 (0.201) | - |
| $\alpha_4$ | 0.282 (0.081)*** | 0.282 (0.081)*** |
| $R^2$ | 0.842 | 0.839 |
| | Specification 1 | Specification 2 |
| Equation 9 | $neer_t=\gamma_0+\gamma_1*neer_{t-1}+\gamma_2*infch_t+\gamma_3*gap_t+v_t$ | $neer_t=\gamma_0+\gamma_1*neer_{t-1}+\gamma_2*infch_t+v_t$ |
| $\gamma_0$ | -0.001 (0.007) | -0.001 (0.005) |
| $\gamma_1$ | 1.035 (0.437)** | 1.024 (0.427)** |
| $\gamma_2$ | 0.370 (0.691) | 0.277 (0.514) |
| $\gamma_3$ | -0.069 (0.334) | - |
| $R^2$ | 0.301 | 0.282 |

Note: Standard errors in parenthesis. */**/*** shows significance at 10%/5%/1% level

Table 3. Two-stage least squares regression results for Lithuania

| | Specification 1 | Specification 2 |
|---|---|---|
| Equation 7 | $infl_t=ß_0+ß_1*infl_{t-1}+ß_2*gap_t+ß_3*reer_t+z_t$ | $infl_t=ß_0+ß_1*infl_{t-1}+ß_3*reer_t+z_t$ |
| $ß_0$ | -0.002 (0.007) | -0.002 (0.005) |
| $ß_1$ | 1.084 (0.179)*** | 1.082 (0.118)*** |
| $ß_2$ | -0.002 (0.148) | - |
| $ß_3$ | -0.150 (0.102) | -0.149 (0.080)* |
| $R^2$ | 0.641 | 0.642 |
| | Specification 1 | Specification 2 |
| Equation 8 | $gap_t=\alpha_0+\alpha_1*gap_{t-1}+\alpha_2*reer_t+\alpha_3*realint_t+\alpha_4*imp_t+u_t$ | $gap_t=\alpha_0+\alpha_1*gap_{t-1}+\alpha_2*reer_t+\alpha_4*imp_t+u_t$ |
| $\alpha_0$ | -0.004 (0.006) | -0.005 (0.006) |
| $\alpha_1$ | 1.173 (0.253)*** | 1.217 (0.294)*** |
| $\alpha_2$ | -0.295 (0.582) | 0.005 (0.261) |
| $\alpha_3$ | 0.332 (0.598) | - |
| $\alpha_4$ | 0.929 (1.204) | 1.488 (0.806)* |
| $R^2$ | 0.569 | 0.341 |
| | Specification 1 | Specification 2 |
| Equation 9 | $neer_t=\gamma_0+\gamma_1*neer_{t-1}+\gamma_2*infl_t+\gamma_3*gap_t+v_t$ | $neer_t=\gamma_1*neer_{t-1}+\gamma_2*infl_t+\gamma_3*gap_t+v_t$ |
| $\gamma_0$ | 0.001 (0.010) | - |
| $\gamma_1$ | 1.005 (0.469)** | 1.012 (0.422)** |
| $\gamma_2$ | -0.021 (0.249) | -0.016 (0.234) |
| $\gamma_3$ | 0.093 (0.198) | 0.092 (0.196) |
| $R^2$ | 0.100 | 0.091 |

Note: Standard errors in parenthesis. */**/*** shows significance at 10%/5%/1% level

The first lag of inflation is found to be statistically significant in Equation 7 (Table 2, Table 3). It is statistically significant at 10% significance level in Switzerland and at 1% significance level in Lithuania. The results imply that the dynamics of inflation is very persistent process in both countries. For instance, a rise in inflation by 1% leads to an increase in inflation by 1.08% in Lithuania and by 0.79% in Switzerland in the next period. While no other variables are statistically significant for Switzerland, REER is statistically significant at 10% significance level in the second specification for Lithuania.

Regarding the Phillips curve equation, results can also be compared to those of Elkhoury (2004). Similarly to the first specification, he finds that the total effect of inflation is positive, close to 1 and significant. While he finds that an increase in inflation by 1% leads to an increase in inflation by 0.90% in the next period, the first specification shows that an increase in inflation by 1% leads to an increase in inflation by 0.79% in the next period in Switzerland, which is strikingly similar. He shows that overall effect of the real exchange rate gap is lower in the IS equation than in the Phillips curve, as there is a combined indirect and direct effect of the real

exchange rate on inflation in the Phillips curve. Table 2 and Table 3 shows that the REER coefficients in absolute values for both the first and the second specification in the Phillips curve are lower than in the IS equation, however the coefficient is statistically significant only for the first specification in the IS equation. Results should be taken cautiously.

Equation 8 shows that an increase in output gap leads to a rise in output gap by 1.01% in Switzerland and by 1.17 or 1.22% depending on specification in Lithuania in the next period. Results for both countries are statistically significant at 1% significance level. The growth rate of euro area imports is also statistically significant in both countries. However, it can be observed that an increase in the growth rate of imports of euro area increases output gap by much more in Lithuania than in Switzerland. Namely, a rise in the growth rate of imports of euro area by 1% raises output gap by 1.49% in Lithuania and only by 0.28% in Switzerland. Such a big coefficient for growth rate of euro area imports reveals great Lithuania's dependence on demand in euro area. Moreover, first specification for Switzerland indicates that a rise in REER by 1% leads to a decrease in output gap by 0.01% at 1% significance level due to competitiveness effects. As to coefficients for real interest rates, they are not statistically significant for any of the two economies.

Elkhoury (2004) also estimates the IS equation for Switzerland, however, he uses the multivariate random walk process model and multivariate model with fundamentals. He finds that an increased depreciation of the real exchange rate positively impacts output gap, but this effect tends to be reversed in the second period when the coefficient is significant, negative and of similar size. Thus, taking into account that even though the first specification shows that an increase in REER by 1% leads to a statistically significant decrease in output gap by 0.01% in Switzerland, this effect is very small and, in general, the results are similar to those of Elkhoury (2004).

Equation 9 shows that neither of the parameters are statistically significant, except for NEER, in both Lithuania and Switzerland. Depending on specification a rise in NEER by 1% leads to a rise in NEER by 1.04 or 1.02%, and by 1.01% in Lithuania in the next period. In case of Lithuania, the fixed exchange rate regime does not permit any discretionary policy in response to changes in activity and inflation. Taking into account that theoretically flexible exchange rate regime allows the nominal exchange rate moves to make the effects of economic disturbances less severe, it is surprising that any other coefficient is not statistically significant in the Swiss case.

Results should be interpreted with caution. Nevertheless, while the Lucas critique argues that it is naive to try to predict the effects of adjustments in the economic policy mainly on the basis of relationships observed in highly aggregate historical data, especially when small number of variables is used in the model, it does not seem to matter much empirically in the applied literature (Ericsson, Irons, (1995), Gerlach-Kristen (2005)).

To sum up, the null hypothesis for Lithuania associated to the first research question cannot be rejected – empirical observations are in line with theory of fixed exchange rate regime. However, the null hypothesis associated to the first research question in Switzerland can be rejected – empirical observations are not in line with the theory of floating exchange rate regime.

## 4. Behavioural equilibrium exchange rate method

Proponents of strict PPP argue that the RER should be equal to zero, meaning that the inflation differential at home and abroad is equal to the corresponding change in the nominal exchange rate. However, the existence of constant transaction costs implies that it may only hold up to a constant term. Cassel (1928) proposes modern PPP and recognises that a number of factors, such as transportation costs, interest rate differentials and foreign exchange market intervention, prevent the exchange rate from always being at its PPP value. Thus, most researchers suggest a less restrictive version of PPP, which relies on exchange rate being mean-reverting to its long run equilibrium. To test for mean reversion property, stationarity test can be employed. Stationarity test tests for the null hypothesis of no unit root in the data series, and if it is rejected, it implies that REER is in long run equilibrium. If the variable considered is not in its long run equilibrium, cointegration is the most often used method for analysis. Then the equilibrium values of the variables affecting the REER are determined and main determinants of the REER are identified. Finally, equilibrium value of the REER taking into account the equilibrium values of the variables affecting the REER is calculated and estimates for the misalignment are provided. On the basis of this methodology, the fourth section will serve to answer the second and the third research questions for Lithuania and Switzerland.

### 4.1. Motivation for the equilibrium real exchange rate method

BEER method is seen both as statistical and theoretical way to evaluate the real exchange rate's behavior and it was suggested by Clark and MacDonald (1998). The BEER method imposes no certain conditions on the structure of the relationship between variables, usually uses cointegration to imply long run relationships, and provides direct estimations of the equilibrium exchange rate, and, thus, exchange rate misalignment. So, the BEER is expressed as a function of certain fundamental variables. This method is very flexible, as it enables a number of auxiliary variables to fit the features of specific countries (AlShehabi, Ding, 2008).

Driver and Westaway (2005) argue that BEER can be categorized as current and cyclical equilibrium exchange rate, as its calculation is based on the current values of the fundamental variables. In addition, it can also include variables, which may have a persistent effect on the exchange rate in short run, but wash out over longer period of time. It is possible to achieve transition from the current to the longer term perspective via decomposing the BEER into permanent and transitory components, in such a way deriving the PEER.

### 4.2. Description of the equilibrium exchange rate method

Clark and MacDonald (1998) suggest the following method to estimate the real exchange rate at time t ($q_t$) in Equation 10:

$$q_t=ß_1Z_{1t}+ß_2Z_{2t}+\gamma T_t+\varepsilon_t, \quad (10)$$

where $ß_1$, $ß_2$ and $\gamma$ are the coefficients of the related estimates, $Z_{1t}$ is an estimate of the economic fundamentals which are likely to constantly affect the real effective exchange rate at time t, $Z_{2t}$ is an estimate of the

fundamental determinants which are expected to impact the real effective exchange rate in the medium term at time t, $T_t$ is an estimate of transitory aspects which affect the real effective exchange rate at time t, $\varepsilon_t$ is a random residual term. Thus, the real equilibrium exchange rate can be decomposed into transitory, medium run and long run components.

Equation 11 defines the medium run (current) equilibrium real effective exchange rate at time t ($q_{ct}$):

$$q_{ct}=ß_1Z_{1t}+ß_2Z_{2t} \quad (11)$$

It is the value of the real exchange rate when transitory components are equal to zero.

Equation 12 illustrates the long run equilibrium real effective exchange rate at time t ($q_{lt}$):

$$q_{lt}=ß_1\overline{Z}_{1t}+ß_2\overline{Z}_{2t}, \quad (12)$$

where $\overline{Z}_{1t}$ is a long-term level of the estimate of the economic fundamentals which are likely to constantly affect the real effective exchange rate at time t, $\overline{Z}_{2t}$ is a long-term level of the estimate of the fundamental determinants which are expected to impact the real effective exchange rate in the medium term at time t. Thus, the long run equilibrium exchange rate is reached when the fundamentals are at their long run values.

As a consequence, current real effective exchange rate misalignment at time t ($cm_{ct}$) can be calculated by Equation 13:

$$cm_{ct}=q_t-q_{ct}=\gamma T_t+\varepsilon_t \quad (13)$$

The current real effective exchange rate misalignment is the sum of the random and transitory errors.

As the current measures of economic fundamentals can be different from the sustainable levels, Clark and MacDonald (1998) calculate the total misalignment of the real effective exchange rate at time t ($tm_{tt}$) in Equation 14:

$$tm_{tt}=q_t-q_{lt}=\gamma T_t+\varepsilon_t+ß_1(Z_{1t}-\overline{Z}_{1t})+ ß_2(Z_{2t}-\overline{Z}_{2t}) \quad (14)$$

The total misalignment of the real effective exchange rate can be decomposed to the effect of the random disturbances, transitory factors, and the extent to which economic fundamentals are away from their sustainable values.

4.3. Influences on the equilibrium exchange rate

A simple and very general model can describe determinants of the equilibrium REER (Wren-Lewis, 2003). Equation 15 illustrates the national income identity:

$$Y(K(\ldots))=C+G+\Delta K+X(Y_w, e)-M(Y_d, e), \quad (15)$$

where Y is domestic output, C is consumers' expenditure, G is government spending, K is capital stock, X is exports which depend on world demand $Y_w$ and the real exchange rate e, M is imports which depend on domestic output $Y_d$ and the real exchange rate. Each variable is expressed in real terms.

Government spending (G) is assumed to be devoted to domestic goods only, and labor supply is assumed to be fixed. Consumption (C) and capital demand ($\Delta K$) determination is not specified. Equating the demand and supply of goods in such a way turns this identity into the behavioral equation. This equation shows why the real exchange rate can be seen as equating aggregate demand and supply.

The private sector budget constraint is illustrated in Equation 16:

$$\Delta(F+B+K)=Y-T-C+r(F+B), \quad (16)$$

where F are overseas financial assets assumed to be denominated in domestic currency, B is government debt, T denotes taxes, and r is the return on all assets.

The government's budget constraint is shown in Equation 17:

$$\Delta B=G-T+rB, \quad (17)$$

The combination of Equation 15, Equation 16 and Equation 17 gives the balance of payments identity in Equation 18:

$$\Delta F=X(Yw, e)-M(Yd, e)+rF \quad (18)$$

Using this balance of payments identity helps to describe the equilibrium real exchange rate (ERER) as the exchange rate that delivers the particular current account and it is exactly the same as the exchange rate which equates the demand for goods and supply for goods in Equation 15.

Equations 15-18 suggest a number of possible determinants of the ERER. First, a fall in the world demand that is not matched by a decrease in the domestic supply, would decrease the demand for domestic output, and, thus, the currency would depreciate to offset this. Second, a rise in the domestic supply, which does not occur overseas, would result in price reduction and thus in the depreciation of the ERER (Wren-Lewis, 2003).

### 4.4. Determinants of equilibrium real exchange rate

Empirical studies use a variety of different possible determinants of ERER, but the most commonly used are summarized in this subsection.

- Net foreign assets

If a country is in debtors` position, then net interest payments, compensated for by improved trade balance, should be paid for accumulated foreign liabilities. It requires for strengthening the international price competitiveness and thus more depreciated country`s currency. On the contrary countries which are in creditors` position can maintain more appreciated currencies and run a trade deficit (Bussiere et al, 2003).

- Fiscal balance

An increase in the budget balance, associated with restrictive fiscal policies, leads to a rise in national savings, weaker domestic demand and, thus, currency depreciation in real terms. Conversely expansionary fiscal policy bringing about deterioration of budget balances ends up in stronger domestic demand and currency appreciation. Crucial assumption behind these developments is an absence of so called Ricardian equivalence, when households undo the effects of fiscal policy by decreasing/increasing private savings (Ahmed, 1986).

- Productivity differential

The effect of the productivity differential on the real exchange rate is expected to follow the Balassa-Samuelson theory, which states that if productivity in the tradables sector grows faster than in the non-tradables sector, the resulting higher wages in the tradables sector put upward pressure on wages in the non-tradables sector, leading to higher relative prices of non-tradables and, thus, real appreciation (Balassa, 1964; Samuelson 1964).

- Investments ratio to GDP

The ratio of investment to GDP is expected to capture the technological progress. Higher investments ratio is expected to raise productivity leading to real appreciation of a currency. On the other hand the effect on the real exchange rate can be ambiguous as an increase in investments may occur via a rise in imports and, thus, negatively impact the trade balance and REER (Glick, Rogoff, 1995).

- Terms of trade

It is expected that higher terms of trade (ratio of export prices to import prices) should lead to real exchange rate appreciation via real income effect. An improvement in the terms of trade leads to higher income and stronger demand for non-tradables while deterioration in a country's terms of trade leads to weaker demand and currency depreciation (IMF, 2006; Bussiere et al, 2010).

- Openness to trade

Countries with higher total trade-to-GDP ratio (proxy for openness to international trade) are subject to tougher competition in international markets and smaller prices of tradables in the domestic market. This leads to more depreciated currencies. Conversely, higher non-tariff barriers and import tariffs to the cross-border trade, which are designed to protect domestically produced goods from the foreign competition, are expected to lower country`s openness to trade, increase domestic prices and lead to real appreciation of a currency (Bussiere et al, 2010).

- Government consumption to GDP

An increase in government consumption biased toward nontradables as a ratio of GDP is likely to increase the relative prices of nontradable goods and lead to real exchange rate appreciation (De Gregorio et al, 1994).

### 4.5. Description of the data for the equilibrium real exchange rate method

Quarterly data on productivity, openness to trade, terms of trade, net foreign assets, investment to GDP ratio, REER, government consumption to GDP ratio and fiscal balance to GDP ratio is collected not only for Switzerland, but also for 14 its main trading partners in the Euro area, including Belgium, Germany, France, Italy, Netherlands, Finland, Ireland, Greece, Luxembourg, Austria, Portugal, Slovenia and Slovakia from the first quarter of 2000 to the first quarter of 2010. Same data is collected not only for Lithuania, but also for seven its main trading partners in the Euro area, including Belgium, Germany, Estonia, France, Italy, Netherlands and Finland from the first quarter of 1999 to the first quarter of 2010. The weights of the main trading partners used in the REER calculations are received from the representatives in the Swiss National Bank and Bank of Lithuania accordingly.

In this Thesis quarterly data covering the period from the first quarter of 2000 to the first quarter of 2010 is used for Switzerland. Accordingly, quarterly data covering the period from the first quarter of 1999 to the first quarter of 2010 is used for Lithuania. The choice of the period is dictated by the availability of the data for the weights of the main euro area trading partners that are used in the REER calculations. Most variables (except for net foreign assets and terms of trade) are calculated as deviations from respective weighted average values

for Switzerland`s and Lithuania's main trading partners. Net foreign assets and terms of trade cannot be calculated against main trading partners by definition. Fiscal balance to GDP ratio and openness to trade are seasonally adjusted by Census X12. Precise definitions of the variables can be found in Table 4.

Table 4. Description of the data for the equilibrium real exchange rate method

| Variable | Definition | Source |
|---|---|---|
| Productivity differential | This variable is defined as the logarithm of the ratio of output per employee in tradables and non-tradables sector in Switzerland/Lithuania, constructed on the basis of six-sector classification of output and employment, relative to product of weighted productivity of Switzerland's/Lithuania's main trading partners. Due to unavailability of other type of data, employment is measured in 1000s of jobs in Switzerland. In all other countries it is measured in 1000s of persons employed. | Eurostat |
| Commodity terms of trade | This variable is defined as a product of the ratios of weighted averages of the main commodity export prices to weighted averages of the main commodity import prices. The commodities considered include food, beverages, agricultural raw materials, metals and energy. The weights reflect the share of particular commodity in Switzerland's/Lithuania's total exports and total imports accordingly. All of the commodity prices are estimated relative to the price of manufacturing exports of advanced countries based on IMF methodology. | World Bank, IMF, Eurostat |
| Openness to trade differential | This variable is defined as the difference between the openness (exports and imports) to GDP in Switzerland/Lithuania and the openness to GDP of the main Switzerland's/Lithuania's trading partners. The variable is seasonally adjusted. | Eurostat |
| REER | This variable is defined as the logarithm of the REER index (1973Q1=100) against 14 main Switzerland's trading partners in the euro area. Similarly this variable is defined as the logarithm of the REER index (1993Q2=100) against seven main Lithuania's trading partners in the euro area. | Swiss National Bank, Bank of Lithuania |
| Net foreign assets | Switzerland's/Lithuania's international investment position is scaled by the sum of exports and imports. | Swiss National bank, Federal Customs Administration, Statistics Bureau of Lithuania, Eurostat |
| Fiscal balance to GDP differential | This variable is defined as the difference between the ratio of the general government budget balance to GDP in Switzerland/Lithuania and the weighted average of the budget balance of the main Switzerland's/Lithuania's trading partners. Switzerland's data for budget | Eurostat, Swiss Statistics Bureau |

| | | |
|---|---|---|
| | deficit (as % of GDP) is interpolated from annual to quarterly data series using cubic match last low to high frequency method. The variable is seasonally adjusted. | |
| Investment to GDP differential | This variable is defined as the difference between the ratio of investment as a share of GDP in Switzerland/Lithuania and the weighted average of investment as a share of GDP of the main Switzerland's/Lithuania's trading partners. | Eurostat |
| Government consumption to GDP differential | This variable is defined as the difference between the ratio of the government consumption to GDP in Switzerland/Lithuania and the weighted average of the government consumption to GDP of the main Switzerland's/Lithuania's trading partners. | Eurostat |

4.6. Stationarity tests

To check if the REER has a mean reversion property, REER, as well as its fundamental determinants, is tested for the unit root. If the null hypothesis of the unit root is not rejected, it cannot be argued that the REER has a mean reversion property. For testing the time series data for non-stationarity, a set of unit root tests, including Augmented Dickey-Fuller (ADF) test, Dickey Fuller GLS (DFGLS) test and Phillips-Perron (PP) test, are employed. The DF-GLS test supposedly improves on the lower power of the conventional ADF test in finite samples (Elliot et al, 1996). Testing the null hypothesis using an ADF, ADF-GLS and PP tests, is tantamount to a test for a single unit root (nonstationarity) in the data-generating process and implies no long run equilibrium. Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test is also employed to check the null hypothesis of stationarity in the data series. Results for the unit root tests for all variables both in levels and in first differences for Swiss data are provided in Table 5, whereas results for unit root tests for Lithuanian data for all variables both in levels and in first differences are provided in Table 6.

Regarding Swiss data, while according to the KPSS test for the REER results are mixed, according to ADF, DFGLS and PP tests in most cases the null hypothesis of a unit root cannot be rejected (Table 5). More precisely the null hypothesis can be rejected in all cases for data in differences, but cannot be rejected in any case for data in levels according to ADF, DFGLS and PP tests. Thus, the REER is non-stationary in levels, but stationary in differences. This implies that the REER does not have mean-reverting property. Turning to REER determinants there is no robust evidence of their stationarity as shown by the results of the ADF, ADFGLS, PP and KPSS tests. For example, productivity differential, commodity terms of trade, openness to trade, net foreign assets, fiscal balance to GDP differential and investment differential seem to be stationary in differences according to ADF, DFGLS, PP and KPSS tests, however, the results are mixed for the variables in levels. More precisely, for all the variables in the first differences the null hypothesis of a unit root can be rejected according to ADF, DFGLS and PP tests.

Table 5. Results of the unit root tests for Swiss data

| | Test for unit root in | Included in test equation | ADF | DFGLS | PP | KPSS |
|---|---|---|---|---|---|---|
| REER, in logs | Level | Intercept | 2.25 | 2.08 | 1.76 | 00.31 |
| | | Trend and intercept | 1.36 | 0.14 | 0.99 | 0.15** |
| | | None | 1.90 | - | 1.44 | - |
| | 1st difference | Intercept | -4.74*** | -4.76*** | -4.82*** | 0.42* |
| | | None | -4.46*** | - | -4.57*** | - |
| Producti-vity differential | Level | Intercept | -0.96 | -0.73 | -0.89 | 0.50** |
| | | Trend and intercept | -1.92 | -2.01 | -2.04 | 0.12* |
| | | None | -1.02 | - | -1.10 | - |
| | 1st difference | Intercept | -6.12*** | -3.53*** | -6.17*** | 0.14 |
| | | None | -5.91*** | - | -5.92*** | - |
| Commodity terms of trade | Level | Intercept | -0.37 | -0.17 | -0.45 | 0.81*** |
| | | Trend and intercept | -2.66 | -2.56 | -2.18 | 0.09 |
| | | None | -1.92* | - | -1.82* | - |
| | 1st difference | Intercept | -5.12*** | -5.03*** | -4.89*** | 0.09 |
| | | None | -4.89*** | - | -4.82*** | - |
| Openness to trade | Level | Intercept | -1.13 | -1.24 | -1.23 | 0.13 |
| | | Trend and intercept | -0.96 | -1.47 | -0.84 | 0.12 |
| | | None | -1.02 | - | -1.02 | - |
| | 1st difference | Intercept | -7.10*** | -6.70*** | -7.10*** | 0.22 |
| | | None | -7.09*** | - | -7.09*** | - |
| Net foreign assets | Level | Intercept | -3.18** | -2.94*** | -3.23** | 0.11 |
| | | Trend and intercept | -3.07 | -3.15* | -3.11 | 0.08 |
| | | None | -0.11 | - | 0.14 | - |
| | 1st difference | Intercept | -6.98*** | -5.63*** | -7.22*** | 0.25 |
| | | None | -7.06*** | - | -7.34*** | - |
| Fiscal balance to GDP differential | Level | Intercept | -1.24 | -1.35 | -2.77* | 0.46* |
| | | Trend and intercept | -2.55 | -2.08 | -4.12** | 0.17** |
| | | None | -0.05 | - | -0.53 | - |
| | 1st difference | Intercept | -10.30*** | -9.25*** | -10.72*** | 0.12 |
| | | None | -10.40*** | - | -11.39*** | - |
| Govern-ment cons- | Level | Intercept | 1.09 | 0.23 | 1.09 | 0.61** |
| | | Trend and intercept | -0.95 | -1.20 | -0.97 | 0.19** |

| | | | | | | |
|---|---|---|---|---|---|---|
| umption to GDP differential | Level | None | 1.06 | - | 1.00 | - |
| | 1st difference | Intercept | -4.59*** | -4.17*** | -4.56*** | 0.53** |
| | | None | -4.47*** | - | -4.45*** | - |
| Investment differential | Level | Intercept | -3.01** | -3.05*** | -3.08** | 0.22 |
| | | Trend and intercept | -3.17 | -3.27** | -3.21* | 0.16** |
| | | None | -0.89 | - | -0.76 | - |
| | 1st difference | Intercept | -8.35*** | -8.15*** | -8.35*** | 0.07 |
| | | None | -8.45*** | - | -8.45*** | - |

Note: Three/two/one asterisks for rejection at 1%/5%/10%

Source: author's calculations, Swiss National Bank, Eurostat, IMF, World Bank

Regarding the REER variable for Lithuania, results also appear to be mixed. While the variable seems to be stationary in the first differences, results according to the ADF, DFGLS, PP and KPSS tests do not show a robust evidence of stationarity in levels (Table 6). This implies that REER does not have a mean-reverting property. At the same time productivity differential, net foreign assets, fiscal balance to GDP differential and investment differential also seem to be stationary in differences according to all tests, however, the results for the variables in levels seem to be mixed. For example, government consumption to GDP differential seems to be stationary according to ADF, PP and KPSS tests, however, DFGLS test implies nonstationarity.

Table 6. Results of the unit root tests for Lithuanian data

| | Test for unit root in | Included in test equation | ADF | DFGLS | PP | KPSS |
|---|---|---|---|---|---|---|
| REER, in logs | Level | Intercept | -1.86 | -0.89 | -1.89 | 0.35* |
| | | Trend and intercept | -2.13 | -2.01 | -2.19 | 0.12 |
| | | None | 1.07 | - | 1.07 | - |
| | 1st difference | Intercept | -7.11*** | -3.58*** | -7.11*** | 0.09 |
| | | None | -7.10*** | - | -7.17*** | - |
| Producti-vity differential | Level | Intercept | -0.61 | 0.18 | -0.37 | 0.81*** |
| | | Trend and intercept | -2.80 | -2.76 | -2.80 | 0.15** |
| | | None | -1.92* | - | -2.15** | - |
| | 1st difference | Intercept | -7.26*** | -6.46*** | -7.79*** | 0.12 |
| | | None | -6.77*** | - | -6.77*** | - |
| Commodity terms of trade | Level | Intercept | -0.94 | -0.18 | -0.98 | 0.73** |
| | | Trend and intercept | -1.81 | -1.86 | -1.85 | 0.10 |
| | | None | -1.55 | - | -1.56 | - |
| | 1st difference | Intercept | -6.13*** | -1.49 | -6.11*** | 0.08 |
| | | None | -5.92*** | - | -5.93*** | - |
| Openness to trade | Level | Intercept | -3.06** | -3.10*** | -3.03** | 0.20 |
| | | Trend and intercept | -3.06 | -3.13* | -3.06 | 0.15** |
| | | None | -0.83 | - | -0.63 | - |
| | 1st difference | Intercept | -6.89*** | -6.31*** | -11.52*** | 0.49** |
| | | None | -6.97*** | - | -11.87*** | - |
| Net foreign assets | Level | Intercept | -2.00 | -0.71 | -1.65 | 0.50** |
| | | Trend and intercept | -2.72 | -2.40 | -2.10 | 0.21** |
| | | None | 0.58 | - | 1.55 | - |
| | 1st difference | Intercept | -4.14*** | -4.05*** | -3.79*** | 0.13 |
| | | None | -4.04*** | - | -3.74*** | - |
| Fiscal balance to GDP differential | Level | Intercept | -2.95** | -2.91*** | -2.95** | 0.22 |
| | | Trend and intercept | -3.03 | -3.07* | -3.00 | 0.20** |
| | | None | -2.67*** | - | -2.58** | - |
| | 1st difference | Intercept | -7.89*** | -7.26*** | -10.94*** | 0.09 |
| | | None | -7.92*** | - | -11.08*** | - |
| Govern-ment cons- | Level | Intercept | -3.83*** | -0.61 | -4.06*** | 0.69** |
| | | Trend and intercept | -4.09** | -2.15 | -4.09** | 0.21** |

| | | | | | | |
|---|---|---|---|---|---|---|
| umption to | Level | None | -3.80*** | - | -3.80** | - |
| GDP | 1st difference | Intercept | -7.29*** | -0.25 | -7.31*** | 0.40* |
| differential | | None | -6.86*** | - | -6.87*** | - |
| Investment | Level | Intercept | -1.19 | -1.30 | -1.24 | 0.24 |
| differential | | Trend and intercept | -0.72 | -1.21 | -0.65 | 0.13* |
| | | None | -1.30 | - | -1.33 | - |
| | 1st difference | Intercept | -8.00*** | -8.05*** | -7.90*** | 0.31 |
| | | None | -8.03*** | - | -7.93*** | - |

Note: Three/two/one asterisks for rejection at 1%/5%/10%

Source: author's calculations, Swiss National Bank, Eurostat, IMF, World Bank

Results for both Swiss and Lithuanian data seem to be similar in response to unit root tests. With a few exceptions for Lithuanian data, in most cases for the variables (including both countries' REERs) in the first differences the unit root tests can be rejected according to ADF, DFGLS and PP tests. This implies that the variables are integrated of order one and there is a possibility of a cointegration relationship between them. Thus, econometric technique designed for non-stationary series is employed for both countries in the next section.

4.7. Cointegration Analysis

Taking into account that there is no robust evidence of the stationarity of the fundamental determinants of the REER in Lithuania and Switzerland, and that the null hypothesis of a unit root can be rejected for these variables, results imply that all of the variables (including the REER itself) are integrated of order one and there is a possibility of cointegration relationship between them. Thus, assuming the existence of the time-varying exchange rate equilibrium, that is represented by the cointegration relationship between real exchange rate and its determinants under condition that the determinants are non-stationary, cointegration technique is applied for these nonstationary data series. This technique enables estimating equilibrium exchange rate and the misalignment between the current REER and EER. Estimation of REER misalignment involves three stages. First, the reduced-form REER equation based on Swiss and Lithuanian macroeconomic series is estimated. Second, by using coefficients estimated in the first stage the ERER is calculated. Cyclical components of the determinants are removed with statistical HP-filter. Third, a gap between the actual REER and the long-term BEER is derived. This gap can be interpreted as the REER misalignment, which, if identified, implies policy changes may be needed.

Taking into consideration that the unit root tests do not reject non-stationarity of the variables, cointegration technique is used to estimate the equilibrium exchange rate. Cointegration analysis is carried out by applying Johansen procedure that estimates vector error correction model (VECM) in Equation 19:

$$\Delta y_t = \gamma + \alpha \beta^T y_{t-1} + \sum_{k=1}^{K-1} \Delta y_{t-k} \Gamma_k + \varepsilon_t \quad (19)$$

where $y_t$ is a (n x 1) vector of n variables, $\mu$ is a (n x 1) vector of constants, $\Gamma_i$ represents (n x n) matrixes of short-run coefficients, $\varepsilon_t$ denotes a (n x 1) vector of identically independently distributed residuals, k is the number of lags used in the VAR related to VECM and $\Pi$ is a (n x n) matrix of coefficients. If the matrix $\Pi$ has reduced rank ($0 < r < n$), it can be split into a (n x r) matrix of loading coefficients $\alpha$ and a (n x r) matrix of cointegrating vectors $\beta$ so that $\Pi = \alpha\beta'$. The former indicates the speed of adjustment to equilibrium, while the later represents the long-term equilibrium relationship.

A number of VECM specifications are estimated in order to check for the existence of the cointegration relationships for both countries. Three VECMs containing vectors for the REER with theoretically plausible signs are identified for Switzerland, and one for Lithuania. Table 7 depicts the trace statistics together with 95% critical values for all four VECMs. The trace tests show that there is a sign of cointegration in all four VECMs.

Table 7. Results of the Johansen cointegration tests

| | | Switzerland | | | Lithuania |
|---|---|---|---|---|---|
| | Hypothesis | VECM1 | VECM2 | VECM3 | VECM1 |
| Trace | None | 39.462* | 34.066* | 33.615* | 65.410* |
| | At most 1 | 11.908 | 13.012 | 11.349 | 31.452* |
| | At most 2 | 0.875 | 0.355 | 1.185 | 12.813 |
| Trace 95% | None | 29.797 | 29.797 | 29.797 | 47.856 |
| | At most 1 | 15.495 | 15.495 | 15.495 | 29.797 |
| | At most 2 | 3.841 | 3.841 | 3.841 | 15.495 |

Note: Asterix implies rejection of null hypothesis at 5% level

4.8. Estimations of the vector error correction models

Cointegrating long run parameters, adjustment coefficients and results of the residual diagnostic tests of the four VECMs are reported in Table 8. It must be noted that in order to avoid outliers in residuals in the Lithuania's VECM1 model, one dummy variable for the first quarter of 2009 is included as exogenous variable.

Table 8. Estimations of VECMs

| | | Switzerland | | | Lithuania |
|---|---|---|---|---|---|
| | Variable | VECM1 | VECM2 | VECM3 | VECM1 |
| Long run parameters | Constant | 5.031 | 4.212 | 4.107 | 0.219 |
| | Productivity differential | 0.799 (8.265) | 0.587 (4.778) | - | 0.249 (3.163) |
| | Openness to trade differential | -0.012 (-9.245) | - | - | - |
| | Terms of trade | - | 0.653 (5.889) | - | 4.975 (3.202) |
| | Net foreign assets | - | - | 0.455 (4.100) | - |
| | Fiscal balance to GDP differential | - | - | -0.038 (-3.027) | -0.017 (-5.887) |
| Adjustment coefficients | Exchange rate | -0.243 (-0.718) | -0.725 (-3.628) | 0.042 (1.509) | -0.137 (-1.685) |
| | Productivity differential | -0.056 (-0.198) | -0.089 (-0.490) | - | 0.139 (0.607) |
| | Openness | -78.829 (-2.518) | - | - | - |
| | Terms of trade | - | -0.152 (-2.209) | - | -0.029 (-3.303) |
| | Net foreign assets | - | - | 0.725 (3.673) | - |
| | Fiscal balance to GDP differential | - | - | -3.364 (-2.176) | -20.569 (-2.338) |
| Residual diagnostic tests | Portmanteau autocorrelation test (12 lags) | 70.179 (0.724) | 65.185 (0.961) | 89.891 (0.954) | 159.110 (0.416) |
| | Autocorrelation LM test (3 lags) | 9.219 (0.417) | 12.557 (0.184) | 8.795 (0.457) | 17.317 (0.365) |
| | Normality test | 3.880 (0.693) | 2.549 (0.863) | 8.294 (0.217) | 7.138 (0.522) |
| | White heteroskedasticity (no cross terms) test | 143.755 (0.750) | 111.364 (0.701) | 22.546 (0.023) | 257.795 (0.693) |

Note: In parentheses t-statistic values are provided for long run parameters and adjustment coefficients, whereas in parenthesis the probability levels for the residual diagnostic tests are shown

As it can be seen from the signs of the long run coefficients, REER is positively correlated with productivity differential and negatively with openness in VECM1 in Switzerland (Table 8). More precisely, an increase in the productivity differential by 1% requires a 0.80% appreciation of the real effective exchange rate in order to restore the equilibrium. Similarly, a rise in openness by 1% requires a fall in the REER by 0.01% so that the equilibrium would be restored. These results are in line with the Balassa-Samuelson theory. According to this theory, if the productivity in the tradables sector grows faster than in the non-tradables sector, this leads to higher salaries in the tradables sector, and then, accordingly in the non-tradables sector. As a consequence, prices in the non-tradables sector increase and currency appreciation takes place. As it can be seen in Figure 1, the productivity in the tradables sector (agriculture and fishing, and industry except construction) was rising much faster than in non-tradables sector (construction, financial intermediation and real estate, public administration, community services and activities of households, as well as wholesale trade, retail trade, hotels, restaurants, and transport) in Switzerland.

Figure 1. Productivity in the tradables sector versus the non-tradables sector in Switzerland

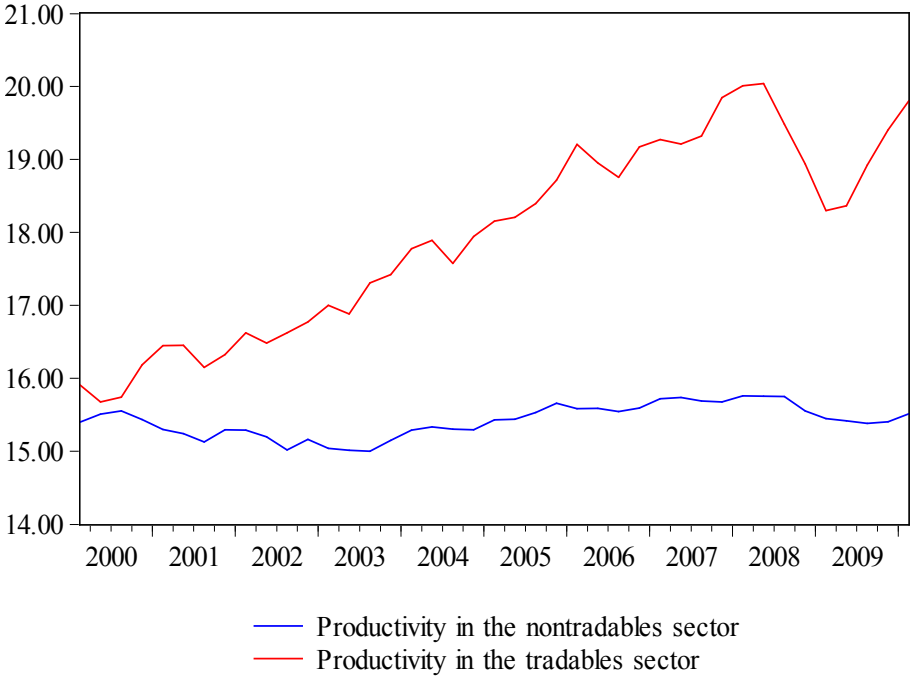
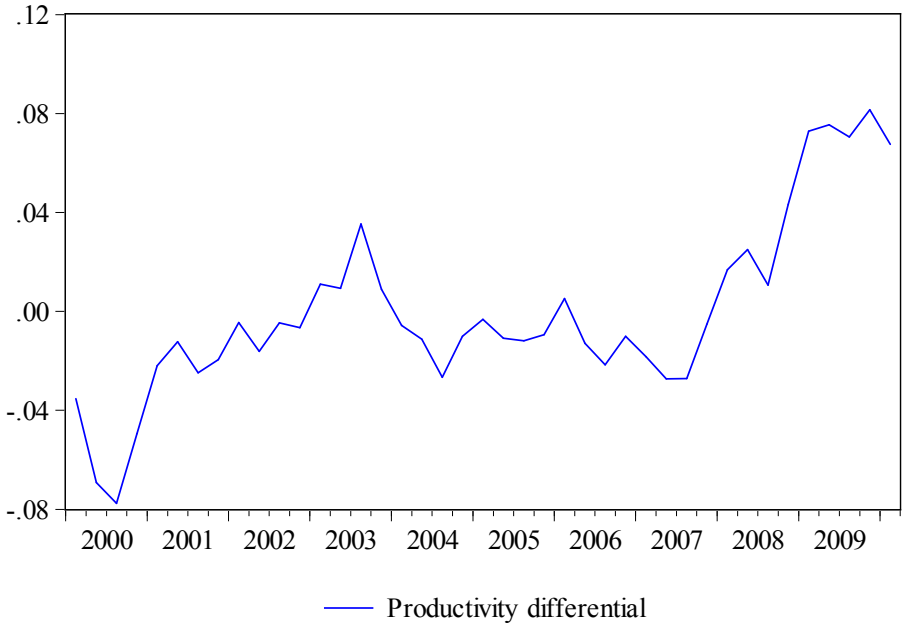


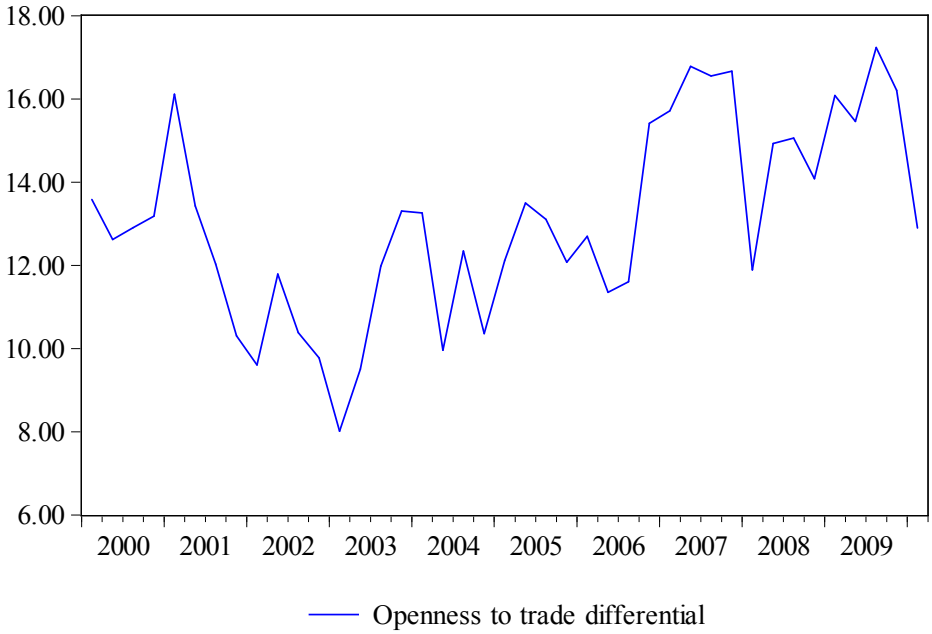

Figure 2 shows that productivity differential increased substantially in Switzerland from the first quarter of 2000 to the first quarter of 2010, which implies that productivity differential was one of the main factors contributing to the REER appreciation.

Figure 2. Productivity differential in Switzerland




Regarding the effect of openness on GDP, it is also in line with theory. Taking into account that the total trade to GDP ratio is high for Switzerland, country is subject to tough competition in the international markets and, therefore, lower prices of goods in the tradables sector and currency depreciation. Figure 3 shows that the total trade to GDP ratio had an upward trend during the period analyzed and it implies that this variable reduced the magnitude of the REER appreciation.

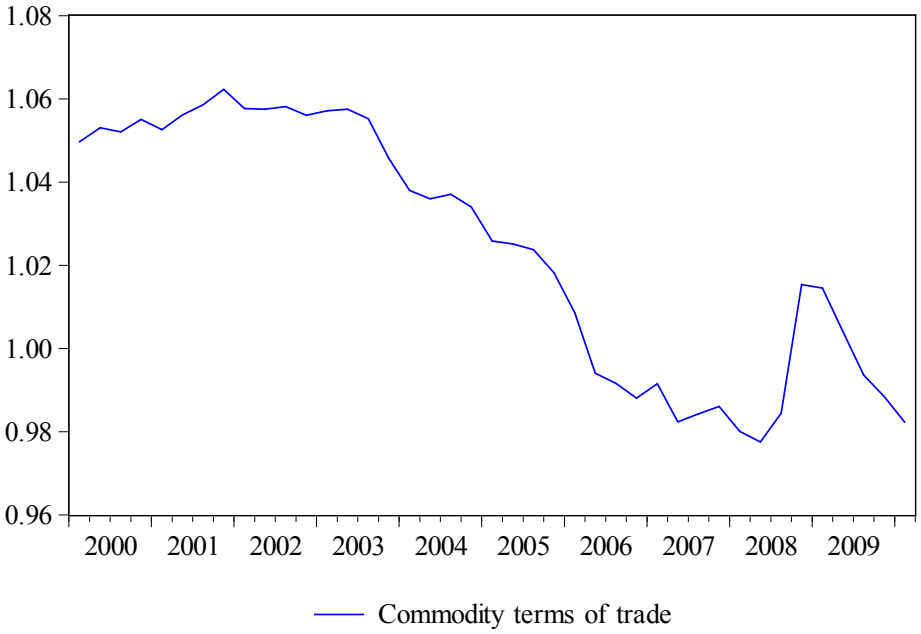
Figure 3. Openness to trade differential in Switzerland




The estimated VECM2 for Switzerland indicates that movements in REER are positively correlated with productivity differential and terms of trade (Table 8). If productivity differential rises by 1%, a 0.59% increase in the REER is required to restore the equilibrium exchange rate. Similarly, if the terms of trade rise by 1%, the REER should increase by 0.65% so that the equilibrium exchange rate would not change. As it was explained

before, the positive correlation between productivity differential and REER is in line with theory. With regards to the commodity terms of trade, its positive correlation with REER was also expected, as an increase in the commodity terms of trade increases income and causes stronger demand for non-tradables, and, thus, domestic currency appreciation. As it is shown in Figure 4, Switzerland's commodity terms of trade decreased substantially during the period considered, which implies that this variable reduced the magnitude of the REER appreciation.

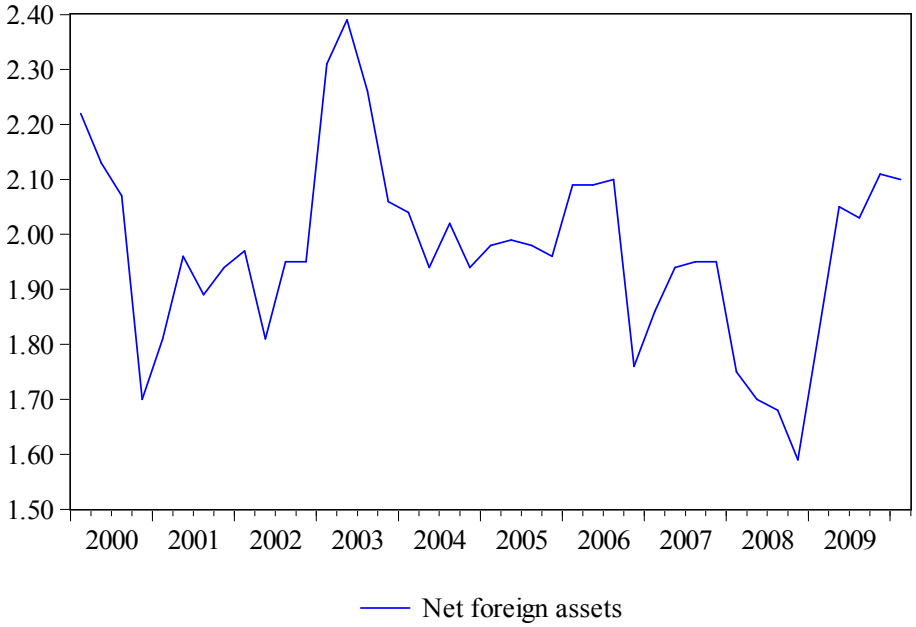
Figure 4. Commodity terms of trade in Switzerland




Results are similar to those of Reynard (2008), who shows that bilateral exchange rates are in match with Balassa-Samuelson proxy, indicating that the highly competitive Swiss export sector seems to be the driving factor behind the long run appreciation of the Swiss franc relative to the German mark and the euro. While data used in the estimations is different, Table 8 shows that productivity is a statistically significant determinant of the equilibrium exchange rate in two out of three VECMs.

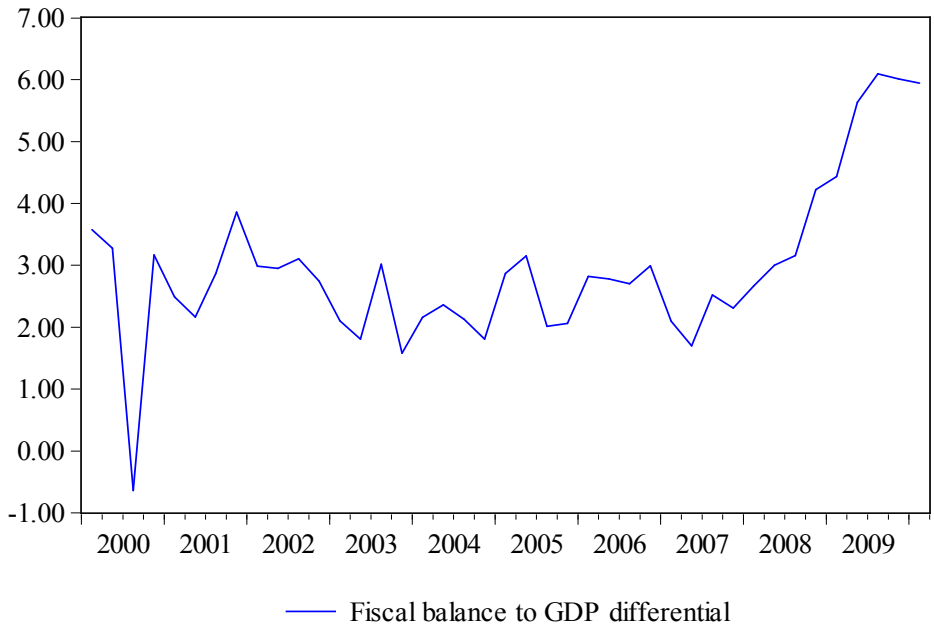
The estimated VECM3 for Switzerland indicates that REER is positively correlated with net foreign assets and negatively with fiscal balance to GDP ratio (Table 8). A rise in the net foreign assets should lead to a 0.45% rise in the REER so that the equilibrium REER would be maintained. Accordingly, a rise in the fiscal balance to GDP ratio by 1% must cause a decrease in the REER by 0.04% to restore the equilibrium. The positive correlation between net foreign assets and REER is theoretically plausible. Taking into account that Switzerland is a creditor country; a rise in the net foreign assets leads to an increase in the current account surplus via higher additional debt interest receipts and is followed by the exchange rate appreciation to offset this for any level of the current account. In addition, higher wealth causes an additional demand for domestic goods via a rise in consumption, and, therefore, leads to currency appreciation. Figure 5 shows that net foreign assets trended downwards in Switzerland during the period analyzed and this implies that this variable did not contribute substantially to the REER appreciation.

Figure 5. Net foreign assets in Switzerland




The negative sign for the coefficient of the fiscal balance to GDP differential was expected, as a rise in the budget balance leads to an increase in the national savings, and, thus, weaker domestic demand and currency depreciation. It is shown in Figure 6 that the fiscal balance to GDP differential increased substantially during the period analyzed in Switzerland, which implies that this variable reduced the magnitude of the REER appreciation.

Figure 6. Fiscal balance to GDP differential in Switzerland




The estimated VECM1 for Lithuania shows that the changes in REER are positively correlated with changes in the productivity differential and terms of trade. At the same time REER is negatively correlated with fiscal balance to GDP differential. A rise in the productivity differential by 1% requires a 0.25% appreciation of the REER so that equilibrium would be restored. Accordingly, an increase in the commodity terms of trade by 1% requires an appreciation of the REER by 4.98% to keep the equilibrium unchanged. At the same time an

increase in the fiscal balance to GDP differential requires for the REER depreciation of 0.02% so that equilibrium would be restored. Similarly to the Swiss case, the results are in line with Balassa-Samuelson theory. As it can be seen in Figure 7, productivity in the tradables sector grew much faster than that in the nontradables sector, which implies that salaries in the tradables sector increased and this increase was followed by higher salaries in the nontradables sector, thus, higher prices in the nontradables sector and currency appreciation.

Figure 7. Productivity in the tradables sector versus the non-tradables sector in Lithuania

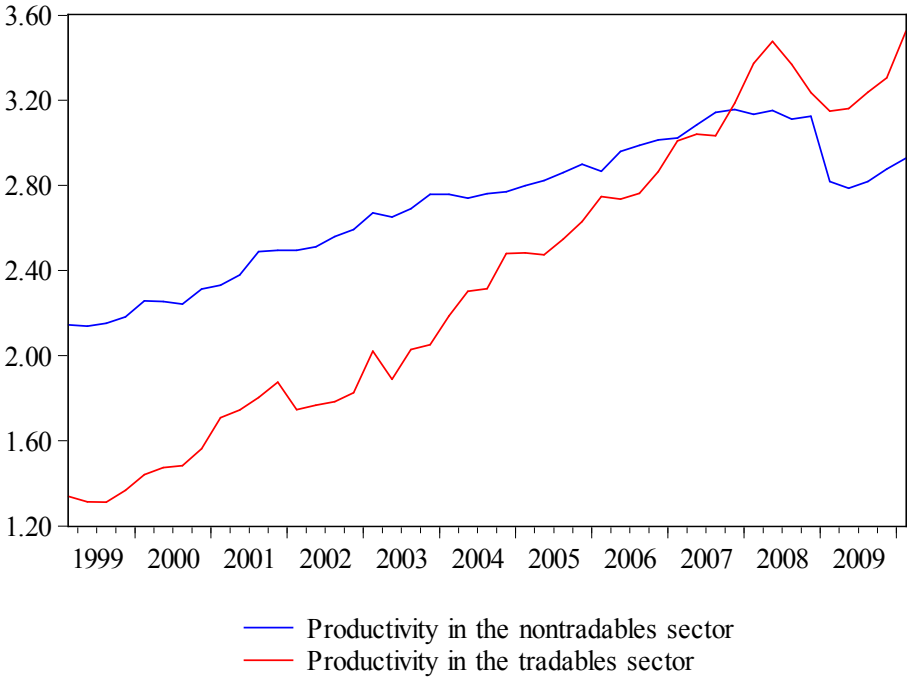
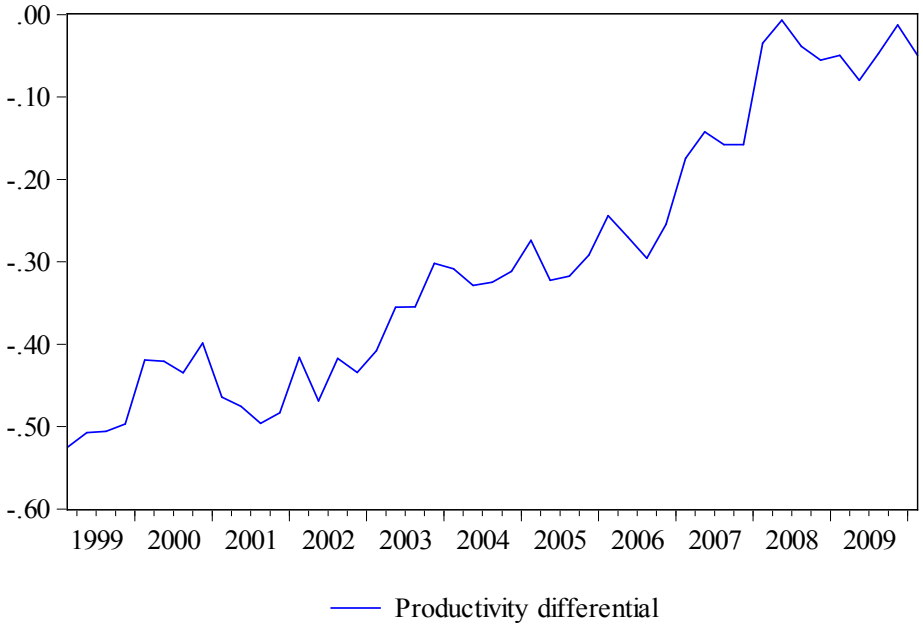


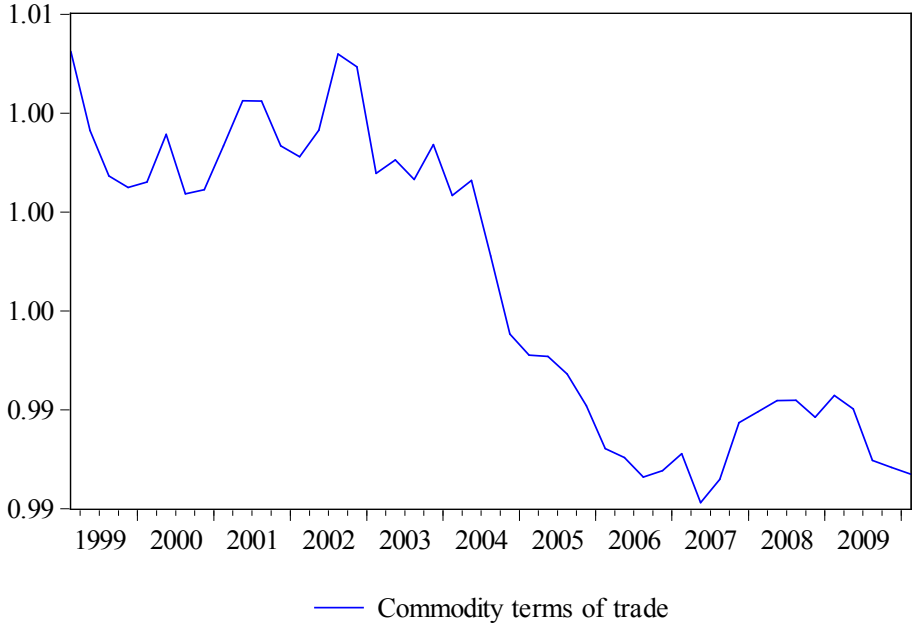

Figure 8 shows that productivity differential increased substantially in Lithuania during the period analyzed and this implies that productivity differential contributed significantly to the REER appreciation.

Figure 8. Productivity differential in Lithuania



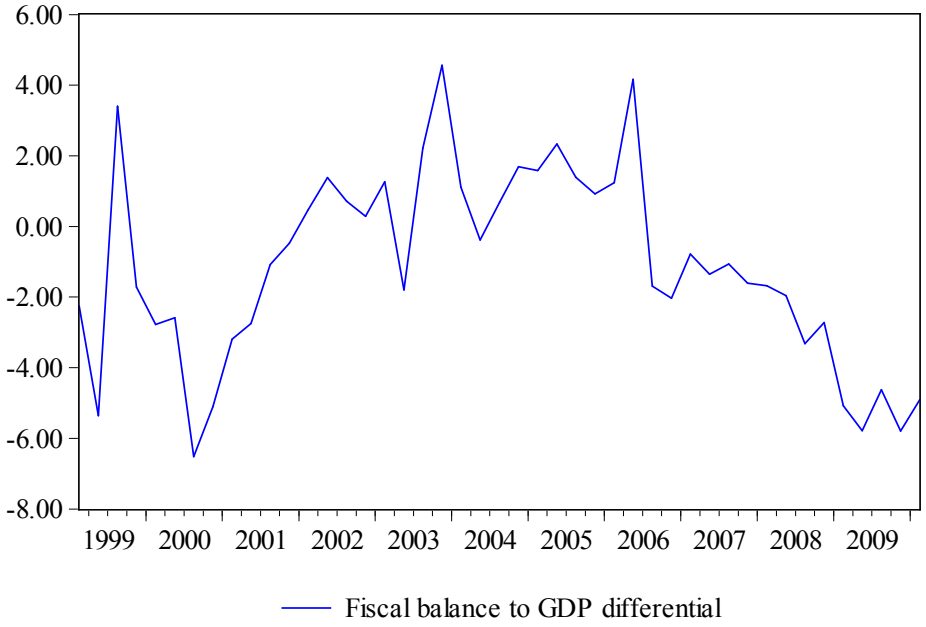

The long run coefficient for the commodity terms of trade is plausible and implies that a rise in commodity terms of trade leads to higher income, stronger demand for nontradables, and, thus, currency appreciation. However, as Figure 9 indicates, commodity terms of trade were worsening in Lithuania during the period analyzed and this variable most likely reduced the extent of the REER appreciation.

Figure 9. Commodity terms of trade in Lithuania




Improvement in the budget balance causes not only a rise in national savings, but also a decrease in domestic demand and currency depreciation. Figure 10 indicates that during big part of the period analyzed budget balance to GDP differential had a downward trend in Lithuania, which, therefore, implies that this variable contributed to the currency appreciation.

Figure 10. Fiscal balance to GDP differential in Lithuania




Adjustment coefficients shed light on the dynamics of the adjustment process towards the equilibrium. However, it must be taken into consideration that the adjustment process is generally affected by the adjustment coefficients, error correction terms, and short run dynamics of the VECM. As it can be seen in Table 8 adjustment coefficients are significant both for REER and terms of trade, which implies that the gap between actual and equilibrium REER of 100% is closed by the decrease in the terms of trade by 0.2% and decrease in REER itself by 0.7% in VECM2 for Switzerland. So, the real exchange rate tends to stabilize itself and this is in line with the fact that Switzerland had floating exchange rate regime against euro during the whole sample period. The gap of 100% between actual and equilibrium REER is closed by a decrease in openness by 79% in VECM1 for Switzerland and by increase in net foreign assets by 0.7% and decrease in fiscal balance to GDP ratio by 3.4% in VECM3 for Switzerland. Regarding the VECM1 for Lithuania, the gap of 100% between the actual and equilibrium exchange rate is closed by a fall of 0.03% in commodity terms of trade and a fall of 20.57% in the fiscal balance to GDP differential. Taking into account the fact that the gap between the actual and equilibrium REER is not closed by the REER itself might reflect the fixed exchange rate regime in Lithuania.

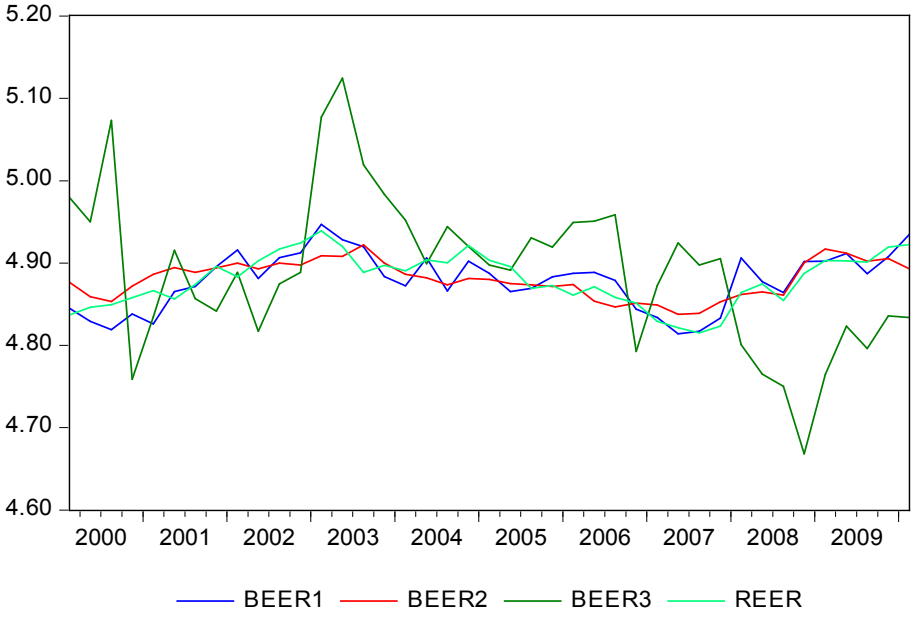
In order to check for the properties of residuals of the estimated VAR, a number of tests are conducted and the results are shown in Table 8. First, Portmanteau autocorrelation test is used to check the null hypothesis of no residual serial autocorrelation. As it is shown in Table 8, the null hypothesis cannot be rejected in any of the four VECMs at 10% significance level and the probabilities for failing to reject the null hypothesis are in a range from 42 to 96%. Second, autocorrelation LM test is conducted to check the null hypothesis of no residual serial correlation. The probabilities for failing to reject the null hypothesis range from 18 to 46%, which implies that there is no residual serial correlation at 10% significance level. Thus, both of the tests show that there is no residual serial correlation for neither of the countries under consideration. Third, normality test is conducted to check the null hypothesis of the normality of residuals. With the range of probabilities from 22 to 86%, it can

be concluded that it is failed to reject the null hypothesis of normality in residuals at 10% significance level in all four VECMs. Fourth, White heteroskedasticity test without cross terms is conducted to check the null hypothesis of homoskedasticity without cross terms. Results indicate that the null hypotheses are failed to be rejected at 10% significance level with the probabilities ranging from 69 to 75% for the VECM1 and VECM2 for Switzerland and VECM1 for Lithuania. Regarding the VECM3 for Switzerland, the null hypothesis is failed to be rejected at 1% significance level with a probability of 2%. There is a probability of heteroskedasticity in VECM3 for Switzerland, because of heteroskedasticity in real exchange rate (RER) and fiscal balance to GDP differential.

4.9. Short run equilibrium real effective exchange rates based on BEER

Based on the VECM estimates of coefficients in cointegration relationship ERER can be assessed. First, estimated coefficients are applied to actual values of regressors. The results for Switzerland are shown in Figure 11 in the time range from the first quarter of 2000 to the first quarter of 2010. While BEER1 estimate from the VECM1 and BEER2 estimate from the VECM2 move in a similar way as actual REER, the BEER3 estimated from the VECM3 exhibits much larger fluctuations on account of substantial fluctuations in the regressors themselves.

Figure 11. REER and current BEERs in Switzerland




Current misalignment of the Swiss franc is shown in Figure 12. The current misalignment based on the BEER1 and BEER2 estimations is in the range of undervaluation of 4.2% to overvaluation of 4.0%. The biggest current misalignment is shown by the BEER3 estimation and it is in the range of undervaluation of 22.4% and overvaluation of 21.9%.

Figure 12. Current misalignments of the Swiss franc based on BEERs

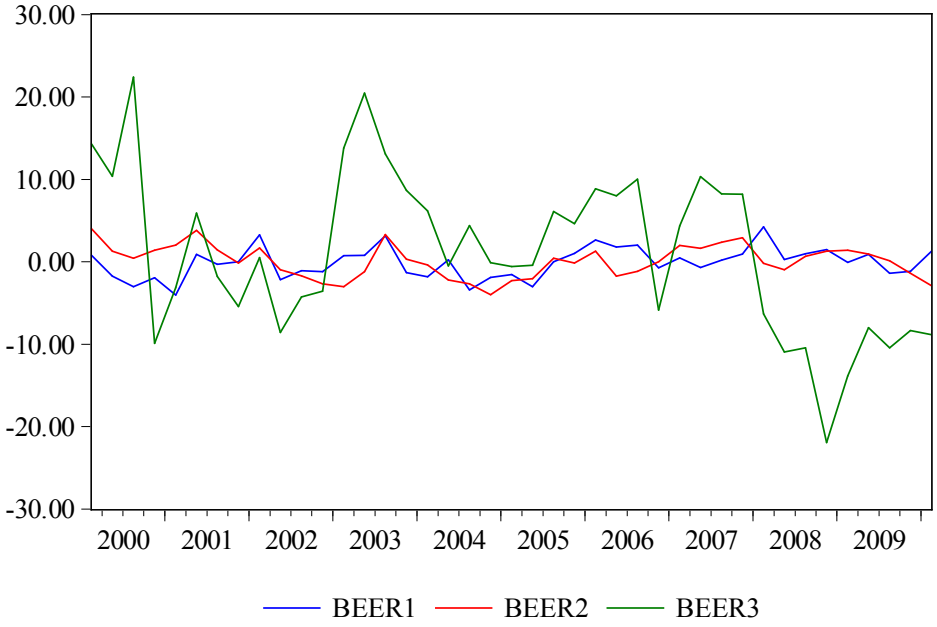
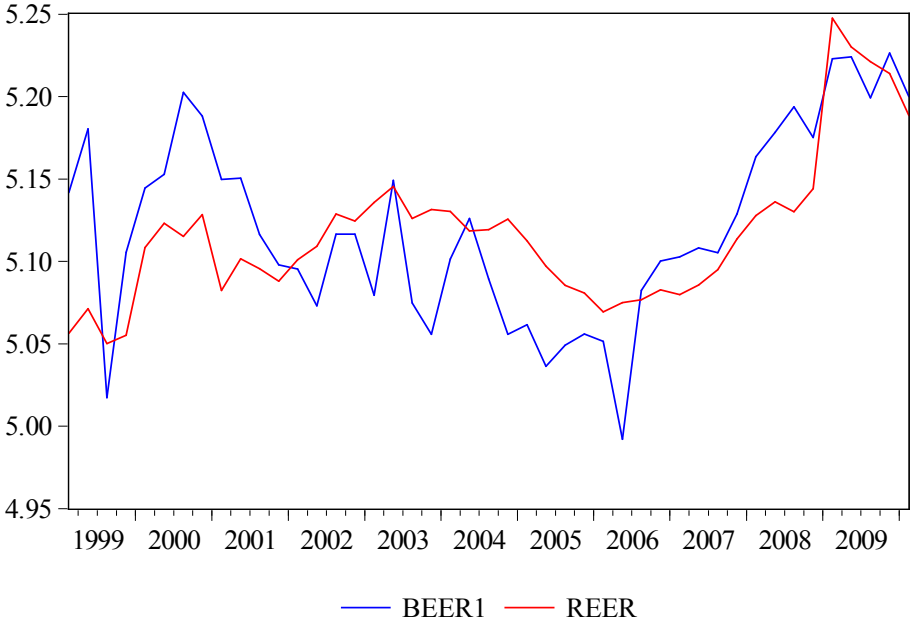


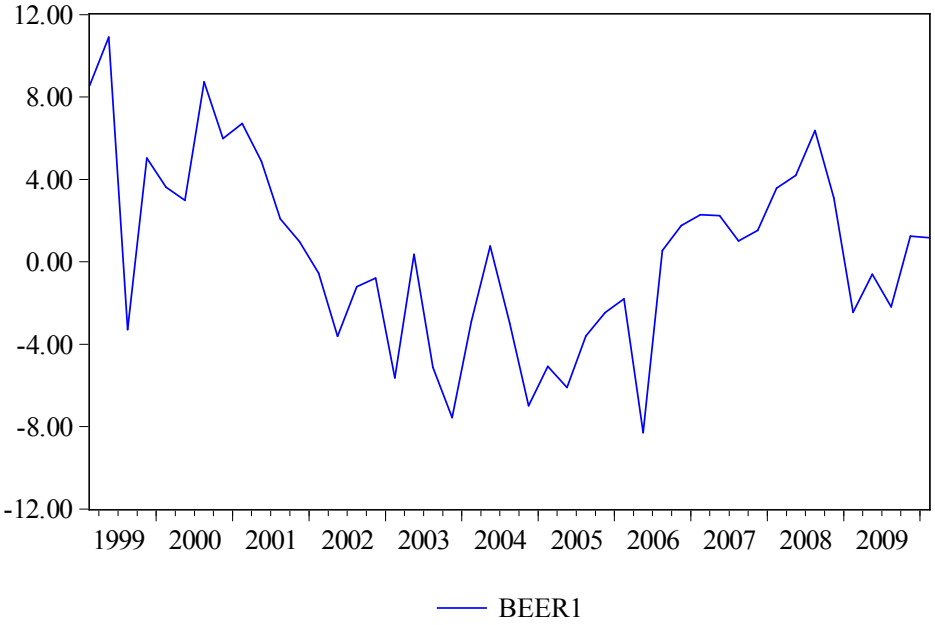

Figure 13 depicts the results for the BEER1 estimated from the VECM1 together with the REER. It can be seen that, similarly to the Swiss case, BEER1 estimated from the VECM1 for Lithuania has bigger fluctuations than the REER. There are so big fluctuations in the BEER1, as there are big fluctuations in the fiscal balance to GDP differential, which is one of the determinants of the equilibrium exchange rate.

Figure 13. REER and current BEER in Lithuania




It can be seen in Figure 14 that the current misalignment of Lithuanian litas ranges from the overvaluation of 8.3% to the undervaluation of 10.9%.

Figure 14. Current misalignment of the Lithuanian litas based on BEER

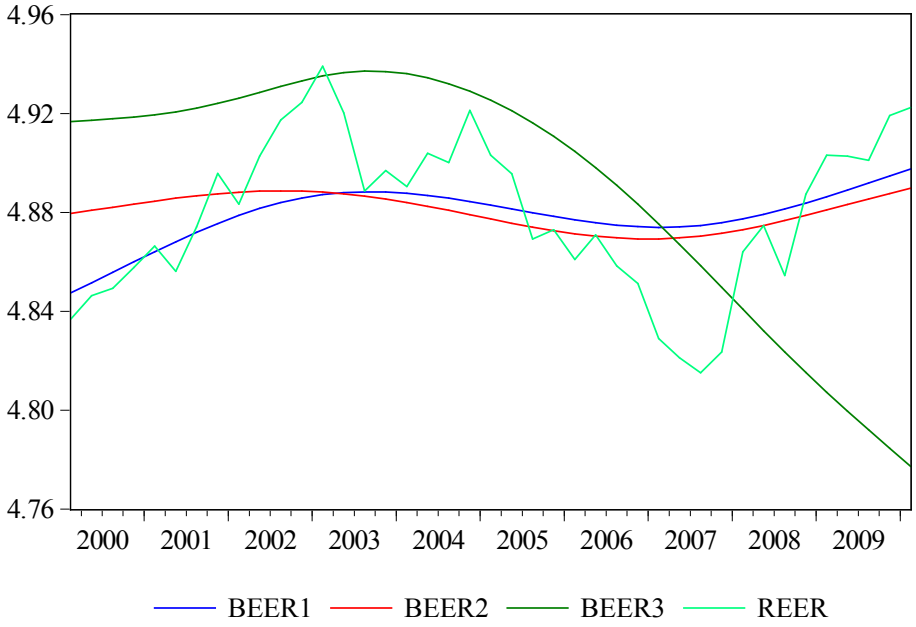



Based on the estimates of current BEER for both Switzerland and Lithuania, it is hard to interpret the equilibrium exchange rate as the determinant of the future movements in the REER, as the fundamental economic variables may themselves not be at their long term (equilibrium) values.

4.10. Long run equilibrium real effective exchange rates based on BEER

Taking into consideration that an interpretation of REER current misalignment, based on current BEER for both countries is misleading, some sort of smoothing of determinants is necessary. The Hodrick-Prescot (HP) statistical filter has been widely used in the literature to estimate equilibrium values (Clark, MacDonald, 1998). However it provides with estimates which are distorted due to assymetries at the beginning and at the end of the sample and, thus, the long-term BEER estimates at the last four quarters should be treated with caution. Dynamics of the long-term BEERs for the three VECMs in Switzerland is depicted in Figure 15.

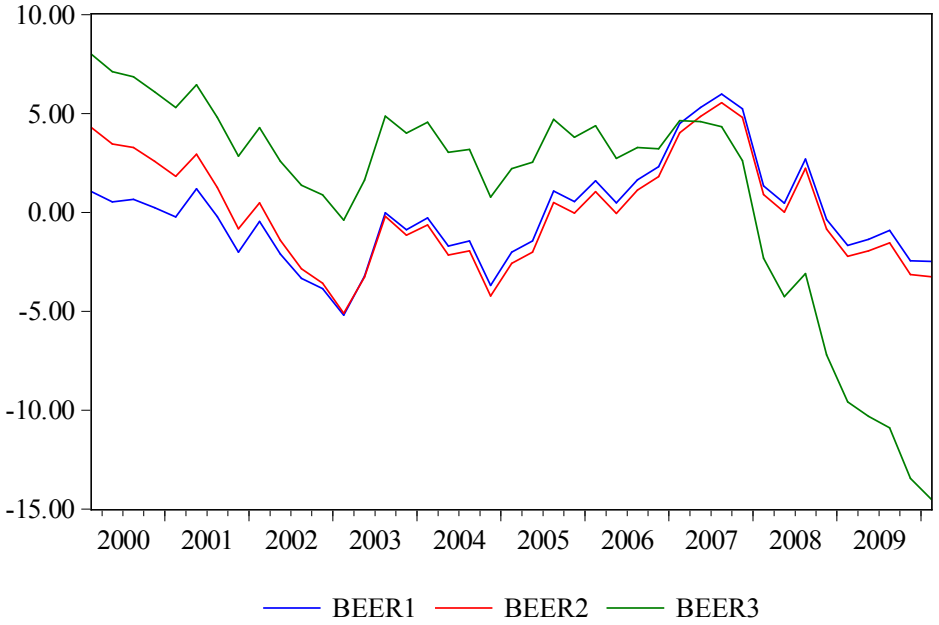
Figure 15. REER and long term BEERs in Switzerland




There is a clear evidence of overvaluation during the most recent period but its extent and exact timing differs somewhat across the models (Figure 15). Dropping out last four observations, which may suffer from the end-point problem inherent to the HP-filter, it is observed that in the first quarter of 2009 Swiss franc was overvalued by 0.35% in comparison to BEER1, by 0.45% in comparison to BEER2 and by 2.00% in comparison to BEER3. While all three BEERs follow similar pattern in 2000-2007, a different trend in the BEER3 in comparison to two other BEERs can be explained by a substantial increase in the fiscal balance to GDP ratio differential in the past few years, leading to a rise in national savings, and, thus, weaker domestic currency demand and depreciation.

In the IMF country report for Switzerland (2011) the estimates for the equilibrium exchange rate according to three different methodologies are provided and it is concluded that Swiss franc is still broadly in equilibrium despite its recent appreciation both according to the external sustainability method and macroeconomic balance method. On the contrary, the equilibrium real exchange rate method implies an overvaluation that is driven by the recent appreciation of the nominal effective exchange rate given stable terms of trade.

Figure 16. Total misalignment of the Swiss franc based on BEERs




As it can be seen in Figure 16, the total misalignment ranges from the undervaluation of 8.0% to overvaluation of 14.5% if not considering the last four observations. The biggest total misalignment is again shown by the BEER3 model. In general, the misalignment found is not big and Elkhoury (2004) does not find any persistent misalignment in the real exchange rate in comparison to the equilibrium as well.

REER and long term BEER for Lithuania is depicted in Figure 17. While REER was significantly overvalued in 2009, after the global economic crisis started and government committed to substantial fiscal consolidation policy, it continued to depreciate and even became undervalued in the very first quarter of 2010. Nevertheless, as it was mentioned before, due to the end-point problem inherent to the HP filter, four last observations should not be considered. And during the biggest part of the sample excluding the final four observations REER was even undervalued.

Figure 17. REER and long term BEER in Lithuania

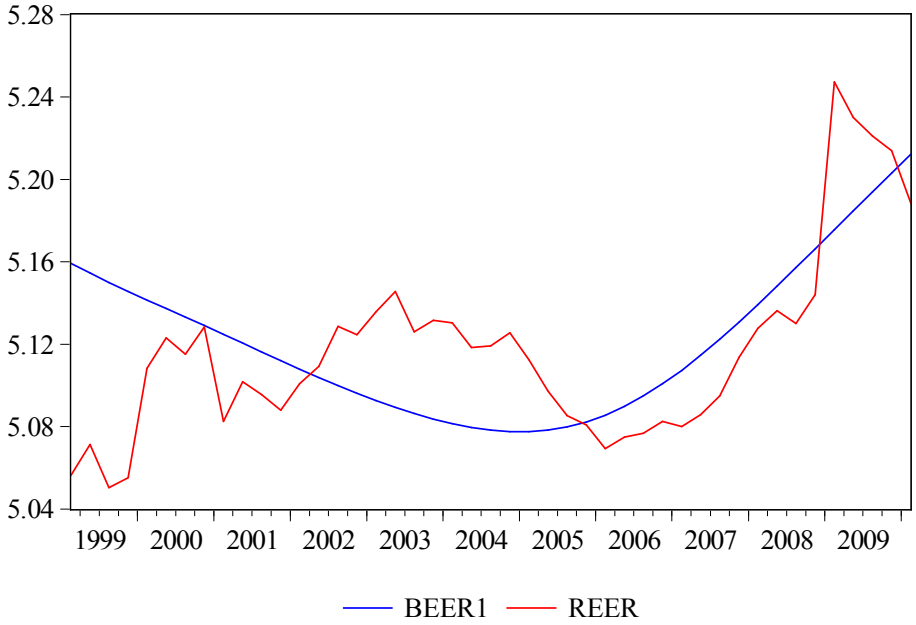
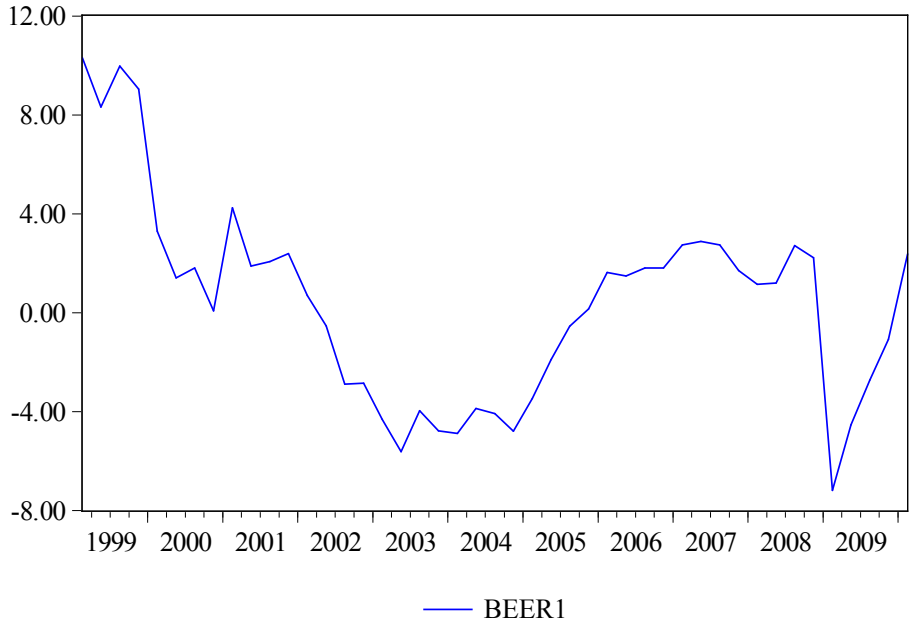



Figure 18 displays the total misalignment of the Lithuanian litas. It can be seen that the total misalignment ranged from the undervaluation of 10.3% to the overvaluation of 7.2%. IMF country report for Lithuania (2011) provides with the estimates for the exchange rate misalignment according to three different methodologies, including the macroeconomic balance method, external sustainability method and equilibrium exchange rate method. On average the misalignment is equal to 0.6%, which is not significantly different from zero.

Figure 18. Total misalignment of the Lithuanian litas based on BEER




To conclude, for Switzerland, the null hypotheses associated to the second research question is not rejected, as each of the variables is statistically significant in at least one of the VECMs, however, for Lithuania it is rejected, as not all of the variables are significant in its VECM. With regards to the third research question, the null hypotheses are not rejected neither for Lithuania nor for Switzerland. This implies that real exchange rate is

overvalued in Switzerland and in Lithuania in 2009. However, the results should be treated carefully due to end-point bias problem associated with using the HP-filter.

### 4.11. Disadvantages of the BEER method

While the BEER method is completely consistent with the econometric viewpoint for using an error correction model, which deals with the non-stationarity of the data, it has a number of disadvantages.

First, the method is not consistent with any macroeconomic model and, therefore, it is theoretically flawed. While the interpretation of the short run adjustments in the cointegrating relations as equilibrium errors refers implicitly to theories about the nonclearing markets and adjustment costs, explicit connections are usually never shown. Thus, it is often hard to interpret what the analysis implies about the economic behavior.

Second, if the cointegration relationship between the exchange rate and the fundamentals exists, the estimation of the error correction model implies that the real exchange rate has been equal to its equilibrium value, which is highly debatable assumption.

Third, the modeling of the expectations of the agents for the exchange rate is questionable. While Clark and MacDonald (1998) assume that agents anticipate the exchange rate to reach its equilibrium value in the next period, their low empirical estimates of the error correction parameter imply that the return to equilibrium is very slow.

Fourth, exchange rate dynamics in the economic models contradict with exchange rate dynamics in the BEER model. In the macroeconomic models exchange rate dynamics depend on slow adjustment of the nominal and real variables, as well as expectations. Thus, it can be shown that if at least two variables in the economy are predetermined, convergence of the system after a shock is not monotonic anymore and exchange rate fluctuates towards the equilibrium (Dornbusch, 1976).

# 5. Structural vector autoregression model

The structural vector autoregression model is employed in this section in order to estimate the equilibrium exchange rate, exchange rate misalignment and determine the shocks that explain most of the variations in the RER. This methodology is helpful on answering the fourth research question for both Lithuania and Switzerland.

## 5.1. Motivation for the structural vector autoregression model

Structural vector autoregression model allows identifying the dynamic effects of exogenous structural shocks on endogenous variables. Prior theoretical views on how certain shocks impact exchange rate are necessary and structural model of the economy is helpful in this respect. Clarida and Gali (1994) method of SVAR model and long-run identification methods of Blanchard and Quah to decompose the real exchange rate into permanent and temporary components are employed. In particular, Clarida and Gali (1994) construct trivariate structural vector autoregressive model (SVAR) to estimate the relative impotance of different types of macroeconomic shocks for changes in relative output, relative inflation and changes in the real exchange rate. The long-run identification methods of Blanchard and Quah is used, in which money, or nominal, shocks do not influence the real exchange rate and relative output in the long run; only supply shocks influence relative output in the long run ; the real exchange rate is affected by both supply and demand shocks influence in the long run. That means they have a permanent effect on the real exchange rate in the long run. These identifying restrictions are based on a modified version of the Mundell-Fleming-Dornbusch model. Then, Clarida and Gali use SVAR historical decomposition to see the contribution of each structural shock to deviation of time series from its base projection.

## 5.2. Description of the structural vector autoregression model

The model can be represented by the following infinite vector moving average process in Equation 20:

$$X_t=A_0\varepsilon_t+A_1\varepsilon_{t-1}+A_2\varepsilon_{t-2}+\ldots=\sum_{i=0}^{\infty} A_i\varepsilon_{t-i}=\sum_{i=0}^{\infty} A_i L^i\varepsilon_t, \quad (20)$$

where $X_t=[\Delta y_t, \Delta q_t, \Delta p_t]'$, $A_i=\begin{bmatrix} a_{11i} & a_{12i} & a_{13i} \\ a_{21i} & a_{22i} & a_{23i} \\ a_{31i} & a_{32i} & a_{33i} \end{bmatrix}$, L is the lag operator, and $\varepsilon_t=[\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}]'$ is a vector of serially uncorrelated, identically normally distributed and mutually orthogonal white noise disturbances.

It is assumed that the model variables are driven by past and current realizations of the structural shocks. Elements of $A_i$ are impulse response coefficients. In order to recover impulse repsonse functions and to identify past structural shocks, the following vector autoregression (VAR) representation of the process is estimated and inverted in Equation 21:

$$X_t=B_1X_{t-1}+B_2X_{t-2}+\ldots+B_pX_{t-p}+e_t=\sum_{i=1}^{p} B_i L^i X_t+e_t=B(L)X_t+e_t=(I-B(L))^{-1}e_t=(I+B(L)+B(L)^2+\ldots)e_t=e_t+C_1e_{t-1}+C_2e_{t-2}+\ldots, \quad (21)$$

where $B_i=\begin{bmatrix} b_{11i} & b_{12i} & b_{13i} \\ b_{21i} & b_{22i} & b_{23i} \\ b_{31i} & b_{32i} & b_{33i} \end{bmatrix}$, $C_i=\begin{bmatrix} c_{11i} & c_{12i} & c_{13i} \\ c_{21i} & c_{22i} & c_{23i} \\ c_{31i} & c_{32i} & c_{33i} \end{bmatrix}$, B(L) is an invertible lag polynomial and $e_t=[e_{1t}, e_{2t}, e_{3t}]'$ is a vector of normally distributed shocks that are serially uncorrelated, but can be contemporaneously correlated with each other.

Comparison of Equation 20 and Equation 21 gives Equation 22:

$$e_t=A_0\varepsilon_t, \quad (22)$$

and Equation 23:

$$\sum_e=A_0\sum_\varepsilon A_0^{-1}=A_0A_0^{-1} \quad (23)$$

Taking into consideration that $A_0$ is a 3x3 matrix, nine parameters are needed in order to convert the residuals from the Equation 21 into the original shocks, which drive the behaviour of the endogenous variables. Six parameters are given by the elements of $\sum_e$ (three estimated covariances and variances of the VAR residuals). In order to obtain the remaining three parameters so that the system would be just identified, assumptions about the structural shocks are made.

We assume that the three structural shocks, including aggregate demand, aggregate supply and nominal shock, are identified through their effect on the model variables. More precisely, $\varepsilon_t^s \equiv \varepsilon_{1t}$ is a supply shock, $\varepsilon_t^d \equiv \varepsilon_{2t}$ is a demand shock and $\varepsilon_t^n \equiv \varepsilon_{3t}$ is a nominal shock. It is assumed that demand shocks do not affect the level of the relative output in long run, and nominal shocks do not affect neither relative output, nor real exchange rate. These assumptions are based on the Dornbusch (1976) monetary model with sticky prices.

Technically, based on the assumptions the following three restrictions on the sum of matrices $A_i$ in Equation 20 are imposed in Equation 24:

$$\sum_{i=0}^{\infty} A_i = \sum_{i=0}^{\infty} \begin{bmatrix} a_{11i} & a_{12i} & a_{13i} \\ a_{21i} & a_{22i} & a_{23i} \\ a_{31i} & a_{32i} & a_{33i} \end{bmatrix} = \begin{bmatrix} na & 0 & 0 \\ na & na & 0 \\ na & na & na \end{bmatrix} \quad (24)$$

Now the system is just identified and it is possible to identify the past structural shocks and compute impulse response functions and forecast error variance decompositions.

## 5.3. Description of the structural vector autoregression model

Quarterly data covering the period from the first quarter of 1995 to the second quarter of 2011 for Lithuania and from the first quarter of 2000 to the first quarter of 2011 for Switzerland is used in the estimation of the SVAR-based equilibrium exchange rates. All of the variables are in the first differences. Precise definitions of the variables can be found in Table 9.

Table 9. Description of the data for the structural vector autoregression model

| Variable | Definition | Source |
|---|---|---|
| REER | This variable is defined as the logarithm of the REER index (1973Q1=100) against 14 main Switzerland's trading partners in the euro area. Similarly this variable is defined as the logarithm of the REER index (1993Q2=100) against seven main Lithuania's trading partners in the euro area. | Swiss National Bank, Bank of Lithuania |
| Relative output | Seasonally and working day adjusted gross domestic product in constant prices in Switzerland is divided by the weighted geometric average of the seasonally and working day adjusted gross domestic product in constant prices in the main Switzerland's trading partners in the euro area. This variable is in logarithms. The identical methodology is used for Lithuanian data. The annual weights in Switzerland's case are transposed to quarterly weights using cubic match last low to high frequency method in Eviews7. In Lithuania's case weights are quarterly. | Eurostat, Swiss National Bank, Bank of Lithuania |
| Relative GDP deflator | Seasonally and working day adjusted price index of gross domestic product in market prices in Lithuania is divided by the weighted geometric average of the seasonally and working day adjusted price index of gross domestic product in market prices in the main Lithuania's trading partners in the euro area. This variable is in logarithms. Similar methodology is applied for the Swiss data, however, taking into account that seasonally adjusted data is not available for all its main trading partners in the euro area, seasonal adjustment is made by author. The annual weights in Switzerland's case are transposed to quarterly weights using cubic match last low to high frequency method in Eviews7. In Lithuania's case weights are quarterly. | Eurostat, Swiss National Bank, Bank of Lithuania |

5.4. Diagnostic tests

In order to avoid outliers in residuals in the Lithuania's SVAR model, three dummy variables are introduced, namely for the first quarter of 2000, first quarter of 2003 and first quarter of 2009. Dummy variables are not needed in Swiss case.

In order to check for the properties of residuals of the estimated SVAR, a number of tests are conducted and the results are shown in Table 10. First, Portmanteau autocorrelation test is used to check the null hypothesis of no residual serial autocorrelation. As it is shown in Table 10, the null hypothesis cannot be rejected neither for Switzerland nor for Lithuania at 10% significance level and the probabilities for failing to reject the null hypothesis are accordingly 37 and 40%. Second, autocorrelation LM test is conducted to check the null hypothesis of no residual serial correlation. The probability for failing to reject the null hypothesis is 79% in Switzerland and 17% in Lithuania, which implies that there is no residual serial correlation at 10% significance level in any of the two countries. So, both of the tests show that there is no residual serial correlation for neither

of the countries under consideration. Third, normality test is conducted to check the null hypothesis of the normality in residuals. It can be concluded that it is failed to reject the null hypothesis of normality in residuals at 10% significance level with a probability of 61% for Switzerland and 64% for Lithuania. Fourth, White heteroskedasticity test without cross terms is conducted to check the null hypothesis of homoskedasticity without cross terms. Results indicate that the null hypotheses are failed to be rejected at 10% significance level with a probability of 83% in Switzerland and 79% in Lithuania.

Table 10. Residual diagnostic tests

| | Portmanteau autocorrelation test (12 lags) | Autocorrelation LM test (3 lags) | Normality test | White heteroskedasticity (no cross terms) test |
|---|---|---|---|---|
| Switzerland | 109.246 (0.369) | 5.448 (0.794) | 4.494 (0.610) | 27.889 (0.831) |
| Lithuania | 107.887 (0.404) | 12.891 (0.168) | 4.283 (0.638) | 45.611 (0.785) |

Note: In parenthesis the probability levels for the residual diagnostic tests are shown.

5.5. Impulse responses

The impulse responses of REER, relative output and relative GDP deflator to each of the three structural shocks are computed from the estimated VAR coefficients for Switzerland and Lithuania and presented accordingly in Figure 19 and Figure 20. Taking into account that relative measures for output and prices are used, the shocks are thought of as relative supply shocks, relative demand shocks and relative nominal shocks. All shocks are equal to one standard deviation. The signs of obtained impulse responses are typically consistent with theoretical priors. Impulse responses are helpful in answering the fourth research questions for both countries, namely, which of the shocks (demand, supply or nominal) affects REER in the long run.

Figure 19. Accumulated responses to shocks in Switzerland

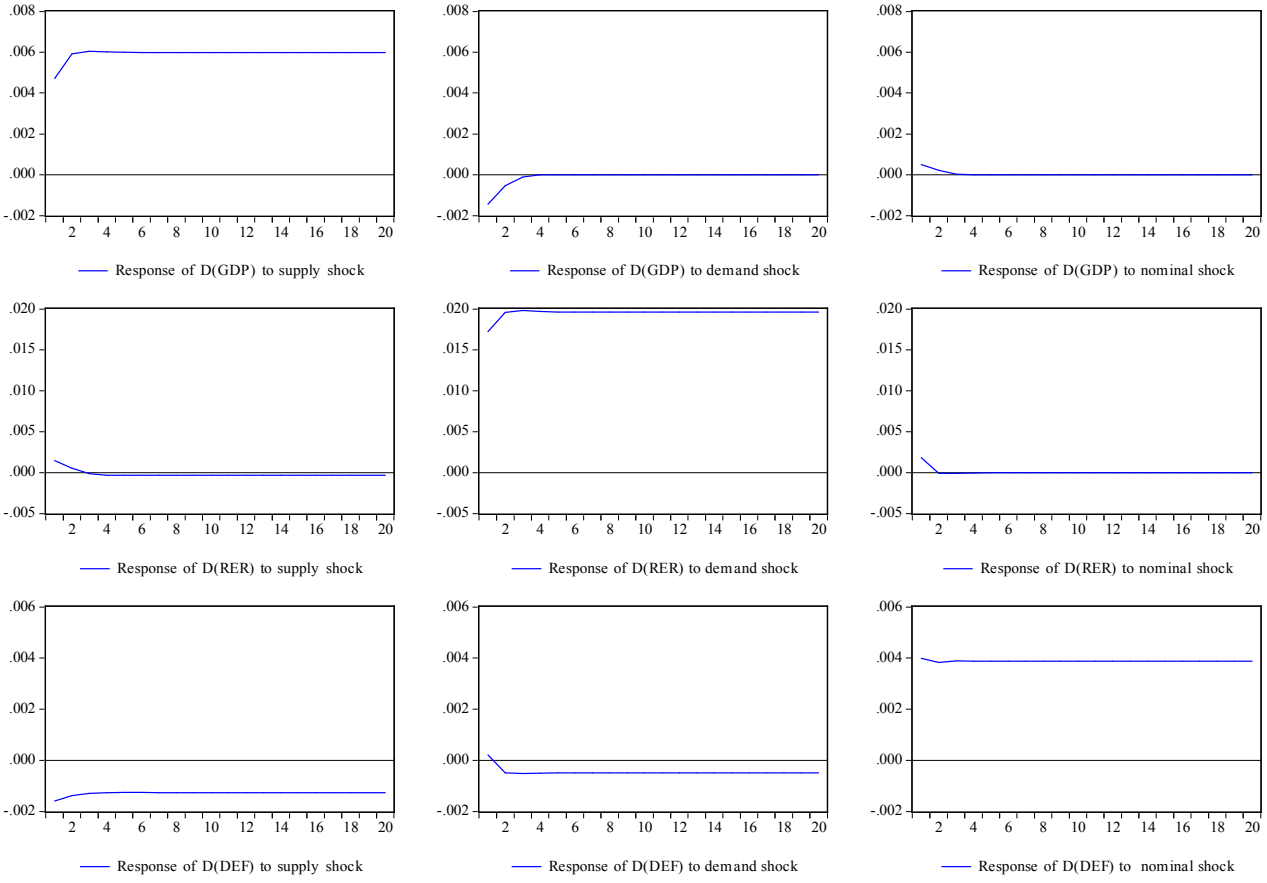
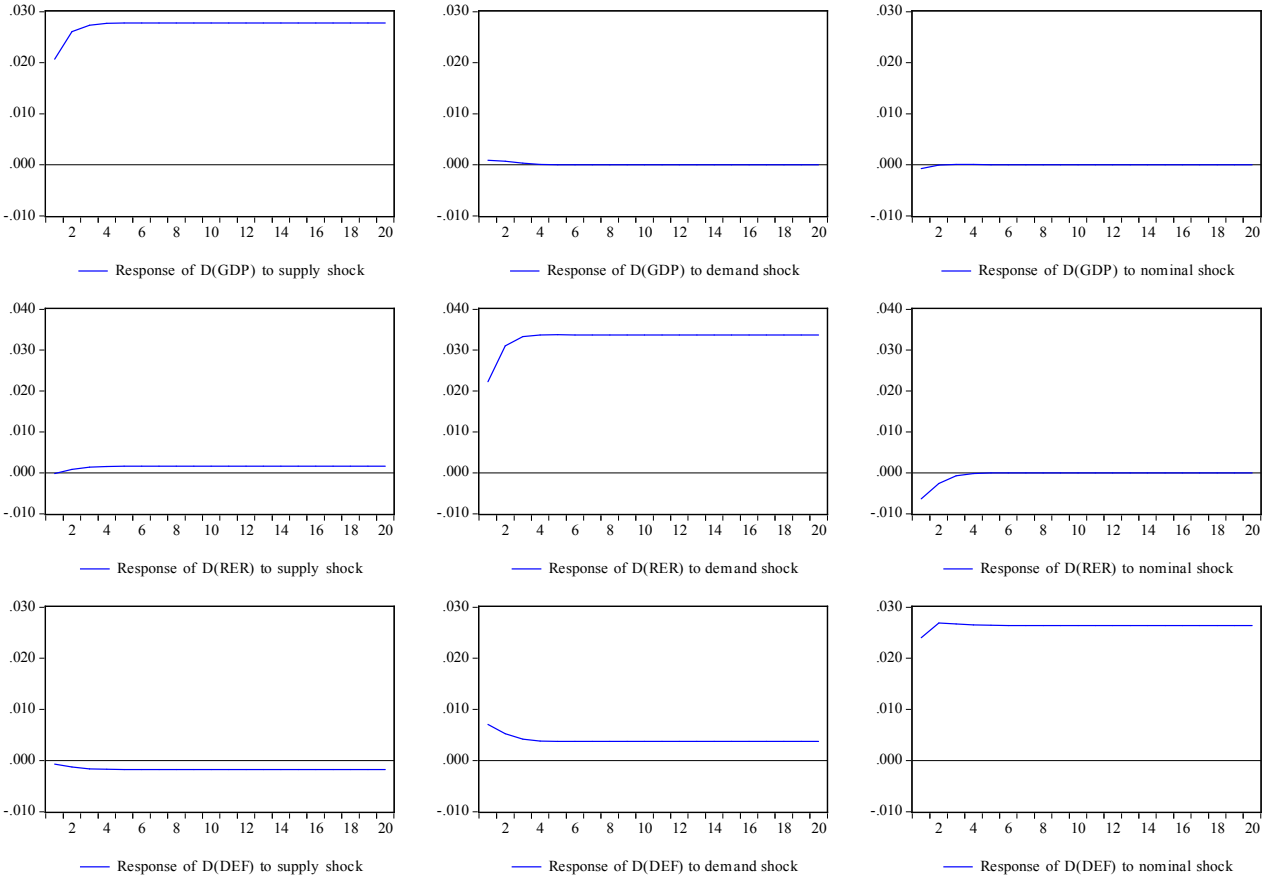


Figure 20. Accumulated responses to shocks in Lithuania




- Supply shock

According to theory, a positive supply shock causes a permanent increase in output, and, thus, in order to stimulate the demand for the additional output, an improvement in competitiveness is necessary. An improvement in competitiveness can be achieved by RER depreciation. However, the results for Switzerland show that supply shock leads to a small appreciation of the RER in the first two quarters. Nevertheless, this response becomes negative in the third quarter in Switzerland and is negligible in the long run. With regards to the response of RER to the supply shock in Lithuania, it is positive, while negligible, in the long run. The positive response can be explained by a rise in domestic real wealth after a supply shock, which leads to consumers' home bias in consumption and, thus, an upward shift in the aggregate demand curve and an appreciation of the currency.

The response of relative output to the supply shock is positive in both countries under consideration. Supply shock brings about a rise in relative output by 0.6% in the long run in Switzerland. Accordingly, relative output rises by 2.8% in Lithuania in the long run. The responses are in line with theory. A supply shock increases the supply of domestic goods and the rate of return on capital, which leads to an inflow of capital and RER appreciation in the traditional Mundell-Fleming model in which capital is mobile. As a result, domestic output increases and domestic prices fall in the long run.

Finally, a positive supply shock leads to a decrease in relative GDP deflator in both countries in long run, which is in line with theory. Namely, a positive supply shock leads to a rise in domestic output, and, therefore, a fall in prices. These responses are negligible in both economies, leading only to a decrease in relative GDP deflator in long run by 0.2%.

- Demand shock

According to theory, a permanent real demand shock raises demand for domestic goods, thus, increases the prices of domestic products and leads to the RER appreciation and a rise in output in short run. In the long run output returns to the long run trend, whereas price level and RER remain above trend. A positive demand shock leads to a rise in the relative output in Lithuania in the first two quarters and a return of the relative output to its initial value in the long run. At the same time, in Switzerland, output falls in response to the demand shock in the first three quarters and returns to its initial level afterwards. However, it must be taken into consideration that the initial fall in Switzerland is very small and the effect in the long run is negligible.

As expected theoretically, demand shock leads to a RER appreciation in both economies. In Switzerland, RER appreciates by 2.0% in the long run, whereas in Lithuania RER appreciates by 3.4% in long run in response to the demand shock.

In line with theory, demand shock leads to a 0.4% rise in the relative GDP deflator in Lithuania in long run. On the contrary the positive response of GDP deflator to the demand shock in Switzerland in the first quarter is followed by a decline in relative GDP deflator in the long run by 0.1%. Nevertheless, this response is negligible for Switzerland.

- Nominal shock

According to theory, a nominal shock is expected to lead to a fall in domestic interest rate, and, therefore, REER depreciation and a rise in output and relative prices in short run. In the long run output and RER are expected to return to their long run levels. While the response of relative output to the nominal shock is positive in Switzerland in the first two quarters following the shock, relative output returns to its initial level afterwards. In Lithuania relative output falls in the first quarter and returns to its initial level afterwards as well.

Interestingly enough the response of RER to the nominal shock in Lithuania is more in line with the theoretical prior of the flexible exchange rate system rather than the fixed one, whereas the same response in Switzerland is more in line with the theoretical prior of the fixed exchange rate system rather than the flexible one. If the exchange rate is fixed, nominal exchange rate is also fixed and a rise in price level in response to the nominal shock is expected to be followed by the exchange rate appreciation. On the contrary, if the exchange rate is flexible, a nominal shock should lead to a fall in domestic interest rates relative to the foreign rates, and, therefore, capital outflow and currency depreciation. Nevertheless, the response of RER to nominal shock in Lithuania, is consistent with the overshooting model of Dornbusch (1976). Nominal shock leads to a decrease in Lithuania's money demand relative to the foreign country and, thus, the response of RER to nominal shock is negative in the first three quarters and RER returns to its initial level afterwards, which is in line with the identifying restriction. In Switzerland, the response of RER to the nominal shock is positive in the first quarter

and returns back to its trend afterwards. It must be taken into consideration that the responses of RER to nominal shocks are negligible in both economies.

The response of relative GDP deflator to the nominal shock is positive in both countries and in line with theory. Relative GDP deflator rises by 0.4% in long run in Switzerland in response to the nominal shock. At the same time, relative GDP deflator rises by 2.6% in Lithuania in response to the nominal shock in long run.

The comparison of the accumulated responses to shocks for Lithuania and Switzerland shows an important difference between the two countries. The magnitude of changes in the relative output, RER and relative GDP deflator to the structural shocks is, in general, much lower in Switzerland than in Lithuania. This can be explained by the fact that due to floating exchange rate regime in Switzerland NEER adjusts much faster in Switzerland, leading to a rapid adjustment in REER and higher possibility for REER to absorb the real shocks than in Lithuania.

Stążka (2006) also used the SVAR method to find the impulse responses and the results are similar to those reported in Figure 20. The major difference lies behinds the response of the GDP deflator to the demand shock. According to theory, a permanent increase in the real demand should lead to a currency appreciation, and, therefore, higher price level and output in the country. While the responses of output are similar both in Figure 20 and the estimations of Stążka (2006), Figure 20 shows the accumulated decrease in the GDP deflator after the demand shock and Stążka's (2006) estimations show a positive response of price level to the demand shock. For comparison, Stążka (2006) finds that the response of price level to the demand shock is not theoretically plausible in seven out of eight transition countries considered. Therefore, these results should be treated with caution and those effects may be perverse because the system variables may be actually driven by more than these three types of structural disturbances. In order to improve the model for Lithuania, more variables might need to be included and longer time series could be used.

### 5.6. Variance decompositions

Variance decompositions show for each endogenous variable the fraction of the forecast error variance at different forecast horizons which can be attributed to each shock in the model. Variance decompositions for Switzerland and Lithuania are presented in accordingly Table 11 and Table 12.

Table 11. Variance decompositions in Switzerland

| | Relative output | | | RER | | | GDP deflator | | |
|---|---|---|---|---|---|---|---|---|---|
| Quarters | Supply shock | Demand shock | Nominal shock | Supply shock | Demand shock | Nominal shock | Supply shock | Demand shock | Nominal shock |
| 1 | 90.41 | 8.56 | 1.02 | 0.73 | 98.14 | 1.13 | 13.53 | 0.24 | 86.23 |
| 2 | 87.83 | 10.92 | 1.25 | 1.00 | 96.75 | 2.25 | 13.36 | 2.81 | 83.83 |
| 3 | 87.15 | 11.51 | 1.34 | 1.14 | 96.61 | 2.25 | 13.39 | 2.81 | 83.80 |
| 4 | 87.11 | 11.55 | 1.35 | 1.15 | 96.60 | 2.25 | 13.40 | 2.81 | 83.79 |
| 5 | 87.11 | 11.55 | 1.35 | 1.15 | 96.60 | 2.25 | 13.40 | 2.81 | 83.79 |
| 6 | 87.11 | 11.55 | 1.35 | 1.15 | 96.60 | 2.25 | 13.40 | 2.81 | 83.79 |
| 7 | 87.11 | 11.55 | 1.35 | 1.15 | 96.60 | 2.25 | 13.40 | 2.81 | 83.79 |
| 8 | 87.11 | 11.55 | 1.35 | 1.15 | 96.60 | 2.25 | 13.40 | 2.81 | 83.79 |
| 9 | 87.11 | 11.55 | 1.35 | 1.15 | 96.60 | 2.25 | 13.40 | 2.81 | 83.79 |
| 10 | 87.11 | 11.55 | 1.35 | 1.15 | 96.60 | 2.25 | 13.40 | 2.81 | 83.79 |
| 11 | 87.11 | 11.55 | 1.35 | 1.15 | 96.60 | 2.25 | 13.40 | 2.81 | 83.79 |
| 12 | 87.11 | 11.55 | 1.35 | 1.15 | 96.60 | 2.25 | 13.40 | 2.81 | 83.79 |
| 13 | 87.11 | 11.55 | 1.35 | 1.15 | 96.60 | 2.25 | 13.40 | 2.81 | 83.79 |
| 14 | 87.11 | 11.55 | 1.35 | 1.15 | 96.60 | 2.25 | 13.40 | 2.81 | 83.79 |
| 15 | 87.11 | 11.55 | 1.35 | 1.15 | 96.60 | 2.25 | 13.40 | 2.81 | 83.79 |
| 16 | 87.11 | 11.55 | 1.35 | 1.15 | 96.60 | 2.25 | 13.40 | 2.81 | 83.79 |
| 17 | 87.11 | 11.55 | 1.35 | 1.15 | 96.60 | 2.25 | 13.40 | 2.81 | 83.79 |
| 18 | 87.11 | 11.55 | 1.35 | 1.15 | 96.60 | 2.25 | 13.40 | 2.81 | 83.79 |
| 19 | 87.11 | 11.55 | 1.35 | 1.15 | 96.60 | 2.25 | 13.40 | 2.81 | 83.79 |
| 20 | 87.11 | 11.55 | 1.35 | 1.15 | 96.60 | 2.25 | 13.40 | 2.81 | 83.79 |

Table 12. Variance decompositions in Lithuania

| | Relative output | | | RER | | | GDP deflator | | |
|---|---|---|---|---|---|---|---|---|---|
| Quarters | Supply shock | Demand shock | Nominal shock | Supply shock | Demand shock | Nominal shock | Supply shock | Demand shock | Nominal shock |
| 1 | 99.69 | 0.20 | 0.12 | 0.01 | 92.50 | 7.49 | 0.07 | 7.98 | 91.95 |
| 2 | 99.60 | 0.20 | 0.20 | 0.18 | 91.17 | 8.65 | 0.13 | 8.34 | 91.53 |
| 3 | 99.57 | 0.23 | 0.21 | 0.21 | 90.69 | 9.10 | 0.15 | 8.51 | 91.34 |
| 4 | 99.56 | 0.23 | 0.21 | 0.22 | 90.65 | 9.14 | 0.15 | 8.52 | 91.33 |
| 5 | 99.56 | 0.24 | 0.21 | 0.22 | 90.64 | 9.14 | 0.15 | 8.53 | 91.32 |
| 6 | 99.56 | 0.24 | 0.21 | 0.22 | 90.64 | 9.14 | 0.15 | 8.53 | 91.32 |
| 7 | 99.56 | 0.24 | 0.21 | 0.22 | 90.64 | 9.14 | 0.15 | 8.53 | 91.32 |
| 8 | 99.56 | 0.24 | 0.21 | 0.22 | 90.64 | 9.14 | 0.15 | 8.53 | 91.32 |
| 9 | 99.56 | 0.24 | 0.21 | 0.22 | 90.64 | 9.14 | 0.15 | 8.53 | 91.32 |
| 10 | 99.56 | 0.24 | 0.21 | 0.22 | 90.64 | 9.14 | 0.15 | 8.53 | 91.32 |
| 11 | 99.56 | 0.24 | 0.21 | 0.22 | 90.64 | 9.14 | 0.15 | 8.53 | 91.32 |
| 12 | 99.56 | 0.24 | 0.21 | 0.22 | 90.64 | 9.14 | 0.15 | 8.53 | 91.32 |
| 13 | 99.56 | 0.24 | 0.21 | 0.22 | 90.64 | 9.14 | 0.15 | 8.53 | 91.32 |
| 14 | 99.56 | 0.24 | 0.21 | 0.22 | 90.64 | 9.14 | 0.15 | 8.53 | 91.32 |
| 15 | 99.56 | 0.24 | 0.21 | 0.22 | 90.64 | 9.14 | 0.15 | 8.53 | 91.32 |
| 16 | 99.56 | 0.24 | 0.21 | 0.22 | 90.64 | 9.14 | 0.15 | 8.53 | 91.32 |
| 17 | 99.56 | 0.24 | 0.21 | 0.22 | 90.64 | 9.14 | 0.15 | 8.53 | 91.32 |
| 18 | 99.56 | 0.24 | 0.21 | 0.22 | 90.64 | 9.14 | 0.15 | 8.53 | 91.32 |
| 19 | 99.56 | 0.24 | 0.21 | 0.22 | 90.64 | 9.14 | 0.15 | 8.53 | 91.32 |
| 20 | 99.56 | 0.24 | 0.21 | 0.22 | 90.64 | 9.14 | 0.15 | 8.53 | 91.32 |

The variance decomposition for the first difference of relative output shows that supply shock is the most important determinant of variation in the forecast errors of relative output and that it contributes to 87.1-90.4% of the variance in the first 20 quarters after the shock in Switzerland. Accordingly, supply shock contributes to 99.6-99.7% of the variance in the relative output in the first 20 quarters after the shock in Lithuania. The remaining variance is attributable to demand and nominal shocks in both countries. Other studies, including Canzoneri et al (1996), Prasad and Chadha (1997), Clarida and Gali (1994), also show evidence that movements in relative output are mainly due to supply shocks.

In contrast, the variance decomposition for the first difference of RER shows that supply shocks play a very weak role in explaining RER's movements in both Switzerland and Lithuania. For example, after 20 quarters the supply shock contributes to only 1.2% of the variance of forecasting the changes in the RER in Switzerland. At the same time the supply shock contributes to 0.2% of the variance of forecasting the changes in the RER in Lithuania after 20 quarters. Demand shocks account for the biggest part of the forecast error variance for this

variable in both countries. Thus, shocks that cause most of the variation in relative output do not seem to result in movements in the real exchange rates in any of the countries. While the results are in line with those of Clarida and Gali (1994), they are denied by Canzoneri et al (1996), who show that demand shocks account for less than 20% of the forecast error variance of the RERs.

Finally, nominal shocks account for 91.3% of the forecast error variance in relative GDP deflator after 20 quarters in Lithuania. At the same time nominal shocks account for 83.8% of the forecast error variance in relative GDP deflator after 20 quarters in Switzerland.

Regarding the structural vector autoregression decompositions, the results shown in Table 12 for Lithuania seem to be different from those of Stążka (2006), who shows that the relative real supply shocks play the most important role in the short run and its contribution to the rate of change in the RER amounts to 58 to 67 percent in the first eight quarters after the shock. However, she estimates the variance decompositions not only for Lithuania, but also for Czech Republic, Estonia, Hungary, Latvia, Poland, Slovakia, and Slovenia, and Lithuania is the only exception among all these countries. Results for all other countries show that those countries, which have joined the Exchange Rate Mechanism II, have their changes in the real exchange rate mainly explained by the nominal shocks, except for Latvia, whereas those countries, which have floating exchange rate regime against the euro, have their changes in RER mainly explained by the demand shocks.

Comparison of the variance decompositions for Lithuania and Switzerland yields interesting results. In both countries changes in GDP deflator are mainly driven by the changes in the nominal shocks, and changes in output gap are mainly explained by supply shocks. While Lithuania has a fixed exchange rate regime against the euro, it seems logical that its changes in the RER are mainly explained by the demand shocks. However, Switzerland, which used to have a floating exchange rate regime against the euro, also has its changes in the RER explained mainly by the demand shock. In order to check these results, further estimations are made to find out what are the main sources for the RER fluctuations in Lithuania and Switzerland.

### 5.7. Estimates of the equilibrium real exchange rate based on SVAR

The equilibrium exchange rate can be defined as the historical component of the real exchange rate driven by the identified real supply and demand shocks, because these shocks influence the real exchange rate in the long run. The equilibrium exchange rate based on the SVAR methodology for both Switzerland and Lithuania is presented in Figure 21 and Figure 22 accordingly. The results indicate that both in Lithuania and in Switzerland the real exchange rate closely follows the equilibrium exchange rate. Results indicate that the actual real exchange rate is slightly overvalued in comparison to the SVAR-based equilibrium exchange rate estimate with some short brakes in Lithuania in the period from the fourth quarter of 2000 to the second quarter of 2007 as well as in the period from the first quarter of 2009 to the fourth quarter of 2010. Regarding the Switzerland's case, its SVAR based EER is a bit overvalued relative to the RER in the period from the third quarter of 2005 to the first quarter of 2011.

Figure 21. EER versus RER in Switzerland based on SVAR methodology

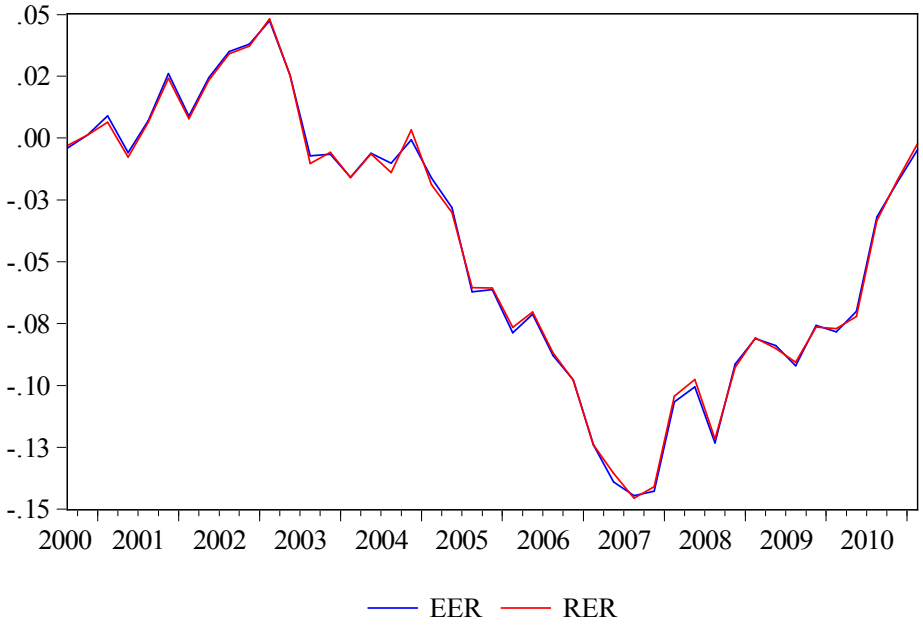



Figure 22. EER versus RER in Lithuania based on SVAR methodology

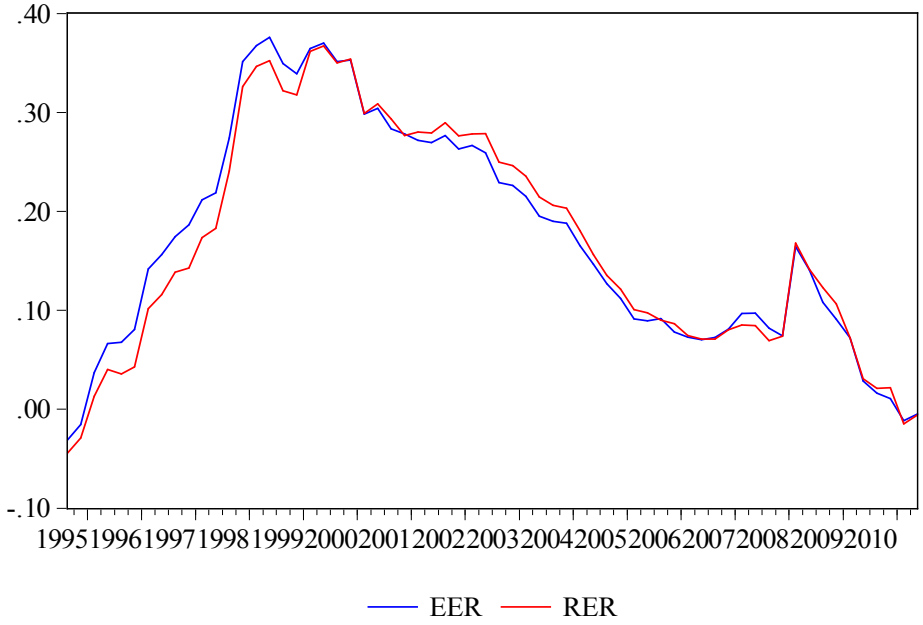



Figure 23 and Figure 24 present the misalignment between the RER and EER based on the SVAR methodology in Switzerland and Lithuania, accordingly. The misalignment lies in the range from the undervaluation of 0.4% to an overvaluation of 0.4% in Switzerland during the period under consideration. Accordingly, misalignment lies in the range from the undervaluation of 4.4% to an overvaluation of 2.1% in Lithuania during the period under consideration.

Figure 23. Exchange rate misalignment in Switzerland based on SVAR methodology

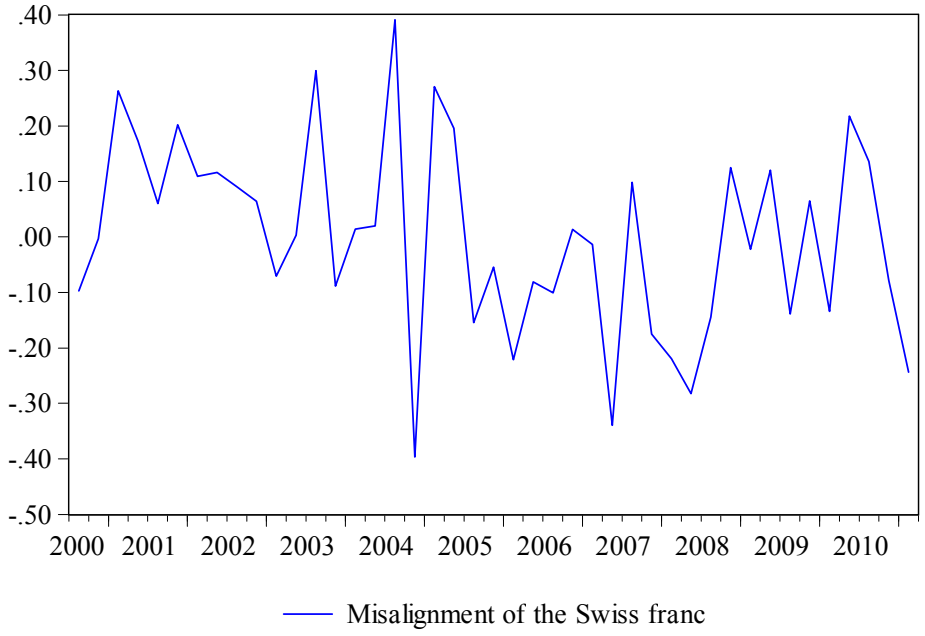
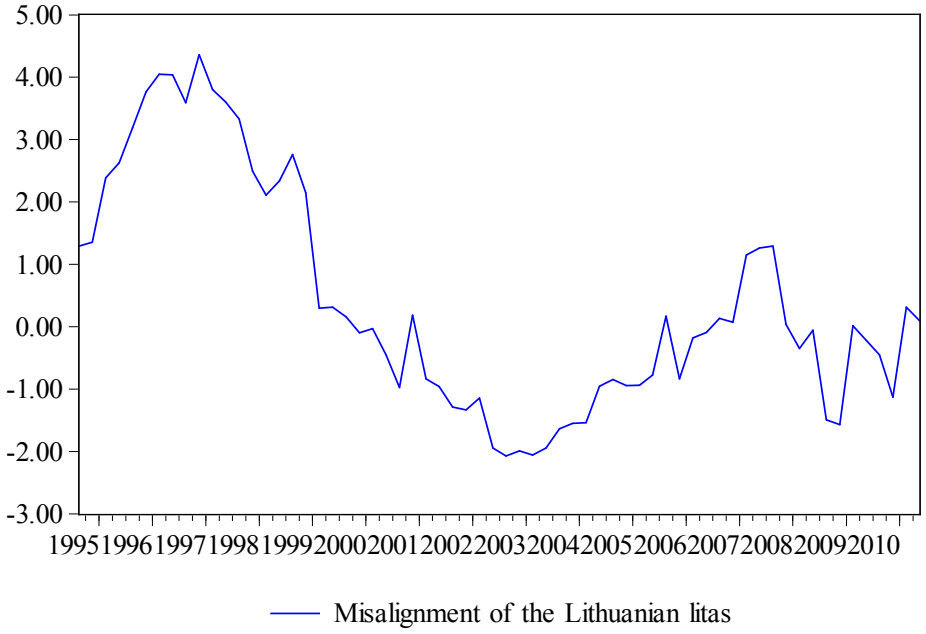



Figure 24. Exchange rate misalignment in Lithuania based on SVAR methodology




5.8. Historical decompositions of the real exchange rate

Based on the estimated SVAR, historical decomposition can be derived in order to find out whether or not the supply, demand and nominal shocks that have been identified can explain plausibly the RER movement in Switzerland and Lithuania during the periods under consideration. A historical decomposition of the real exchange rate for Switzerland and Lithuania is provided accordingly in Figure 25 and Figure 26. Results indicate that both in Switzerland and Lithuania unexpected movements in the RER are mainly driven by demand shocks, which implies that null hypothesis is rejected for Switzerland and not rejected for Lithuania.

Figure 25. Historical decomposition of RER in Switzerland

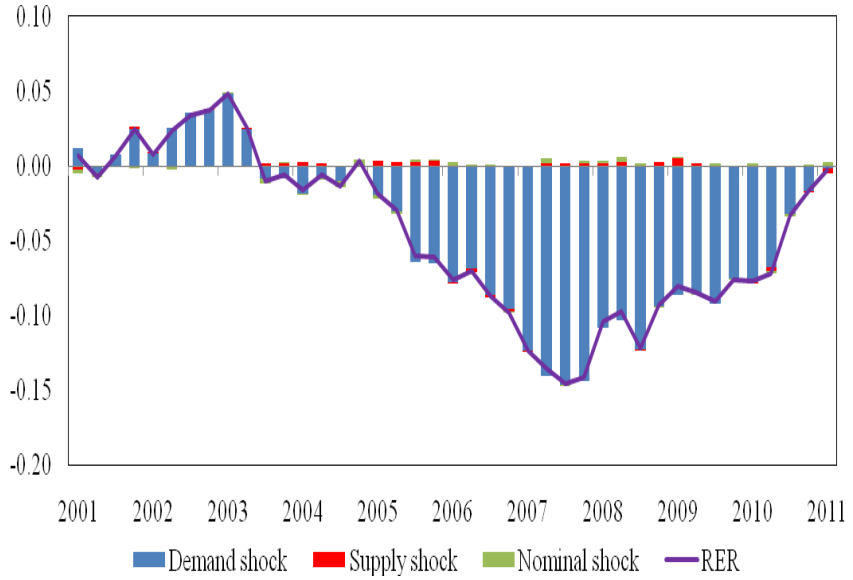
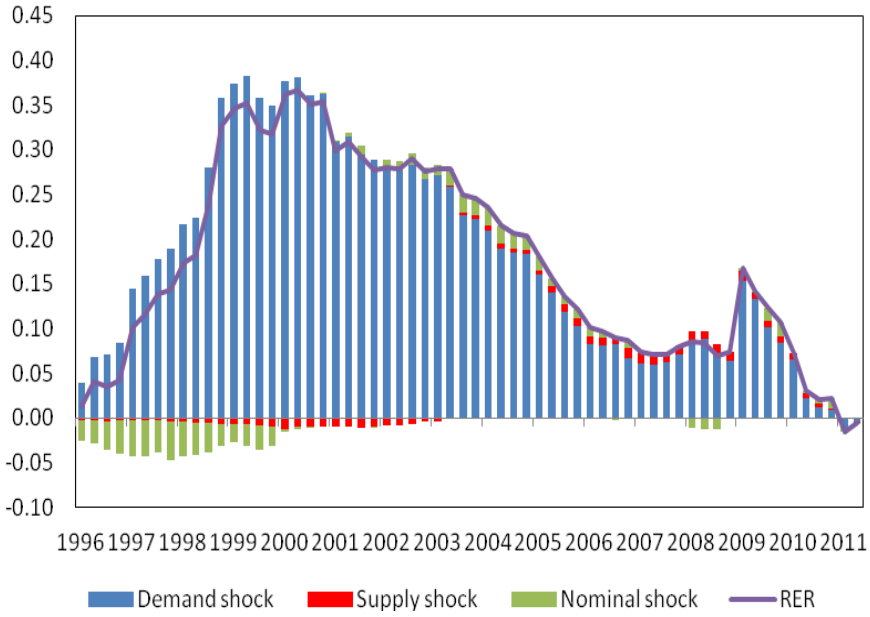



Figure 26. Historical decomposition of RER in Lithuania



# 6. Conclusion

This Master Thesis aimed at estimating the equilibrium exchange rate and its misalignment in Switzerland and Lithuania using BEER method and SVAR methodology, as well as at understanding of the effects of the monetary policy strategies in both countries using semi-structural economic model of business cycles.

Regarding the first research question for Switzerland (Are empirical observations in line with theory of floating exchange rate regime in Switzerland?) and for Lithuania (Are empirical observations in line with theory of fixed exchange rate regime in Lithuania?), results indicate that the null hypothesis (Empirical observations are in line with theory of fixed exchange rate regime in Lithuania.) cannot be rejected for Lithuania and the null hypothesis (Empirical observations are in line with theory of floating exchange rate regime in Switzerland.) can be rejected for Switzerland. Namely, in Lithuania, a country which pursues the peg to the euro, NEER is affected solely by the lagged value of NEER, which is in line with the fact that the fixed exchange rate regime does not permit any discretionary policy in response to changes in activity and inflation. On the other hand, in Switzerland, a country which conducts the floating exchange rate policy during the period analyzed, it is expected that flexible exchange rate regime enables the nominal exchange rate moves to make the effects of economic disturbances potentially less severe. However, NEER is impacted solely by the lagged value of NEER in Switzerland. Obviously, the results should be interpreted with caution due to the Lucas critique. Nevertheless, Ericsson and Irons (1995) and Gerlach-Kristen (2005) show that the Lucas critique recently matters empirically less in the applied literature. Moreover, results from the semi-structural economic model of business cycles show that Lithuania is more dependent than Switzerland on demand in the euro area.

Regarding the second research question for Switzerland (Do all of the variables, comprising productivity differential, openness to trade differential, commodity terms of trade, net foreign assets and fiscal balance to GDP differential, have impact on the equilibrium exchange rate in Switzerland?) and for Lithuania (Do all of the variables, comprising productivity differential, openness to trade differential, commodity terms of trade, net foreign assets and fiscal balance to GDP differential, have impact on the equilibrium exchange rate in Lithuania?), results indicate that the null hypothesis (All of the variables, comprising productivity differential, openness to trade differential, commodity terms of trade, net foreign assets and fiscal balance to GDP differential, have impact on the equilibrium exchange rate in Lithuania.) can be rejected for Lithuania, but the null hypothesis (All of the variables, comprising productivity differential, openness to trade differential, commodity terms of trade, net foreign assets and fiscal balance to GDP differential, have impact on the equilibrium exchange rate in Switzerland.) cannot be rejected for Switzerland, as each of the variables is statistically significant in at least one of the VECMs. Productivity differential is found to be statistically significant and to have an effect on REER in two VECMs in Switzerland, and in one VECM in Lithuania. The results also imply that the Balassa-Samuelson effect holds in both Switzerland and Lithuania. Some other variables, such as openness differential, commodity terms of trade, net foreign assets and fiscal balance to GDP differential were also found to be statistically significant and affect REER in the countries under consideration.

Estimates show that in one VECM for Switzerland the gap between current BEER and REER is closed by the adjustment in the REER itself, whereas this adjustment coefficient is not found to be statistically significant in Lithuania's case. This can be explained by the existence of the floating exchange rate regime in Switzerland and fixed exchange rate regime in Lithuania during the period analyzed. Current BEER estimates were found to be more volatile than REER due to large fluctuations in regressors themselves in both economies, however, long run BEER estimates were found to be less volatile and to follow similar trend as the REER in both economies.

With regards to the third research question for Switzerland (Is the real exchange rate overvalued, undervalued or at the equilibrium in 2009 in Switzerland?) and for Lithuania (Is the real exchange rate overvalued, undervalued or at the equilibrium in 2009 in Lithuania?), both the null hypotheses for Lithuania (Real exchange rate is overvalued in 2009 in Lithuania.) and the null hypothesis for Switzerland (Real exchange rate is overvalued in 2009 in Switzerland.) cannot be rejected. This implies that real exchange rate is overvalued in Switzerland and in Lithuania in 2009. However, the results should be treated carefully due to end-point bias problem associated with using the HP-filter. Based on the BEER method, the total exchange rate misalignment in Switzerland ranges from the undervaluation of 8.0% to the overvaluation of 14.5% from the first quarter of 2000 to the first quarter of 2010. Accordingly the total exchange rate misalignment ranges from the undervaluation of 10.3% to the overvaluation of 7.2% from the first quarter of 1999 to the first quarter of 2010 in Lithuania. These results have to be treated cautiously, as the models provide with estimates to substantial uncertainty. In addition, economists are usually cautious to interpret any big deviation from equilibrium as an indicator of serious misalignment, as the deviation may result from distortions that arise during the process of estimation.

With regards to the fourth research question for Switzerland (Is the REER affected by the demand shock, nominal shock or supply shock in Switzerland in the long run?) and for Lithuania (Is the REER affected by the demand shock, nominal shock or supply shock in Lithuania in the long run?), the null hypothesis (The REER is affected by the demand shock in Lithuania in the long run.) cannot be rejected for Lithuania, but the null hypothesis (The REER is affected by the nominal shock in Switzerland in the long run.) can be rejected for Switzerland. In Lithuania demand shock plays the dominant role in driving the changes in RER, which is in line with expectations, as Lithuania has already joined the ERMII. Taking into account the flexible exchange rate regime in Switzerland, its changes in RER are expected to be driven by nominal shocks. Nevertheless, results show that in Switzerland changes in RER are mainly driven by demand shocks. Historical decompositions of the RER show that changes in RER are mainly driven by demand shocks in both countries during the period considered, giving evidence that results are robust. The results indicate that SVAR-based EERs and RERs are very close to each other in Switzerland due to low importance of nominal shocks on the changes in RER over there. While SVAR-based EERs and RERs are also close to each other in Lithuania, the misalignment is more pronounced due to bigger effect of nominal shocks on the RER.

The estimates of the equilibrium exchange rates and their misalignment are in line with what is usually found in empirical researches about other currencies, namely that the estimates of the equilibrium exchange rates are dependent on the models chosen and surrounded by some uncertainty. Nevertheless, it is important that the methodologies used differ considerably in terms of the macroeconomic times series and underlying theoretical frameworks.

This research supports the exchange rate policy employed by the Swiss National Bank. More precisely, this research shows that real exchange rate is overvalued in Switzerland. Thus, in order to overcome the further exchange rate appreciation and, therefore, risk of deflation due to lower import prices, Swiss National Bank's policy is highly supported – it aims to weaken the national currency. It could be argued that fiscal policy could be employed to fight with the risk of deflation. However, even if the budget balance and public debt in Switzerland is in favourable situation and government could increase spending to overcome the risk of deflation under the appreciation of the Swiss franc, it must be noted that the problem lies not in the Swiss domestic economy, but rather in the world's economy and Switzerland's government is not able to stimulate the whole world's economy. Moreover, the government cannot really influence the foreigners' perception about the Swiss franc being the safe harbour and if it would raise spending substantially, it would only worsen country's domestic situation in longer term. Thus, the Swiss National Bank should continue with its current exchange rate policy.

In case of Lithuania the exchange rate is overvalued in 2009, but undervalued in the first quarter of 2010, which is a result of the internal adjustment strategy implemented by the Lithuanian Government. This strategy has proved to be very successful for Lithuania – the country recovered from the economic crisis very fast.

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