LATVIJAS BANKA

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VIKTORS AJEVSKIS
RAMUNE RIMGAILAITE
ULDIS RUTKASTE
OĻEGS TKAČEVS

THE ASSESSMENT OF EQUILIBRIUM REAL EXCHANGE RATE OF LATVIA

WORKING PAPER

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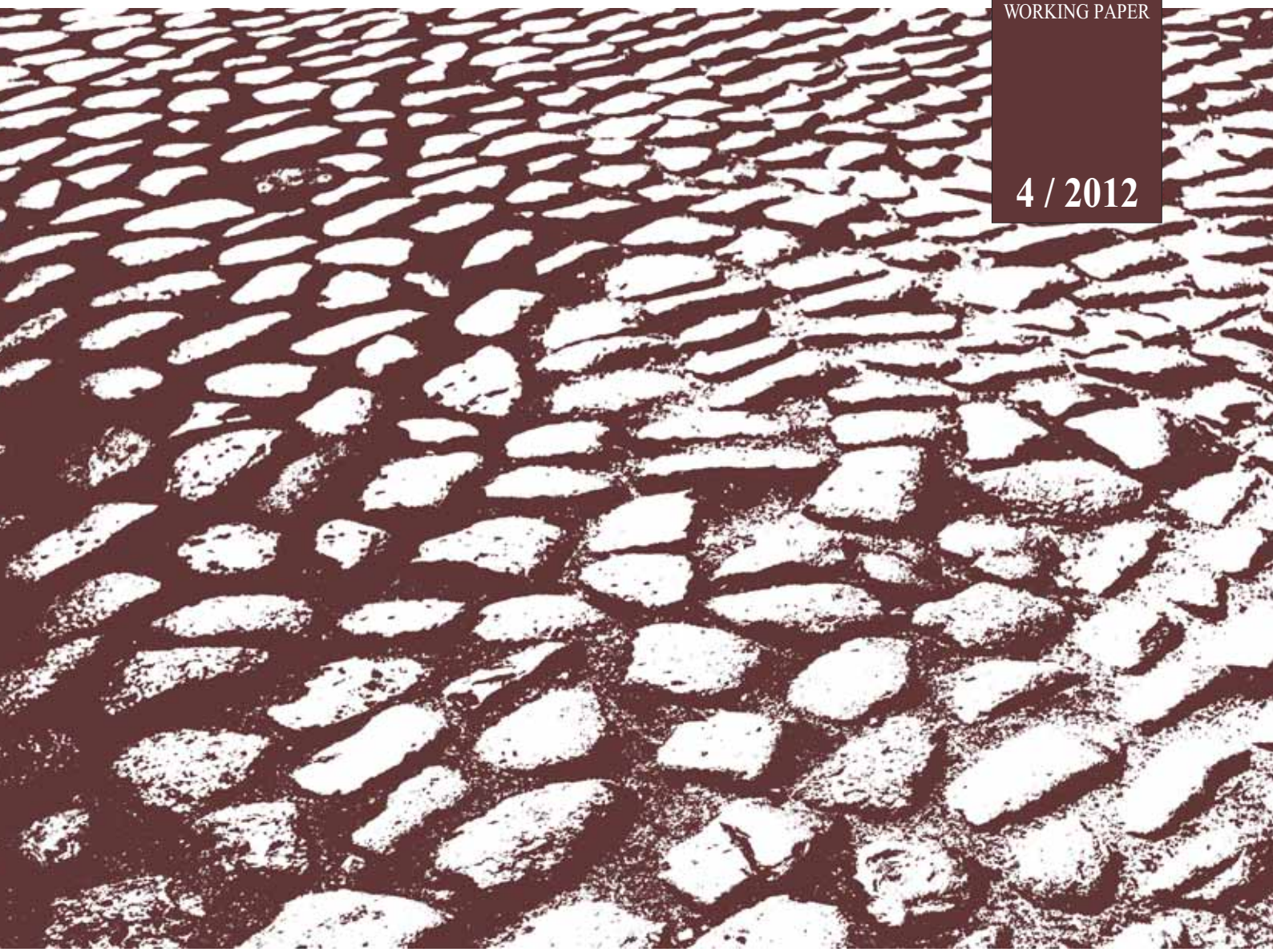


CONTENTS

ABBREVIATIONS

ADF – Augmented Dickey-Fuller Test
BEER – behavioural equilibrium exchange rate
BG – Bulgaria
CA – current account
CEE – Central and Eastern Europe
CGER – Consultative Group on Exchange Rate Issues
CPI – Consumer Price Index
CIS – Commonwealth of Independent States
CZ – Czech Republic
DF-GLS – Dickey-Fuller Generalised Least Square Test
EC – European Commission
ECM – Error Correction Model
EE – Estonia
EMU – Economic and Monetary Union
ERER – equilibrium real exchange rate
ES – external sustainability
EU – European Union
FEER – fundamental equilibrium exchange rate
HP – Hodrick-Prescott (filter)
HU – Hungary
GDP – Gross Domestic Product
GR – Greece
IMF – International Monetary Fund
KPSS – Kwiatkowski-Phillips-Schmidt-Shinn Test
LT – Lithuania
LV – Latvia
MB – macroeconomic balance
NATREX – natural real exchange rate
NFA – net foreign assets
NMS – new Member State
OLS – Ordinary Least Squares Method
PL – Poland
PP – Phillips-Perron Test
PPP – Purchasing Power Parity
PT – Portugal
REER – real effective exchange rate
RO – Romania
RUR – Russian ruble
SK – Slovakia
SL – Slovenia
SVAR – structural vector autoregression
VECM – Vector Error Correction Model
WEO – World Economic Outlook

ABSTRACT

The aim of this study is to estimate the equilibrium REER of Latvia, which was done by using different methodologies, including IMF CGER approach, and the NATREX and SVAR models. The IMF methodology implies the application of three different methods: the macroeconomic balance method, the external sustainability method and the reduced-form equilibrium real exchange rate method. The results of all approaches used in this study indicate that the real exchange rate of Latvia, after appreciation during the boom years and subsequent adjustment afterwards, remained close to its equilibrium level at the end of the sample period, i.e. at end-2010.

Keywords: equilibrium real exchange rate, BEER, macroeconomic balance, external sustainability, NATREX, SVAR, Latvia

JEL codes: F31, F32, O24

INTRODUCTION

Real exchange rate is an important economic variable as it reflects movements in relative prices. It is essential that the real exchange rate does not depart significantly and persistently from its equilibrium level determined by economic fundamentals so that relative prices remain close to equilibrium over time and country's external position is sustainable. However, the equilibrium exchange rate is not directly observable and requires to be estimated with appropriate models.

Over the past decade, Latvia experienced substantial macroeconomic fluctuations, and accumulation of internal and external imbalances brought about by unsustainably high economic growth were followed by a severe economic downturn and elimination of accrued imbalances. The real effective exchange rate has also undergone significant movements from appreciation in the boom years to subsequent adjustments in the recession period. These developments warrant an assessment of the equilibrium real exchange rate of Latvia to find out if the headline real exchange rate remains close to its equilibrium after the material fluctuations observed over past years.

This study aims at estimating the equilibrium real exchange rate of Latvia. For the purpose of assessment, we make use of a variety of different methodologies. First, we employ approaches designed by the IMF Consultative Group on Exchange Rate Issues (CGER): the macroeconomic balance (MB) approach, the external sustainability (ES) approach, and the reduced-form of the equilibrium real exchange rate (ERER) approach. The first two approaches used by the IMF stem from the concept of fundamental equilibrium exchange rate (FEER), defined by Wren-Lewis (1992) as "a method of calculation of a real exchange rate which is consistent with medium-term macroeconomic equilibrium", whereas the latter is rooted in the behavioural equilibrium exchange rate (BEER) concept introduced by Clark and MacDonald (1998). In contrast to the other two approaches, the external sustainability approach implies some normative analysis, as it hinges on the assumption of sustainable level of foreign assets/liabilities. The BEER concept, in turn, involves direct econometric estimation of the real effective exchange rate (REER) equation as a function of the set of fundamental determinants without referring to internal and/or external equilibrium of the economy. Complimentary to the above listed approaches traditionally used by the IMF, we also use two additional approaches employed by central banks and other governmental and international institutions as well as academia: the natural real exchange rate (NATREX) approach and an approach based on structural vector autoregressions (SVAR). NATREX is the real exchange rate that equates the current account balance consistent with full employment to the difference between desired savings and investment. Behavioural equations of consumption, investment and trade balance are derived by optimising economic agents' decisions. It is thus supposed to be a structurally sound model of equilibrium real exchange rate estimation. The SVAR methodology, in turn, aims at decomposing real exchange rate into permanent and transition components by identifying the supply, demand and nominal shocks using a long-run identification scheme, and then assessing the equilibrium exchange rate by assuming that only the supply (or supply and demand) shock affects REER in the long run.

The structure of this study is as follows. Section 1 makes a survey of recent studies that have dealt with the REER in Latvia. In Section 2, we lay down the theoretical background of different approaches aimed at estimating the equilibrium real exchange rate. Section 3 presents the estimates of equilibrium REER of Latvia consistently with three different approaches used by the IMF CGER. In Section 4, we estimate medium-run and long-run NATREX and make use of the SVAR approach. Section 5 compares the findings and is followed by conclusions.

1. LITERATURE REVIEW

There are several comprehensive surveys of research on equilibrium real exchange rate, with most prominent of them written by MacDonald (2000), Driver and Westaway (2004), and Egert (2006). In particular, the survey by Egert (2006) is devoted to the issues of equilibrium exchange rate estimation in the countries with transition economies. In this section, we focus only on those studies where the equilibrium real exchange rate of Latvia is considered. In the studies below, Latvia is usually a part of the broad panel of countries with only few exceptions where the co-integration technique is applied solely to the Latvian macroeconomic series.

Kazaks (2000) runs an error correction model (ECM) for the REER of Latvia and concludes that purchasing power parity concept (PPP) is a wrong way to follow, since the appreciation of Latvian real exchange rate observed in the 1990s is attributable to structural factors, particularly to economic and institutional efficiency gains. Thus the author argues that "real exchange rate appreciation in Latvia since 1994 can be viewed as equilibrium response to transition", which is a widely accepted conclusion in transition literature. An adjustment towards equilibrium is gauged to be achieved over the period of three quarters, i.e. rather rapidly.

By employing several different approaches, Bitans (2002) does not find any evidence of a significant misalignment of the Latvian lats, since the real appreciation of exchange rate vis-à-vis the countries of Western Europe is in line with the appreciation of equilibrium exchange rate driven mainly by rising productivity in the tradable sector.

Candelon et al. (2007) apply the panel co-integration approach to the panel of Baltic States using quarterly data covering the time period of 1993–2001. The real exchange rate of Baltic States' currencies vis-à-vis the euro is found to be driven by productivity differential with the euro area and openness of the economy, whereas there is no clear evidence whether the demand for non-tradables (as proxied by government, private or total consumption) plays any role. Co-integration tests, however, provide quite mixed results, with only some of them indicating that the variables are cointegrated. On the basis of estimated coefficients, the authors construct time paths of equilibrium REER for each country and conclude that there have not been sizeable misalignment episodes across the Baltic countries, with Latvia experiencing undervaluation of 6%–10% at the end of the period.

Fic et al. (2008) study macroeconomic consequences of setting irrevocably fixed parity against the euro at a misaligned rate. They carry out the study by estimating equilibrium exchange rates for eight out of ten NMSs committed to enter the EMU after fulfilling the Maastricht criteria. The equilibrium REER is assessed by using a variant of FEER approach, whereby a target is formulated in terms of external debt. The results show that in case the parity rate is set at a misaligned rate, the Baltic States' REERs would converge to their real long-run equilibrium faster than REERs of the other NMS economies, closing 70%–90% of the gap in 2–3 years. In the Baltic States, a 5% misalignment of the entry rate on average results in a 0.4% cumulative impact on output in 3 years and 4.1% cumulative change in the price level. Higher speed of convergence in the Baltic States is brought about by a very good microeconomic performance of these countries, including business environment of high quality and a flexible labour market.

Several studies have been conducted in the period after the economic crisis. Among them is the one by Babecký et al. (2011). By employing the approach consistent with both stock and flow equilibrium and similar to the one used in Fic et al. (2008), the authors focus on recent changes in the equilibrium REER and projections for 2010–2014. The authors conclude that most sample countries, including Latvia, appeared to be misaligned in 2009, particularly the countries with hard pegs. By applying BEER to the panel of CEE countries, Albulescu and Goyeau (2011) argue that Latvia's real exchange rate seems undervalued in comparison with the equilibrium exchange rate. Caporale et al. (2011) argue that the generalised PPP hypothesis holds for the real exchange rate of each Baltic state with respect to the euro, reflecting a degree of real convergence consistent with the optimum currency area criteria. Finally, Syllignakis and Kouretas (2011) examine the dynamic relationship between bilateral exchange rates of 10 CEE countries against the euro and their fundamentals within the framework of the monetary model. By employing a Markov-Switching Vector Error-Correction model (VECM), the study finds that the adjustment towards the long-run equilibrium during the periods of fixed exchange rate occurs through the fundamentals rather than through the exchange rate itself. Similar conclusions are made in the present study as will be shown later. In Latvia's case, the authors claim that this result is consistent with monetary authorities adopting a fixed exchange rate regime at the beginning of 1994.

Table 1
Summary of empirical studies involving REER of Latvia

Author, year	Misalignment	Metho-dology	Econometric approach	Country	Period
Kazaks (2000)	No sizeable misalignment	BEER	ECM	Latvia	1993M3–1998M6
Bitāns (2002)	No sizeable misalignment	BEER	ECM	Latvia	1994Q1–2001Q4
Bitāns (2002)	No sizeable misalignment	FEER	Macro balance approach	Latvia	1994Q1–2001Q4
Babecky et al. (2011)	27.9% overvaluation in 2009	FEER	ECM	NMSs (excluding Cyprus and Malta), GR, ES, PT	1998Q1–2009Q3
Albulescu and Goyeau (2011)	Undervalued	BEER	Panel regression	BU, CZ, ES, HU, LT, LV, PL, RO	1999–2009
Caporale et al. (2011)				LV, LT, EE	1993M1–2005M12
Candelon et al. (2007)	6%–10% undervaluation in 2003Q1	BEER	Panel cointegration	LV, LT, EE	1993Q1–2003Q1, 1995Q1–2003Q1
Fic et al. (2008)	Overvalued over 2002–2005	FEER	ECM	NMSs (excluding Malta and Cyprus)	1995Q1–2005Q4
Syllignakis and Kouretas (2011)	–	Monetary model	Markov-Switching VECM	BG, CZ, LT, SK, EE, HU, SL, LV, RO, PL	1995M12–2010M5

2. OVERVIEW OF EQUILIBRIUM REAL EXCHANGE RATE ESTIMATION APPROACHES

Broadly speaking, all approaches aimed at assessing the equilibrium real exchange rate could be divided into two groups: the approaches involving structural models where internal and external balances are assumed to hold, and the direct estimation approaches where the equilibrium real exchange rate is obtained by estimating reduced-form equations with real exchange rate specified as a function of fundamental determinants. The most popular representation of structural approaches is FEER, while of the direct approaches the BEER is the most commonly used.

Fundamental equilibrium exchange rate

The FEER, an acronym introduced by Williamson (1983), is the REER consistent with macroeconomic (more specifically, internal and external macroeconomic) balance whereby the current account (economy operates in the situation of full employment and low inflation) is made equal with a sustainable capital account position. The approach starts from the balance of payments identity:

$$CA_t + KA_t = 0 \quad [1]$$

where CA_t and KA_t denote current account and capital account respectively. The current account may be represented as the sum of net exports and interest received on the stock of net foreign assets as follows:

$$CA_t = NX_t + i_t NFA_t \quad [2]$$

where NX_t denotes net exports, NFA_t is the notation for net foreign assets, and i_t is interest rate.

For net exports NX_t, the following relationship is usually supposed to hold:

$$NX_t = -a_1(s_t + p_t - p_t^*) - a_2 y_t + a_3 y_t^* \quad [3]$$

where s_t is the log of nominal exchange rate, and an increase in s_t means appreciation of national currency, p_t is the log of price index, and y_t is the log of aggregate demand. Asterisk denotes foreign variables, and a_s are elasticities. The first term represents the effect of real exchange rate on net exports. If a country's REER appreciates, the term increases and net exports worsen, assuming that the Marshall-Lerner condition holds. When the domestic demand increases, imports presumably rise, and this has a negative impact on net exports. By contrast, an increase in foreign demand is associated with an increase in the country's exports and improvement in net exports and current account balance.

Inserting equations [2] and [3] into identity [1] gives:

$$-a_1(s_t - p_t^* + p_t) - a_2 y_t + a_3 y_t^* + i_t NFA_t = -KA_t \quad [4]$$

or, alternatively,:

$$-a_1 q_t - a_2 y_t + a_3 y_t^* + i_t NFA_t = -KA_t \quad [5]$$

where the real exchange rate is defined as $q_t = p_t - p_t^* + s_t$. As mentioned above, the FEER can be obtained by setting the current account (at full employment) equal to sustainable capital account:

$$-a_1 q_t - a_2 \bar{y}_t + a_3 \bar{y}_t^* + i_t \overline{NFA}_t = -\overline{KA}_t^{st} \quad [6].$$

Here a bar denotes a long-run/sustainable level of variable. Subscript *st* means structural capital flows that emphasise the exclusion of speculative capital flows from the capital account balance. As shown by Wren-Lewis (2003), the FEER is automatically also the exchange rate that equates the aggregate demand and supply as the balance of payments identity can alternatively be derived from the national income identity.

Such an approach involves a form of normative analysis, since one needs to make an assumption regarding the equilibrium level of the capital account position. The difference between desired aggregate saving and investment at full employment (S – I) could be used as a proxy for the equilibrium capital account balance. The full employment levels of savings and investment are estimated as functions of various macroeconomic and demographic variables (as in the *macroeconomic balance* approach of the IMF CGER employed in this study below). One should bear in mind that FEER estimated by the approach above represents flow equilibrium with no reference to long-term stock equilibrium. However, some versions of FEER are consistent with stock equilibrium as well. For instance the *external sustainability* approach of the IMF CGER employed in the following section is the stock-flow equilibrium consistent variant of the FEER methodology.

Behavioural equilibrium exchange rate

This approach rests on the direct econometric estimation of equilibrium real exchange rate using the following reduced-form equation:

$$q_t = \beta_1' Z_{1t} + \beta_2' Z_{2t} + \tau' T_t + \varepsilon_t \quad [7]$$

where Z_{1t} is a vector of economic fundamentals having effect on REER in the long-run and Z_{2t} denotes a vector of economic fundamentals having effect on REER in the medium-term, while T_t is a transitory short-term component, ε_t is a random disturbance term, β_1, β_2 and τ are vectors of reduced-form coefficients. According to Clark and MacDonald (1998), two types of misalignment can be distinguished.

Current misalignment is the difference between the actual REER and the REER given by the current values of the medium and long-term fundamentals q':

$$cm_t = q_t - q_t' = q_t - \beta_1' Z_{1t} - \beta_2' Z_{2t} = \tau' T_t + \varepsilon_t \quad [8].$$

Due to the fact that medium- and long-term fundamentals may divert from sustainable or equilibrium levels, which are denoted by $\bar{Z}_{1t}$ and $\bar{Z}_{2t}$, Clark and MacDonald (1998) also introduce the definition of total misalignment:

$$tm_t = q_t - \beta_1' \bar{Z}_{1t} - \beta_2' \bar{Z}_{2t} \quad [9].$$

Using equations [7] and [8], total misalignment can be written as:

$$tm_t = \tau' T_t + \varepsilon_t + \beta_1' (Z_{1t} - \bar{Z}_{1t}) + \beta_2' (Z_{2t} - \bar{Z}_{2t}) \quad [10]$$

where transitory factors and the deviation of medium and long-run determinants from their equilibrium levels are taken into account. In practice, the cointegration technique is used to find medium-run relationship between the REER and economic fundamentals.

3. EXCHANGE RATE ASSESSMENT USING IMF CGER METHODOLOGY

The IMF Consultative Group on Exchange Rate Issues was established with the mandate to provide exchange rate assessments for a number of advanced and emerging economies. Now the IMF applies CGER methodology to all advanced, emerging and developing economies covered by the World Economic Outlook. The CGER approach consists of three distinctive but complimentary methodologies. Those are the reduced-form ERER, the MB and the ES approaches. The MB and ES approaches stem from the concept of FEER consistent with medium-term macroeconomic equilibrium, whereas the ERER is rooted in the BEER concept. Whenever these methods point to similar outcomes, one may come to a more confident conclusion about the deviation of real exchange rate from its equilibrium. In this section we assess equilibrium real effective exchange rate of Latvia using IMF CGER methodologies and start with ERER approach based on BEER.

3.1 The ERER approach

The ERER approach involves the following two steps (IMF, 2006 and Lee et al. (2008)):

- A reduced-form relationship between the real exchange rate and a set of fundamentals is estimated.
- The equilibrium real exchange rate is calculated using the coefficients obtained from the econometric relationship.

The ERER approach uses the panel cointegration technique and a broad set of countries for the estimation of cointegrating relationship for real exchange rate. Despite the fact that the use of the panel econometric technique increases the number of observations significantly, thus improving the precision of estimation, the use of it may come at the cost of inconsistent and biased estimates if the assumption of homogeneity across countries does not hold. As Latvia is out-of-sample in IMF panel estimations, we use single-country (time series) estimation in this paper. Calculations and findings obtained by applying formal IMF CGER coefficients to Latvia's data are provided in Appendix 1.

3.1.1 REER determinants in the framework of ERER approach

In choosing REER determinants, we follow the IMF (2006), Lee et al. (2008) and Bussière et al. (2010), that also include a comprehensive review of literature on medium to long run factors determining the equilibrium real exchange rate. Below we summarise a variety of possible determinants of equilibrium real exchange rate and deal with their historical developments based on Latvia`s macroeconomic series in the next sub-section.

Net foreign assets

If a country is in debtor's position, net interest payments weigh on the current account balances. These should be compensated for by improved trade balance. The latter requires strengthening the international price competitiveness and a more depreciated real exchange rate. On the contrary, the countries in creditors' position can maintain more appreciated currencies and run a trade deficit.

Fiscal balance

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

Productivity differential

The effect of 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 will put upward pressure on wages in the non-tradables sector, leading to higher relative prices of non-tradables and, thus, real appreciation. The Balassa-Samuelson theory rests on few strict assumptions, e.g. labour is perfectly mobile across sectors of the economy, and as a consequence the wages are equalised between both sectors.

Investment ratio

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

Commodity terms of trade

It is expected that higher commodity terms of trade 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.

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. This leads to more depreciated currencies. Conversely, higher non-tariff barriers and import tariffs for cross-border trade, which are designed to protect domestically produced goods from foreign competition, are expected to lower country's openness to trade and increase domestic prices as well as to lead to real appreciation of currency.

Government consumption to GDP

An increase in government consumption biased toward nontradables as a ratio of GDP is likely to increase relative prices of nontradable goods and lead to real exchange rate appreciation.

3.1.2 Description of Data

In this study, quarterly data covering the period from the first quarter of 2001 to the fourth quarter of 2010 are used. The choice of the period is dictated by the absence of some of the variables for earlier years on the one hand, and structural changes of Latvia's economy that took place right after the Russian crisis when Latvia switched

away from CIS markets towards European markets on the other. For instance, the data on productivity differential vis-à-vis trading partners are available only from 2001 due to the fact that Poland's data on employment by sectors of the economy are missing for the years preceding 2001. As to the structural changes, a significant shift in external trade pattern was represented by a change in Latvia's merchandise export share to the CIS countries that before the Russian financial crisis had stood between 35%–45% and quickly declined to around 10%–15% after it. Given that lagged foreign trade weights are used in the REER calculations and the switch of external trade towards more developed markets was likely to carry with it also a change in quality of exported goods, these developments may have distorted the REER data, and they may, to some extent, mask the underlying developments of real exchange rate at that time.

Most variables (except for net foreign assets and terms of trade) are calculated as deviations from the respective weighted average values for Latvia's major trading partners Denmark, Germany, Estonia, France, Italy, Lithuania, the Netherlands, Poland, Finland, Sweden and the United Kingdom. All variables have been seasonally adjusted by census X12. Precise definitions of the variables can be found in Appendix 2. Figure 1 plots the series used for ERER estimations.

Commodity terms of trade showed a downward trend in 2001–2009 mainly because of the sharp fall in the agricultural raw material price index. A notable increase in Latvia's commodity terms of trade in 2009–2011 was likewise mainly driven by the agricultural raw material price index for two reasons. First, of all traded Latvian goods, the agricultural raw material price index increased most. Second, the share of agricultural raw material exports in total exports was larger than the share of agricultural raw material imports in total imports. It implies that an increase in the prices of agricultural raw materials affected Latvia's export deflator more that Latvia's import deflator.

The fiscal balance as a ratio to GDP in Latvia was close to zero over 2005–2008 on the background of huge tax revenue windfalls; it deteriorated significantly as the crisis set in and revenues fell sharply.

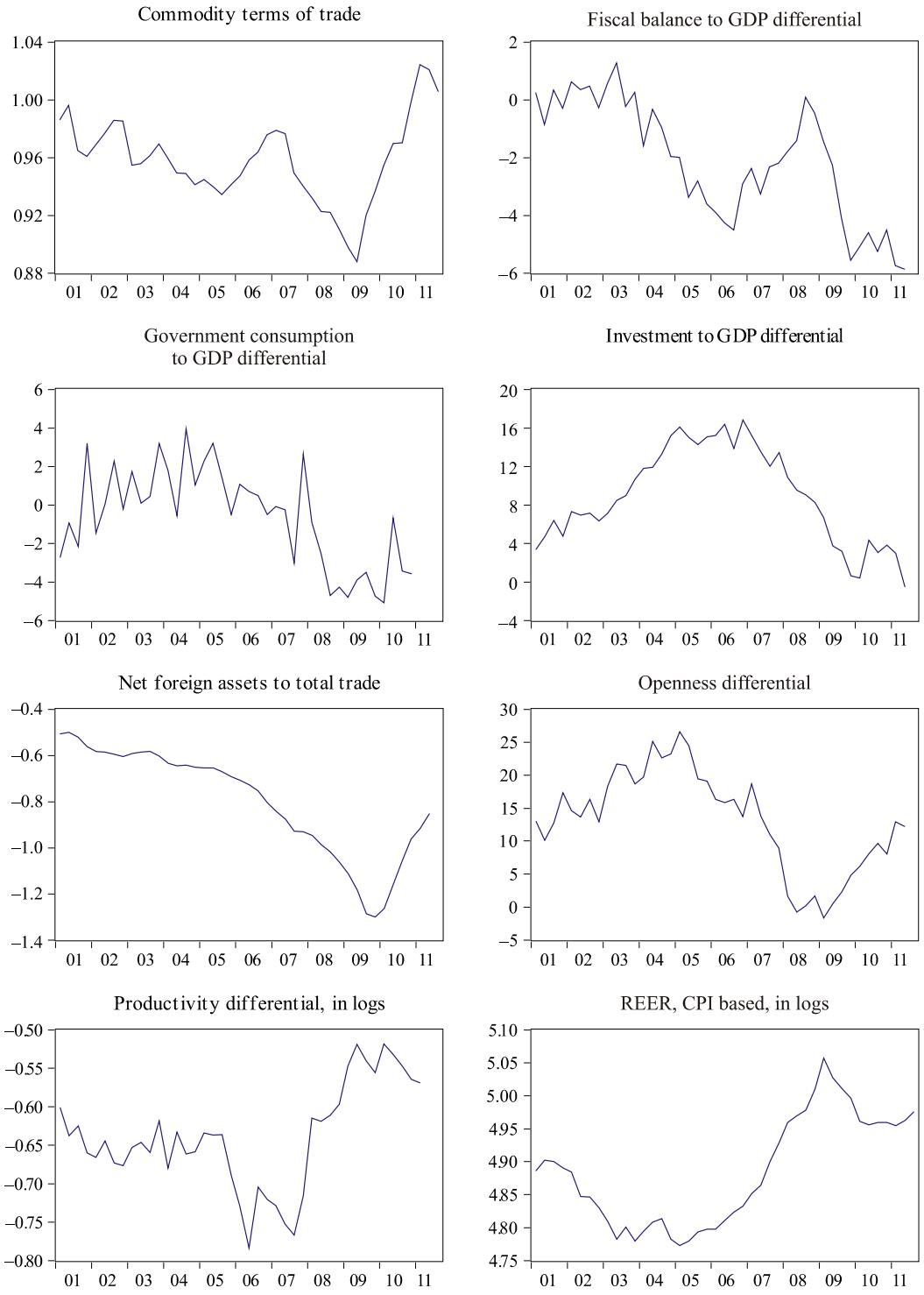
The government consumption ratio to GDP in Latvia was higher than that in the economies of trading partners but has been brought below the trading partners' average since the outset of the crisis.

The investment to GDP ratio differential was steadily growing from 2001 to 2005 owing to substantial capital inflows related to the EU accession; afterwards, it started to fall reacting to deteriorating confidence in the Latvian economy. Finally, as the crisis set in, it plummeted dramatically.

With the financial market developing and lending activity rising, Latvia's foreign liabilities soared and the ratio of net foreign assets to total foreign trade turnover decreased significantly from 2001 to 2007. At the outset of the global financial crisis, this ratio was lower than the average 2000 level by more than 2.5 times. It started to increase in 2009, reflecting the deleveraging process in the private sector.

A fall in openness relative to trade partners over 2005–2008 can be explained not only by a decline in Latvia's openness but also by a larger increase in openness of Germany and Lithuania.

Figure 1
Evolution of equilibrium real exchange rate determinants in Latvia

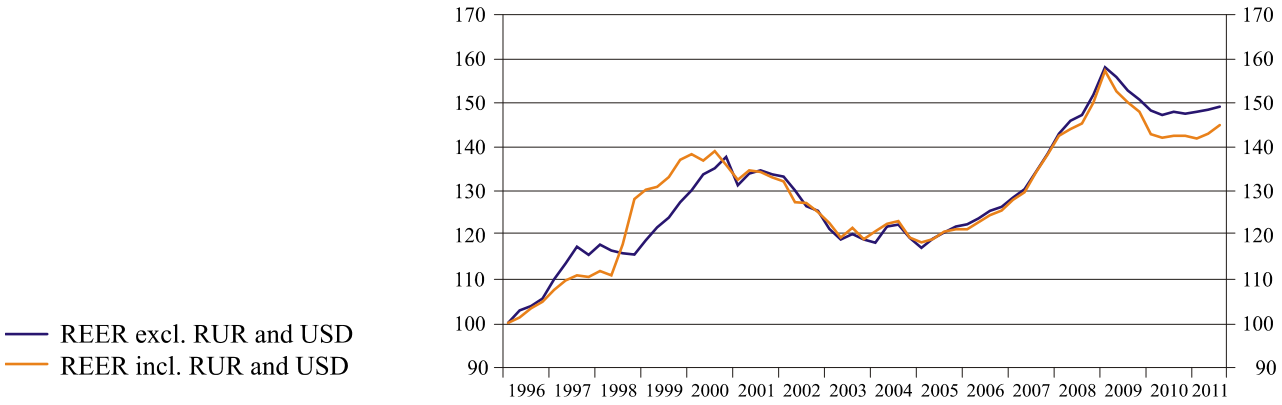


Sources: Authors' estimates, Bank of Latvia, Eurostat and World Bank.

The dynamics of CPI-based REER is presented in Figure 2. To give a more complete view of the REER development, we show its dynamics for a broader time period, i.e. from 1996 to 2011. In the calculations throughout this study, we use the

REER of Latvia with respect to the currencies of 11 major trading partners listed above (constituting 61% of Latvia's exports and 64% of Latvia's imports in 2011). Double export weights are used to calculate the REER and also to weight the variables used in this study. The Russian rouble and the US dollar are excluded due to problems in gathering data for REER determinants. Their exclusion, however, does not change significantly the path of REER (see Figure 2).

Figure 2
Evolution of REER of Latvia including and excluding RUR and USD



Sources: Bank of Latvia and authors' calculations.

The appreciation period from 1996 to 2001 can be described as the initial stage of the catching-up process. It is worth noting, though, that the REER including RUR underwent steeper appreciation in real terms in the second half of 1998 than its counterpart without RUR due to nominal devaluation of RUR on the background of the Russian financial crisis; afterwards, as the structure of Latvia's international trade changed considerably and the share of Russia and other CIS countries declined but that of other countries (primarily the EU countries) increased, this effect faded out. During 2001–2003, the Latvian REER depreciated somewhat in real terms on account of low domestic inflation. The latter resulted from low domestic demand after the crisis, stagnating Western European economies and subsequently low imported inflation, declining oil prices in the aftermath of 11 September and the absence of pressure on administratively regulated prices. In 2005, the Latvian REER started to appreciate on account of a rapid rise in domestic prices brought about by substantial capital inflows and unsustainably high domestic demand; however, an improvement in the quality of Latvian goods and several supply related factors raised prices even further. At the end of 2008, the crisis set in, domestic demand fell and the government pursued internal adjustment strategy aimed at restoring cost competitiveness of the Latvian economy. In 2009, a significant decline in labour costs led to a fall in prices and, as a result, the REER started to depreciate. After the first quarter of 2010, the REER stabilised.

3.1.3 Direct estimates of equilibrium real exchange rate

A simple approach to pin down equilibrium real exchange rate is to use one of the forms of the PPP theory, which states that the exchange rate moves to equate the price of goods and services across countries. The strict form of the PPP (which is based on an assumption of no arbitrage that ensures the law of one price) supposes that the log of REER should always equal zero, although the cross-country

differences in the composition of price indices used to calculate the real exchange rate or the existence of constant transaction costs mean that the PPP may only hold for a constant different from zero.

Less restrictive form of PPP assumes that there is a level around which the REER may fluctuate, thus it can deviate from this level for some time due to a number of factors like transportation costs and foreign exchange market intervention. This means that instead of the log of REER being equal to zero it should be a mean-reverting process.

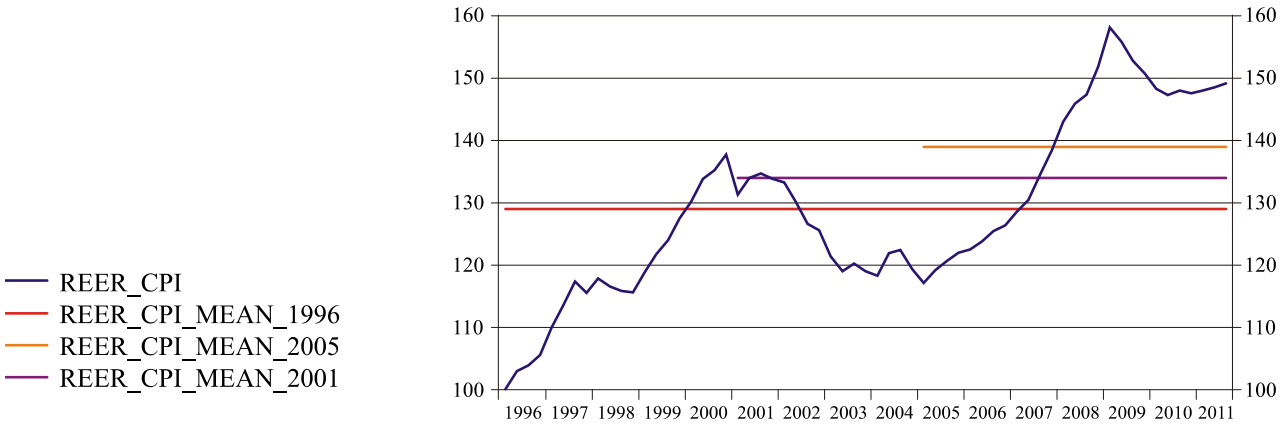
One may assess the equilibrium real exchange rate and extent of misalignment by simply looking at the mean value of REER and the gap vis-à-vis the actual REER. The idea behind this approach is related to an assumption that PPP holds and the equilibrium real exchange rate is the mean around which the REER fluctuates. If PPP holds in this form, the REER must be stationary.

We estimate the equilibrium real exchange rate as an average of historical observations of REER as an initial rough benchmark for further calculations. Observations from the early years of the transition period may not be relevant, given substantial transformations the economy had undergone. Therefore, along with the whole period for which data is available (since 1996), we also use average values for the period for which our model is estimated in the next subsection (post-2001) and the last six years (after 2005 when the peg was changed to the euro) to roughly estimate the equilibrium real exchange rate for Latvia.

Figure 3 shows that in the third quarter of 2011, the CPI-based REER points to overvaluation of 15.6% relative to the average level calculated for the period from the first quarter of 1996 to the third quarter of 2011, 11.3% for the period from the first quarter of 2001 to the third quarter of 2011, and 7.3% for the period from the first quarter of 2005 to the third quarter of 2011.

Figure 3

Average of historical observations of CPI-based real exchange rate using three different periods



Sources: Authors' calculations and Bank of Latvia.

The biggest misalignment at the last date, the third quarter of 2011, is found for the full sample, i.e. from the first quarter of 1996 to the third quarter of 2011. It results from improper accounting for initial undervaluation. As noted by Halpern and Wyplosz (1997), the exchange rate for catching-up economies was largely undervalued at the outset of transition mainly due to widespread price regulation.

To check whether the REER has a mean reverting property, we test the REER series for the unit root. If the null hypothesis of unit root is not rejected, we are not able to argue that the REER has a mean reverting property and equilibrium real exchange rate cannot be estimated correctly as an average for a certain period of time.

We use a set of unit root tests: the Augmented Dickey-Fuller (ADF) test, the Dickey-Fuller GLS (DF-GLS) test and the Phillips-Perron (PP) test. The DF-GLS test supposedly improves the low power of conventional ADF test in finite samples (Elliott et al., 1996). Testing the null hypothesis using ADF, DF-GLS and PP tests is tantamount to a test for a single unit root in the data-generating process and implies no long-run equilibrium.

The unit root test results for all variables, both in levels and in first differences, are provided in Appendix 3. The null hypothesis of a unit root cannot be rejected according to ADF, DF-GLS and PP tests. Thus the REER does not have a mean reverting property.

Turning to the REER determinants, we do not have robust evidence of their stationarity as shown by the test results. At the same time, for these variables in the first differences, the null hypothesis of a unit root can be rejected, implying that all these variables (along with the REER itself) appear to be integrated of order one, and there is a possibility of cointegration relationship between them. Non-rejection of the hypothesis of nonstationarity of the REER over the time span used in this study brings about the conclusion that a constant level to which the REER may converge does not exist, and thus the PPP is rejected over the time horizon analysed in this study. The next step is to assume the existence of the time-varying exchange rate equilibrium, which can be represented by cointegration relationship between the real exchange rate and its determinants under the condition that the determinants are also nonstationary. This enables us to employ an econometric technique designed for non-stationary series in the next section.

3.1.4 Cointegration analysis, current and long-run equilibrium REER

The ERER approach to exchange rate assessment involves three stages. First, we estimate the reduced-form REER equation based on the Latvian macroeconomic series. Second, by using the coefficients estimated in the first stage, we calculate the equilibrium real exchange rate. The coefficients could be applied both to the actual values of regressors (resulting in the so-called current BEER) and to their cyclically-adjusted values (long-term BEER). Third, we derive the gap between the actual REER and the long-term BEER estimated in stage 2. We interpret this gap as the REER misalignment.

Taking into consideration that the unit root tests conducted in the previous section do not reject non-stationarity of the variables, we make use of cointegration technique to estimate the equilibrium exchange rate. Cointegration analysis is carried out by applying the Johansen procedure that estimates the following VECM:

$$\Delta y_t = \gamma + \Pi y_{t-1} + \sum_{k}^{K-1} \Gamma_k \Delta y_{t-k} + \varepsilon_t \qquad [11]$$

where y_t is a (n × 1) vector of n variables, γ is a (n × 1) vector of constants, Γ_i represents (n × n) matrixes of short-run coefficients, ε_t denotes a (n × 1) vector of n

iid residuals, k is the number of lags used in the VAR related to VECM, and Π is a (n × n) matrix of coefficients. If matrix Π has a reduced rank (0<r<n), it can be split into a (n × r) matrix of loading coefficients α and a (n × r) matrix of cointegrating vectors β, so that Π = αβ'. The former indicates the speed of adjustment to equilibrium, while the latter represents the long-term equilibrium relationship.

In order to check the existence of cointegration relationships, we estimate 256 VECM specifications for all possible subsets of 3 to 7 variables with different number of lags. We identify 21 VECMs containing cointegrating vectors for the REER with theoretically plausible signs. However, only four of them pass the diagnostic tests on normality, heteroskedasticity and serial correlation of residuals, and contain statistically significant (at 5% reference value) cointegrating parameters. In Table 4A3 of Appendix 3, the trace statistics together with 95% critical values are reported for these models.

Table 2
Estimation of VECMs for reduced-form REER equation

	Variable	VECM1	VECM2	VECM3	VECM4
	Constant	5.210	4.944	3.750	4.409
Long-run parameters	Productivity differential	0.267 (2.067)	_	0.752 (4.193)	0.825 (5.560)
	Total trade to GDP ratio	–0.012 (–11.416)	_	_	–0.008 (–8.191)
	Net foreign assets	_	0.109 (1.908)	_	_
	Terms of trade	_	_	1.685 (3.706)	1.176 (2.975)
	Fiscal balance to GDP ratio	_	–0.052 (–8.553)	–0.031 (–7.162)	_
Adjustment coefficients	Exchange rate	–0.089 (–0.769)	–0.002 (–0.027)	0.080 (0.973)	0.078 (0.743)
	Productivity differential	–0.014 (–0.054)	_	0.551 (3.793)	0.683 (3.474)
	Total trade to GDP ratio	–95.553 (–3.858)	_	_	–50.880 (–1.978)
	Net foreign assets	_	0.004 (0.043)	_	_
	Terms of trade	_	_	–0.019 (–0.305)	0.022 (0.304)
	Fiscal balance to GDP ratio	_	–28.070 (–5.408)	–20.806 (–2.644)	_
Diagnostic tests	Serial correlation test	9.702 [0.375]	6.442 [0.695]	6.387 [0.983]	21.823 [0.149]
	Normality test	7.207 [0.302]	11.196 [0.083]	12.377 [0.135]	11.810 [0.160]
	Heteroskedasticity test	99.690 [0.131]	50.480 [0.376]	168.651 [0.717]	180.124 [0.483]

Source: authors' estimates.

Note: *t*-statistic values for long-run parameters and adjustment coefficients are provided in parenthesis, probability levels for diagnostic tests are placed in square brackets.

The trace tests show that there is at least one cointegrating relationship in the models chosen, while the second cointegrating relationship is only marginally significant in

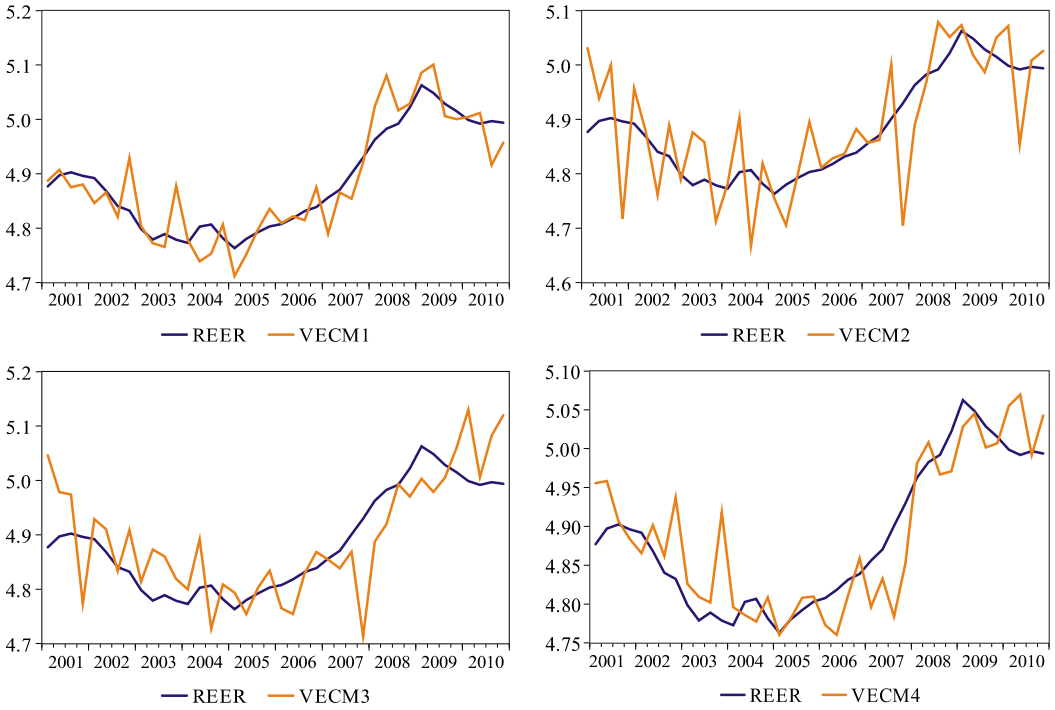
VECM1 and VECM2. We therefore focus on the specification with only one cointegrating relationship (we cannot reject the existence of at most one cointegrating relationship at the 1% level for all chosen specifications). Cointegrating parameters, their *t*-values, adjustment coefficients and the results of diagnostic tests of four VECMs are reported in Table 2.

The estimated VECM1 shows that movements in REER are correlated positively with the developments in productivity differential vis-à-vis trading partners and negatively with the degree of openness. We identify the statistical significance of productivity differential in three VECMs out of four chosen, while the total trade to GDP ratio appears to be statistically significant in only two of them. By contrast in VECM2, the real exchange rate is correlated positively with the net foreign assets and negatively with the fiscal balance to GDP ratio. It should be noted that none of the VECMs identifies statistical significance of the investment ratio and government consumption ratio in a long-run relationship for REER.

What seems to be striking is the fact that the adjustment coefficients for REER are not significant in any VECM specification, i.e. the gap between the actual and equilibrium REER is not closed by an adjustment in the REER itself, which may be the outcome reflecting the fixed exchange rate regime in Latvia and inertia of prices and is in line with the above cited study by Syllignakis and Kouretas (2011). In VECM1, the gap of 100% is reduced in the following period by the total trade to GDP ratio falling by 95.6 percentage points, in VECM2 by budget deficit growing by 28 percentage points thus driving an equilibrium towards its actual level and not *vice versa*. In VECM3, the gap is decreased by both productivity differential and fiscal balance adjustments, while in VECM4 by productivity differential and trade to GDP ratio adjustments.

Now we move on to the next stage aimed at assessing the equilibrium real exchange rate of Latvia based on VECM estimates of coefficients in cointegration relationship. First, we apply the estimated coefficients to the actual (non-filtered) values of regressors. The results are presented in Figure 4. The current BEER seems to exhibit larger fluctuations than the REER for all four sets of VECM estimates on account of substantial fluctuations in regressors themselves. Such "equilibrium" could hardly be interpreted as the determinant of future movements in REER. This type of "equilibrium" reflects the relationship between REER and fundamental economic variables after full adjustment in a sense of the error-correction model. However, fundamentals may themselves not be at their long-run or "equilibrium" values in the current BEER. That is the reason why most studies apply smoothing of regressors to derive their long-term values. Next, we apply the widely used Hodrick-Prescott statistical filter to obtain long-run values of the variables.

Figure 4
REER and current BEER (2001Q1–2010Q4)



Source: Authors' estimates.

Long-run equilibrium using Hodrick-Prescott filter approach

An interpretation of REER current misalignment based on the current BEER could be misleading because the fundamentals themselves could be far away from equilibrium. To estimate total misalignment (equation [10]), we need a method to obtain potential values of determinants. It can be done by applying a normative procedure in the same manner as in FEER or by applying a smoothing technique like the Hodrick-Prescott (HP) filter, which has been widely used in the BEER literature to estimate potential values of fundamental variables starting from seminal paper by Clark and MacDonald (1998). But we acknowledge that it provides estimates that are distorted due to asymmetries at the beginning and at the end of the sample. Therefore the long-term BEER estimates for the last four quarters should be treated with caution.

When looking at regressors' actual and HP-filtered values (see Figure 5), one may come to several conclusions. The trend of productivity differential has been growing steadily since the third quarter of 2006, pointing at the productivity catch-up in Latvia and a fall in productivity in the non-tradables sector. The trend of the total trade to GDP ratio has been heading downwards since the fourth quarter of 2004 because the openness of Latvia's major trading partners was growing at a faster pace than that of Latvia. Building up external liabilities resulted in a steady fall in the trend NFA position. The actual NFA bottomed out in 2010 and started to reverse owing to deleveraging of the private sector. However, this has not been reflected in the NFA trend dynamics yet. Before stabilising, the commodity-terms-of-trade trend had been slowly declining till 2009 and even slightly increasing over the period between the third quarter of 2009 and the fourth quarter of 2010. Finally, the HP-

filtered budget balance to GDP ratio had been constantly declining since 2004, reflecting the pro-cyclical fiscal policies implemented by Latvian authorities before the economic downturn.

Figure 5
Regressors: actual vs HP-filtered values

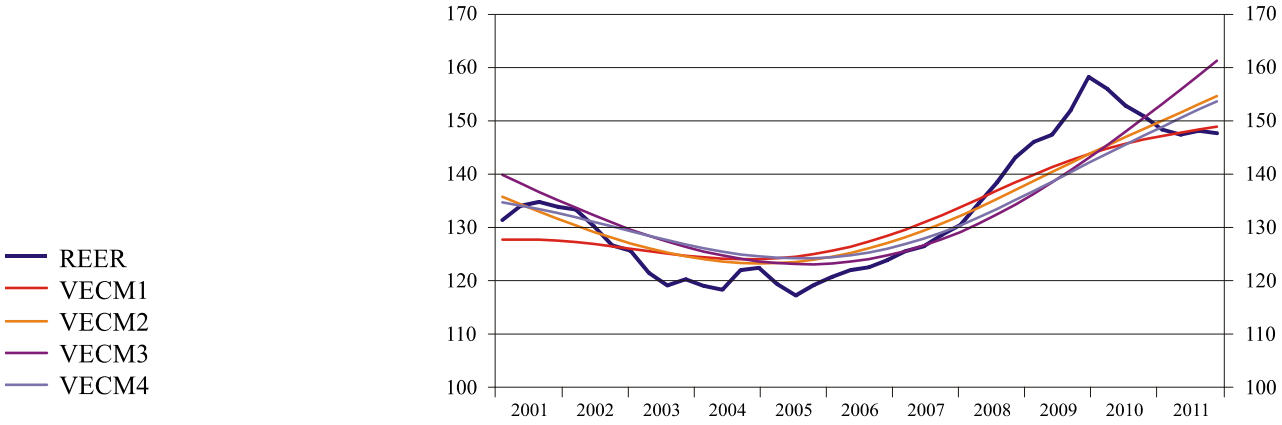
Source: Authors' estimates.

Note: PROD – denotes productivity differential, OPEN – openness to trade, NFA – net foreign assets, TOT – commodity terms of trade, and FISC_BAL – general government fiscal balance.

Figure 6 shows the dynamics of the long-term BEER for four estimated models. All four long-term BEER estimates follow broadly similar paths: a somewhat declining BEER until the end-2004 is followed by appreciation. Depreciation observed over 2001–2004 was mainly driven by deteriorating commodity terms of trade and restrictive fiscal policies. The appreciation that followed was brought about by

declining openness vis-à-vis trading partners, fiscal expansion and catch-up in terms of productivity of the tradables sector. There is a clear evidence of overvaluation during the period of unsustainable economic development resulting in double-digit inflation, but its extent and exact timing differ somewhat across the models. Dropping out last four observations, which may suffer from the end-point problem inherent to the HP-filter, we observe that by the end of 2009 the REER was close to its equilibrium level. The magnitude of misalignment was in the range of 0.2%–2.9%, suggesting marginal overvaluation. The deceleration in trend real appreciation of equilibrium exchange rate identified by VECM1 for the last four quarters of the sample stems from stabilisation in the trend trade-to-GDP ratio, which, however, may just be a reflection of the abovementioned end-point problem.

Figure 6
REER and long-term BEER (2001Q1–2010Q4)



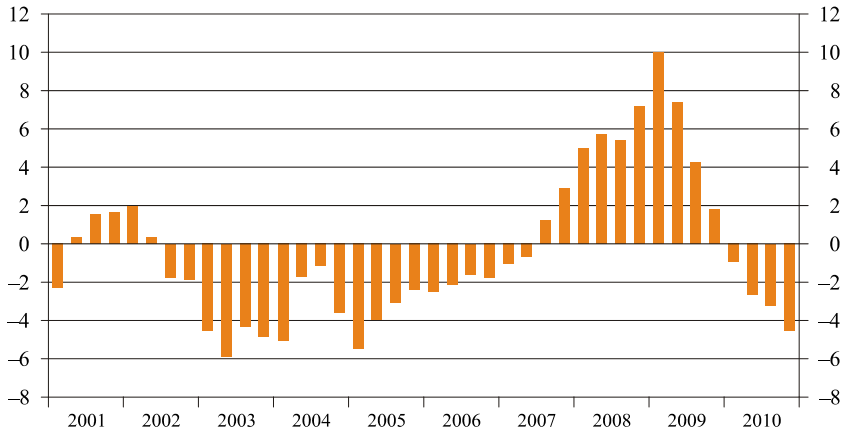
Source: Authors' estimates.

In addition, we have also estimated an arithmetic average of four misalignment measures as stemming from four different VECMs (see Figure 7). It suggests that real misalignment reached 10% at the beginning of 2009 but the gap was closed thereafter. An adjustment was attained via internal adjustment strategy implemented by the Latvian government as part of the Stabilisation Programme of the Latvian Economy supported by the IMF/EC and other lenders. Across-the-board cuts in labour costs backed by structural reforms in the public sector have led to real depreciation of REER and improvement in competitiveness of the Latvian economy. The last observation for the fourth quarter of 2010 shows a minor undervaluation of around 4%, which may still suffer from the end-point problem.

Policy conclusions from the above results should be drawn with caution. Not only the end-point problem could be an obstacle for laying down straightforward policy suggestions but also caveats regarding the arbitrary choice of statistical filter itself and its parameters could be subject to critique. Setting the value of lambda by applying the HP-filter reflects an agreement regarding the length of the business cycle. In this study we set it equal to the conventional value of 1 600 as suggested by Hodrick and Prescott (1980) for quarterly data. However, this choice is based on the analysis of advanced economies' (primarily the US) series and an assumption of relatively long cycles that may not be directly applicable for economies in transition. Furthermore, some of the variables used as regressors may not exhibit business cycles whatsoever (Saadi-Sedik and Petri, 2006). By choosing a smaller value of

lambda, we would end up in filtered determinants that more closely follow the actual series. That would mean that at any point of time the equilibrium REER is closer to the actual REER, thus reducing the extent of REER misalignment. Therefore, to make more definitive conclusions, other techniques of REER misalignment identification could be employed to see whether they point to the same direction.

Figure 7
Misalignment of Latvia's REER (%)



Source: Authors' estimates.

Note: Based on average misalignments stemming from four different VECMs.

3.2 The macroeconomic balance approach

The MB approach estimates the difference between the *underlying* current account balance projected over the medium term at prevailing exchange rates and an estimated *equilibrium* current account balance, or *"CA norm"*. The real exchange rate adjustment that would eliminate this difference over the medium term, i.e. a horizon over which domestic and trading partner output gaps are closed and the lagged effects of past exchange rate changes are fully realised, is then obtained using country-specific elasticities of the current account with respect to the real exchange rate.

The MB approach implies three steps.

1. The *underlying* current account balance is estimated by correcting the headline balance for the value of domestic output gap and output gaps of trading partners as well as accounting for recent changes in the real exchange rate.

2. An equation linking the current account balance to the set of fundamentals obtains *equilibrium* current account balance. An equation is estimated using the cross-country panel regression approach; then the equilibrium current account balance is derived based on the estimated coefficients and taking projected values of fundamentals over the medium-term.

3. The required *exchange rate adjustment* to close the gap between the equilibrium and underlying current account balances is calculated. This step involves the estimation of price elasticities of exports and imports.

3.2.1 The underlying current account balance

Two methodologies are used to estimate the underlying current account balance: the projection-based method and the elasticities-based method. *The projection-based method* equates the underlying current account with the IMF staff medium-term current account balance projections (the WEO projection). *The elasticities-based method* uses elasticities of a reduced-form equation which links the current account balance to domestic and foreign economic activity and the changes in REER.

The reduced-form equation for the current account balance to GDP ratio can be written as follows:

$$\frac{CA}{Y} = \alpha - \left[\left(\frac{M}{Y}\right)\beta_m + \left(\frac{X}{Y}\right)\beta_x\right](\delta_0 lnR + \delta_1 lnR_{-1} + \cdots + \delta_n lnR_{-n}) + \left(\frac{M}{Y}\right) lnR - \\ - \left(\frac{M}{Y}\right)\psi_m YGAP + (\frac{X}{Y})\psi_x YGAPF \quad [12]$$

where CA is the current account balance, Y denotes GDP at current prices, M is import value, X is export value, R stands for the real exchange rate, YGAP denotes domestic output gap, YGAPF represents the output gap of trading partners, α is a constant term reflecting initial conditions, β_m is the elasticity of imports with respect to REER, β_x is the elasticity of exports with respect to REER, ψ_m and ψ_x are the elasticities of imports and exports with respect to output. Parameters δ_i show the lagged effect of changes in REER. It should be noted that the sum of δ_i is equal to unity. It is usually supposed that changes in the real exchange rate tend to be passed to the current account over a three year period (Chapter V in Isard and Faruqee (1998)).

Setting domestic and foreign output gaps to zero and average exchange rates for the current and previous two years to R gives an equation for the underlying current account balance:

$$(\frac{CA}{Y})_{und} = \alpha - \left[\left(\frac{M}{Y}\right)\beta_m + \left(\frac{X}{Y}\right)\beta_x\right](\delta_0 lnR + \delta_1 lnR + \cdots + \delta_n lnR) + \left(\frac{M}{Y}\right) lnR \quad [13].$$

The underlying current account balance is therefore obtained by subtracting from the headline current account balance the short-term effect of output gap and recent changes in real exchange rate as follows:

$$(\frac{CA}{Y})_{und} = \frac{CA}{Y} + \left(\frac{M}{Y}\right)\psi_m YGAP - \left(\frac{X}{Y}\right)\psi_x YGAPF - \left[\left(\frac{M}{Y}\right)\beta_m + \left(\frac{X}{Y}\right)\beta_x\right](\delta_1(lnR - \\ lnR_{-1}) + \cdots + \delta_n(lnR - lnR_{-n})) \quad [14].$$

This means that the underlying CA balance is estimated under an assumption that both domestic and foreign economies operate at their potential and domestic currency stays at its trend level. The parameters of the reduced-form equation were estimated by Isard and Faruqee (1998, Chapter V) for industrial countries, and these estimates have been widely used by the IMF. The parameter values are as follows:

$\beta_x = 0.71$, $\beta_m = 0.92$, $\psi_x = 1.50$, $\psi_m = 1.50$, $\delta_1 = 0.25$, $\delta_2 = 0.15$.

It should be stressed that, as the parameter values have been estimated for industrially developed countries, they could be different for transition/developing economies. Isard and Faruqee (1998) report that the real exchange rate elasticities of

exports and imports are estimated at 0.53 and 0.69 respectively, but these estimates are based on the panel of developing countries that does not include Latvia.

Table 3 shows the estimates of the underlying current account balance of Latvia for 2011 using price elasticities of exports/imports estimated for the panel of both industrial countries and developing economies. The results indicate that the difference between these two estimates is minor, indicating that the current account of Latvia recorded a small deficit when accounting for temporary factors. At the same time the value of the underlying current account balance is quite sensitive to the estimates of domestic and foreign output gaps, which are widely known to be quite uncertain. The recent estimates of the European Commission assume that the output gap of Latvia was –4.3% of GDP in 2011 (EC (2012)). However, the potential output estimates are subject to frequent revisions especially in light of unexpected changes in the economic activity. One percentage point of GDP revision in the level of output gap for 2011 would yield a change in the underlying current account balance by 0.9 percentage point of GDP.

Table 3
The underlying current account balance of Latvia in 2011

		Price elasticities for industrial countries	**Price elasticities for developing countries**
Headline CA balance	**1**	**–1.2**	**–1.2**
Latvia's output gap	2	–4.3	–4.3
Latvia's imports (% of GDP)	3	0.63	0.63
coefficient	4	1.5	1.5
Impact of Latvia's output gap	*5 = 2 × 3 × 4*	*–4.1*	*–4.1*
Trading partners' output gap	6	–1.5	–1.5
Latvia's exports (% of GDP)	7	0.59	0.59
coefficient	8	1.5	1.5
Impact of output gaps in trading partners	*9 = 6 × 7 × 8*	*–1.4*	*–1.4*
Lagged effects of past changes in competitiveness	*10*	*–0.5*	*–0.3*
Adjustment for temporary factors	**11 = 5 – 9 – 10**	**–2.2**	**–2.4**
Underlying CA balance	**12 = 1 + 11**	**–3.5**	**–3.6**

Sources: Authors' calculations, European Commission (2012), Eurostat and Isard and Faruqee (1998, Chapter V).

3.2.2 Estimating equilibrium current account balance

As mentioned above, an equilibrium level of the current account balance is derived on the basis of estimated coefficients of the cross-section panel regression and taking projected values of fundamentals over the medium-term.

The relationship between the current account balance and its fundamental determinants has been estimated by Lee et al. (2008) for a large set of industrial and developing countries over 1973–2004 using the pooled OLS regression. The regression coefficients may not be directly applicable to Latvia due to the fact that Latvia is not included in the country sample. However, when estimating the equilibrium exchange rate the IMF uses these coefficients for the assessment of equilibrium current account balance. The regression includes the following variables.

Budget balance. An increase in the budget balance raises national savings and improves the current account balance. Lee et al. (2008) use the general government budget balance ratio to GDP relative to trading partners.

Old-age dependency ratio. A higher share of inactive population reduces national savings and deteriorates the current account balance. In the regression, Lee et al. (2008) use the ratio of the population above 65 to the population between 30 and 64. Again, this variable is calculated as deviation from the average for trading partners.

Population growth. Economy with a higher rate of population growth is usually characterised by a higher ratio of dependent young people that reduces the level of national savings and decreases the current account balance. Annual population growth relative to trading partners is used.

Net foreign assets. Impact of net foreign assets on current account balance theoretically is ambiguous. Economies with high positive NFA are able to run high current account deficits while remaining solvent. At the same time, highly indebted countries would have to run current account surpluses, implying that the effect of NFA on CA balance is negative. On the other hand, countries with a large stock of NFA (highly indebted countries) receive (pay) interest and therefore there should be positive (negative) flows, implying a positive relationship between the two variables. In empirical studies, the later effect usually dominates. The NFA is measured as the ratio of NFA to GDP at the beginning of the period.

Oil balance. Oil exporting countries are usually associated with high positive oil balance that automatically improves the current account balance. The oil balance is expressed as a ratio to GDP.

Relative income. It shows the stage of economic development of a country. For less matured economies, the process of economic convergence is associated with large investment needs and negative current account balances, therefore, the lower the relative income (proxied by GDP per capita vis-à-vis trading partners), the lower the current account balance is. Thus the sign is expected to be positive.

Output growth. For similar countries, the higher the rate of economic growth, the lower the current account balance tends to be. Thus the real per capita GDP growth vis-à-vis trading partners is supposed to have a negative impact on the current account balance.

The values of the budget balance, oil balance and output growth forecast for 2017 are taken from the IMF WEO (2012), whereas the forecasts of old-age dependency ratio, population growth and initial foreign assets (% of GDP) are taken from the Eurostat. According to the IMF WEO (2012), in 2017 Latvia's output growth is expected to be 4%, the budget balance ratio 0.4% of GDP, and oil balance –6.1%. According to the IMF WEO (2012), the relative income of Latvia was by 67.6% lower than that of the US in 2011. The old age dependency ratio is calculated as a ratio of the population above 65 to the population between 30 and 64, using the Eurostat EUROPOP2010 forecast for 2015, and is equal to –0.5% in Latvia in 2015. The population growth is calculated as an average growth rate based on the Eurostat EUROPOP2010 forecast for 2010 and 2015. The ratio of foreign assets in 2011 in Latvia was –72.5% of GDP. As shown, the budget balance, old-age dependency ratio, population growth and output growth are expressed as deviations from the

weighted average values of major trading partners, except for those variables which by construction express deviations from trading partners, i.e. the oil balance, NFA and relative income.

To increase the robustness of equilibrium current account balance estimates, we apply three different sets of coefficients: coefficients estimated by Lee et al. (2008) using pooled and hybrid pooled regressions, and those estimated by Rahman (2008) for a panel of both industrial and developing countries, including Latvia. In addition to variables described above, Rahman (2008) includes an index capturing the effect of investment climate, which is constructed using the average of the European Bank for Reconstruction and Development transition indicators in such areas as large scale privatisation, small scale privatisation, governance and enterprise restructuring, price liberalisation, trade and foreign exchange system, and competition policy. Rahman (2008) shows that the transition indicator exhibits a strong negative correlation with the CA balance.

Coefficient estimates, medium-term values of fundamentals applied to these estimates and estimates of equilibrium current account balance of Latvia are shown in Table 4. The results suggest that the equilibrium current account balance for Latvia is in the range of –3.3% to –5.8% of GDP. These estimates imply that the underlying current account balance is either close to or larger than the equilibrium level of current account, meaning that REER is close to its equilibrium (or even somewhat undervalued).

Table 4
The medium term equilibrium current account balance of Latvia

Regressors	Value (%)	Coefficients			Contribution (%)		
		Lee et al.: pooled estimation	Lee et al.: hybrid pooled estimation	Rahman: pooled estimation	Lee et al.: pooled estimation	Lee et al.: hybrid pooled estimation	Rahman: pooled estimation
Budget balance	–0.9	0.20	0.19	0.22	0.2	0.2	0.2
Old-age dependency	–2.4	–0.14	–0.12	–0.04	0.3	0.3	0.1
Population growth	–0.6	–1.21	–1.03	–0.63	0.7	0.6	0.4
Initial foreign assets (% of GDP)	–72.5	0.02	–	0.03	–1.4	–	–2.2
Lagged current account balance	–5.0	–	0.37	–	–	–1.9	–
Oil balance	–6.1	0.23	0.17	0.44	–1.4	–1.0	–2.7
Output growth	1.5	–0.21	–0.16	–0.18	–0.3	–0.2	–0.3
Relative income	–67.6	0.02	0.02	–0.01	–1.4	–1.4	0.7
Investment climate	400.0	–	–	–0.01	–	–	–4.0
Constant	100.0	0.00	0.00	0.02	0.00	0.00	2.0
Equilibrium current account	–	–	–	–	–3.3	–3.4	–5.8

Sources: Authors' calculations, Lee et al. (2008), Rahman (2008), Eurostat and International Monetary Fund (2012).

3.2.3 Real exchange rate misalignment

The real exchange rate gap, i.e. the gap between the current value of REER and the equilibrium REER needed to bring the current account balance to its equilibrium level, is calculated using the value of price elasticity of exports and imports:

current account elasticity = export elasticity × export ratio to GDP – (import elasticity – 1) × import ratio to GDP.

The extent of misalignment is shown in Table 5 under different assumptions regarding price elasticities and the equilibrium current account. The elasticity of the current account balance ratio to GDP with respect to the REER is calculated to be –0.37 if price elasticities of industrial economies are used, and much smaller, –0.14, if elasticities of developing economies are explored. Under all mentioned assumptions, the REER is close to its equilibrium or estimated to be somewhat undervalued when the coefficients estimated by Rahman (2008) are used. The estimates of REER misalignment shown in the last column of Table 5 implying huge undervaluation of the REER, seem implausible owing to the fact that the current account balance elasticity is close to zero, making the estimate of REER misalignment extremely sensitive to any deviation in the current account balance.

Table 5
Real exchange rate misalignment in 2011 according to MB approach

	Price elasticities for industrial countries			**Elasticities for developing countries**		
	Lee et al.: pooled estimation	**Lee et al.: hybrid pooled estimation**	**Rahman: pooled estimation**	**Lee et al.: pooled estimation**	**Lee et al.: hybrid pooled estimation**	**Rahman: pooled estimation**
Underlying CA balance	–3.5	–3.5	–3.5	–3.6	–3.6	–3.6
CA norm	–3.3	–3.4	–5.8	–3.3	–3.4	–5.8
CA misalignment	*–0.2*	*0.0*	*2.3*	*–0.28*	*–0.15*	*2.2*
Elasticity	–0.37	–0.37	–0.37	–0.14	–0.14	–0.14
RER misalignment	**0.5**	**0.1**	**–6.2**	**2.1**	**–1.1**	**–16.2**

Sources: Authors' calculations and Isard and Faruqee (1998).

3.3 The external sustainability approach

Similarly to the MB approach, the external sustainability approach is a method of calculation of real exchange rate which is consistent with the medium-term macroeconomic equilibrium, but this medium-term equilibrium is calculated in a different way. To some extent, this approach is similar to the public debt sustainability analysis where budget deficit consistent with some steady state public debt ratio is determined. Here, in contrast, the level of current account balance stabilising the NFA at a given level is estimated by applying the accumulation equation for NFA. The equation states that changes in NFA are due either to net financial flows or changes in the valuation of outstanding foreign assets and liabilities. Assuming zero capital gains, the CA norm (ca^s) that would be compatible with some steady state level of NFA (bs) is given by

$$ca^s = \frac{g+\pi}{(1+g)(1+\pi)} b^s \qquad [15]$$

where g is the growth rate of real GDP, π is the inflation rate, whereas b^s and ca^s are NFA and CA as shares of GDP respectively.

Applying WEO (April 2012) forecasts for Latvia, where g = 4.0% and π = 2.1% in 2017, and assuming that the NFA remains unchanged, i.e. b^s = –72% (the figure reflects position in 2011, which is in line with the CGER methodology, and is calculated using Eurostat data), yields the CA norm ca^s = –4.2%. If we assume that the current NFA stock is unsustainable *per se* and use more conservative assumptions on equilibrium NFA stock, i.e. b^s = –50% or –35%, the CA norm increases to –2.9% and –2.0% accordingly. Following these assumptions, the extent of misalignment is calculated to be in the range from –1.9% to +3.9%.

Table 6
Real exchange rate misalignment in 2011 according to ES approach

	Three scenarios according to different assumptions on benchmark level of NFA		
Growth rate of real GDP	0.04	0.04	0.04
Inflation rate	0.02	0.02	0.02
Benchmark level of NFA (%)	–72	–50	–35
Equilibrium CA (%)	*–4.2*	*–2.9*	*–2.0*
Underlying CA balance in 2011 (%)	*–3.5*	*–3.5*	*–3.5*
CA balance misalignment (%)	*0.7*	*–0.6*	*–1.4*
Elasticity	–0.37	–0.37	–0.37
RER misalignment (%)	**–1.9**	**1.6**	**3.9**

Sources: Authors' calculations, Eurostat, Isard and Faruqee (1998, Chapter V) and International Monetary Fund (2012).

3.4 Advantages and disadvantages of macroeconomic balance and external sustainability approaches

The most obvious advantage of the MB and ES approaches is that both could be easily applied to any country, even one that does not have long series of macroeconomic variables to estimate the current account regression or has not been included in the panel estimation implemented by Lee et al. (2008) or similar studies.

There is also a number of drawbacks of these approaches which overall may imply that the REER misalignment estimates could be incorrect.

1. The equilibrium current account estimates under the MB approach are very sensitive to coefficients used. For example, small changes in the coefficient of NFA may trigger substantial shifts in the CA norm. Unfortunately, the IMF study (Lee et al. (2008)) does not report standard deviations of the estimated coefficients, thus we are not able to conduct a meaningful sensitivity exercise. However, the study by Bussière et al. (2010) by running 16 384 different regressions shows that the range of coefficient estimates is actually very broad.

2. Medium-term values of regressors are proxied by the WEO projections for the last year available. However, there are some reasons to believe that even medium-term projected values could deviate from the steady state. In addition, using the initial NFA level may be dubious since it can also be in disequilibrium.

3. It should be noted that coefficients on both the CA norm and price elasticities of exports and imports estimated for a panel of countries which does not include Latvia

may not be directly applicable when assessing the equilibrium REER of Latvia. Furthermore, price elasticities estimated for developing economies (with characteristics that may be shared by Latvia) are small, implying that the current account balance is very insensitive to the movements in REER. Any discrepancies in the current account balance may imply quite substantial overvaluation or undervaluation of the REER that may not be plausible. This is exactly the case of Latvia shown in the last column of Table 5.

4. The underlying current account balance is sensitive to the estimate of the output gap. As mentioned earlier, a 1 percentage point of GDP change in the level of output gap would yield a change in the underlying current account balance of Latvia by 0.9 percentage point of GDP that would modify the estimates of REER misalignment by 2.6–7.0 percentage points.

In the following two sections we will dwell on two supplementary methods to the IMF CGER, namely NATREX and SVAR, to see whether the results are robust across different methodologies.

4. THE STRUCTURAL VAR APPROACH AND NATURAL REAL EXCHANGE RATE

4.1 The NATREX approach

4.1.1 Theoretical background of NATREX approach

In this section, we will consider the NATREX approach introduced and developed by Stein in a series of papers and books (1994, 1997, 1999, 2006), which is regarded to be a theoretically sound model with strong theoretical micro-founded structure. It links the developments in the REER to the developments in the factors explaining investment, consumption and trade balance behaviour. These factors, in turn, are derived by optimising agents' decision making. The model is stock-flow consistent and explicitly distinguishes between the medium-term NATREX and long-term NATREX.

The medium-term NATREX is characterised by internal equilibrium (i.e. there are no deflationary/inflationary pressures in the economy) and external equilibrium (the real interest rate is equal to the world's real interest rate), and capital stock and net foreign assets/debt are exogenous. In the long-term NATREX, capital stock and net foreign assets/debt reach their steady state level, i.e. are assumed to be endogenous. In this model, there are decisions on how much to invest (by maximising firm profits) and how much to spend and save correspondingly (by optimising consumers' intertemporal utility). By optimising economic agents' decisions on consumption, production and investment, one can derive behavioural equations consistent with the internal-external balance. Following Detken et al. (2002) who used this approach to estimate the equilibrium exchange rate of euro, we estimate the following behavioural equations in linear form:

$$\frac{C}{Y} = \alpha_1 + \alpha_2 \frac{K}{Y_r} + \alpha_3 \frac{F}{Y} \quad [16],$$

$$\frac{I}{Y} = \alpha_4 + \alpha_5 (Pr - i_L) + \alpha_6 \mathrm{R} \quad [17],$$

$$\frac{TB}{Y} = \alpha_7 + \alpha_8 R + \alpha_9 \frac{A}{Y} + \alpha_{10} (\mathrm{C}_{\mathrm{Y}})^* \quad [18]$$

where C is aggregate consumption (private and public), K is capital stock at constant prices, Y is GDP at current prices, Y_r is GDP at constant prices, F is net foreign debt, I is investment (public and private), Pr denotes marginal product of capital and is measured as a capital share in the production function times output over capital ratio, i_L is long-term interest rates, R is the REER, TB denotes trade balance, A denotes total economy's absorption (investment plus consumption), and, finally, * is the notation for foreign consumption to GDP ratio.

Consumption is a positive function of net wealth which is represented by the difference between capital stock and stock of net foreign debt. The wealthier the society, the higher the aggregate spending is. Therefore α_2 is supposed to be positive and α_3 negative.

Investment is supposed to depend negatively on real exchange rate ($\alpha_6<0$) and positively on the difference between marginal product of capital and long-term real interest rate ($\alpha_5>0$). The rationale for the former relationship is that relative price between tradables and non-tradables is deemed to crowd out investment. Appreciation of exchange rate lowers the demand for tradable goods and decreases firm profits, and consequently, their willingness to invest. As regards the latter relationship, an increase in net return on investment usually associated with low level of capital stock is supposed to have a positive effect on investment, as more firms find it profitable to expand their activities, which is a standard result of microeconomic theory.

Finally, the trade balance depends positively on the measure of foreign demand (proxied by foreign consumption ratio to output, $\alpha_{10}>0$) and negatively on the measure of domestic demand (proxied by domestic absorption (the sum of consumption and investment) ratio to output, $\alpha_9<0$) and real exchange rate ($\alpha_8<0$). Real appreciation of currency is supposed to worsen the trade balance by reducing exports and increasing imports.

In addition to the three behavioural relationships, the following national account identity is specified:

$$\frac{C}{Y}+\frac{I}{Y}+\frac{TB}{Y}=1-\frac{SCN}{Y} \quad [19]$$

where SCN denotes variation in debt stocks. The current account is divided into two components, i.e. the trade balance and residual component.

The long-term NATREX can be obtained under an assumption that capital stock and net foreign debt reach their steady state levels. These, in turn, stem from stock accumulation rules and can be represented by the following relationships:

$$\frac{F}{Y}=-\left(\frac{1+q}{q}\right)\frac{CA}{Y} \quad [20],$$

$$\frac{K}{Y_r}=\frac{1+g}{\delta+g}\frac{I}{Y}\frac{P_Y}{P_I} \quad [21]$$

where the parameter δ is the depreciation rate of capital stock per quarter, q is nominal GDP growth rate, g is real GDP growth rate, P_Y is GDP deflator, and P_I is gross fixed capital formation deflator. Noteworthy, equation [20] is just another representation of equation [15].

4.1.2 Estimates of behavioural equations

We use the following approach to estimate the medium-term NATREX. First, we identify the order of integration of variables under consideration. Second, we estimate three behavioural equations [16]–[18] using VECMs and test for the presence of cointegrating vectors using the Johansen cointegration test. Third, by using the national account identity [19], estimated coefficients of cointegrating vectors and medium-term values of variables, we estimate the medium-term NATREX.

We use the data for the period between the first quarter of 2001 and the third quarter of 2011 in the estimation. Appendix 4 provides the results of unit root tests. It can be concluded that all considered variables are integrated of order 1.

To estimate the vector error correction model, we make use of the Johansen cointegration approach (in a similar way as in Subsection 3.1.4). We identify cointegrating vectors for the consumption ratio (1), investment ratio (2) and trade balance ratio (3) with theoretically plausible signs, except for the sign of the impact of net marginal product of capital[1] on investment. The VECMs pass the diagnostic tests on normality, heteroskedasticity and serial correlation of residuals, and all cointegrating parameters are statistically significant (at 5% reference value). In Table 6A4 of Appendix 4, the trace statistics together with 95% critical values are reported for these equations. The cointegrating parameters, their *t*-values, adjustment coefficients and the results of diagnostic tests of three VECMs are reported in Table 7. In all estimated VECMs, we have found one cointegrating vector. The adjustment coefficients for endogenous variables are significant at 5% level, except for the error correction term for the trade balance. The gap between the actual and equilibrium trade balance ratio is not closed by adjustment in the trade balance itself, and it returns to its equilibrium by adjustment in domestic absorption and/or foreign consumption. It should be also noted that the REER has a negative impact on investment and trade balance where the negative impact of REER appreciation is higher on the former than on the latter.

As regards the surprisingly negative elasticity of investment with respect to net marginal product of capital, the phenomenon could be explained by the fact that a decline in the marginal product observed over the period under consideration reflects a rise in capital stock from a low level. Rising capital stock, however, in theory should mean smaller investment. Yet this rationale may not apply to emerging economies where initial capital stock is very low and its increase is expected to result in an improvement in infrastructure and technology that makes the economy even more attractive for investors to invest in productive capital.

[1] We refer to net marginal product of capital as a differential between marginal product of capital and nominal interest rate.

Table 7
Estimations of VECMs for behavioural equations

	Variable	Consumption function	Investment function	Trade balance function
	Constant	86.822	401.625	93.142
Long-run parameters	Capital ratio	0.037 (2.055)	–	–
	Net foreign debt	–0.185 (–5.529)	–	–
	MPK minus interest rate	–	–4.577 (–3.971)	–
	Real exchange rate	–	–2.528 (–4.945)	–0.231 (–3.759)
	Absorption	–	–	–1.651 (–9.367)
	Foreign consumption	–	–	1.341 (2.325)
Adjustment coefficients	Consumption	–0.607 (–4.347)	–	–
	Investment	–	–0.068 (–4.597)	–
	Trade balance	–	–	0.126 (0.752)
Diagnostic tests	Serial correlation test	12.781 [0.173]	13.509 [0.141]	17.360 [0.363]
	Normality test	37.080 [0.057]	11.771 [0.988]	49.078 [0.699]
	Heteroscedasticity test	58.914 [0.720]	58.693 [0.139]	183.280 [0.418]

Source: Authors' estimates.

Note: t-statistic values for long-run parameters and adjustment coefficients are provided in parenthesis, probability levels for the diagnostic tests are reflected in square brackets.

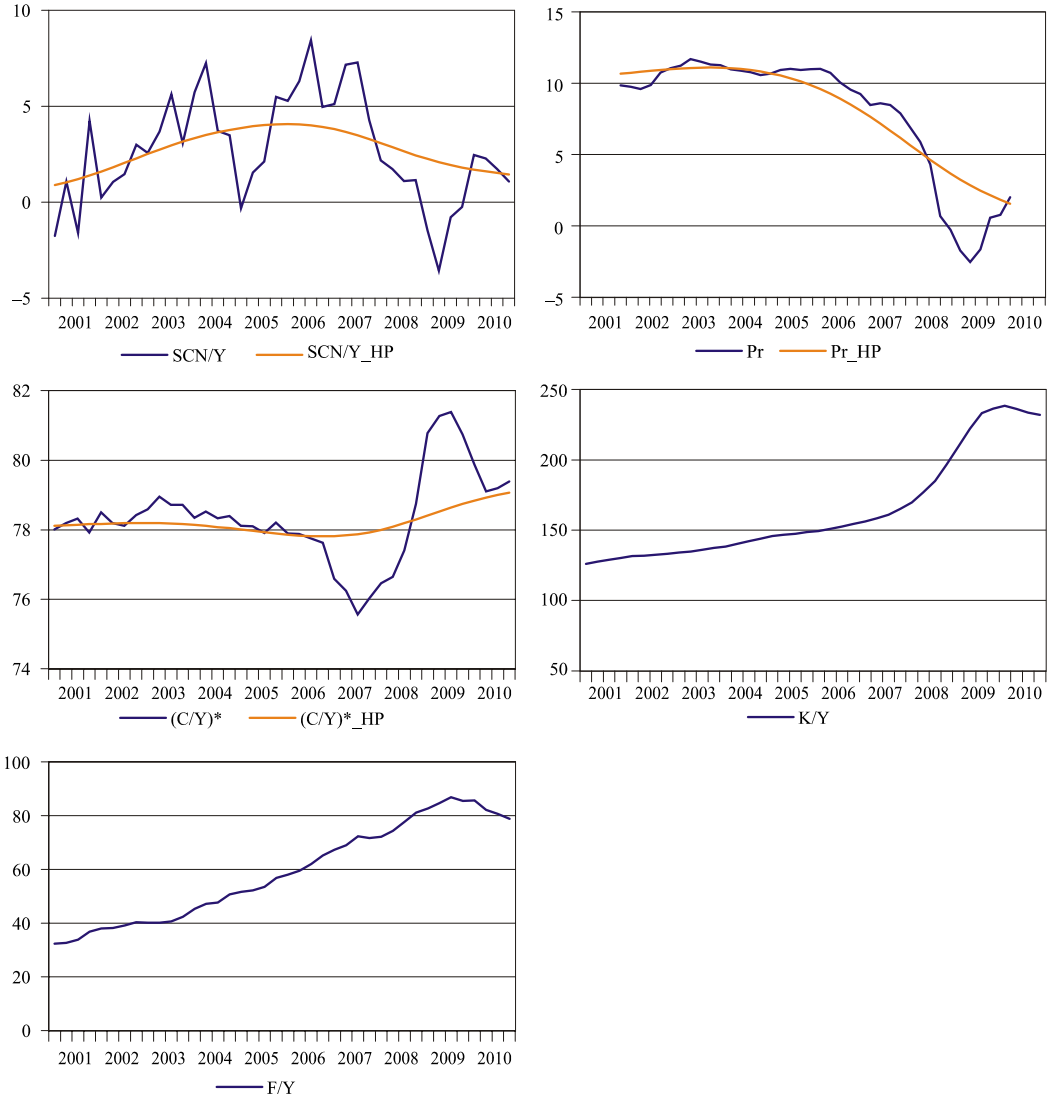
4.1.3 Medium-run and long-run NATREX

As has already been mentioned, to obtain medium-run NATREX one should insert cointegration relationships [16]–[18] into identity [19] and express the real exchange rate R as a function of exogenous regressors. Then, in order to obtain a medium-run NATREX, cyclical components of the following regressors should be removed using the HP filter: variation in debt stocks ($\frac{SCN}{Y}$), net marginal product ($Pr - i_L$), and foreign consumption ratio $(\frac{C}{Y})^*$. The medium-term NATREX is estimated on the basis of the actual values of capital stock and net foreign debt. When looking at the regressors' actual and HP-filtered values (see Figure 8), one may come to several conclusions. First, variations in debt stocks seem to have been quite large (consistent with findings by Marín Martínez (2003)), whereas the trend values have been mainly in the range of 1%–4% of GDP, with an upward trend in the first half of the period observed and a downward trend afterwards. Net marginal product of capital has been declining, indicating that the increased capital stock has reduced net return on capital. Besides, there was a hike in the nominal interest rate at the outset of the economic crisis in 2008–2009, as confidence of economic agents in the Latvian economy shrank and was gradually restored only after the Latvian government undertook substantial fiscal adjustments. The trend values of the foreign

consumption ratio had been broadly stable before a rise since 2008. Capital stock and net foreign debt were growing steadily, reflecting accumulation of investment and current account deficit.

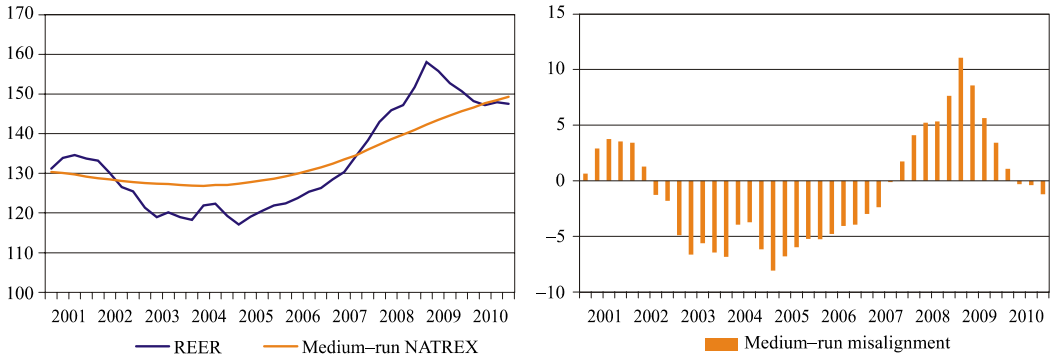
Figure 9 presents medium-run NATREX together with medium-run misalignment. It shows that the actual real exchange rate had converged to its medium-run NATREX by the second quarter of 2010. The REER seems to have been undervalued over the period from the third quarter of 2002 to the third quarter of 2007, followed by a period of overvaluation from the fourth quarter of 2007 to the first quarter of 2010. During the time span from the first quarter of 2001 to the fourth quarter of 2004, the medium-run NATREX was broadly stable. After 2004, it showed a clear upward path. The major contributing factor to the appreciation of the medium-run NATREX was the fall in net return on capital. At the same time, only minor part of the medium-run NATREX evolution is explained by the behaviour of capital stock, stock of net foreign debt and foreign consumption ratio.

Figure 8
Regressors: actual and HP-filtered values



Sources: Eurostat and authors' estimates.

Figure 9
REER, medium-run NATREX and medium-run misalignment

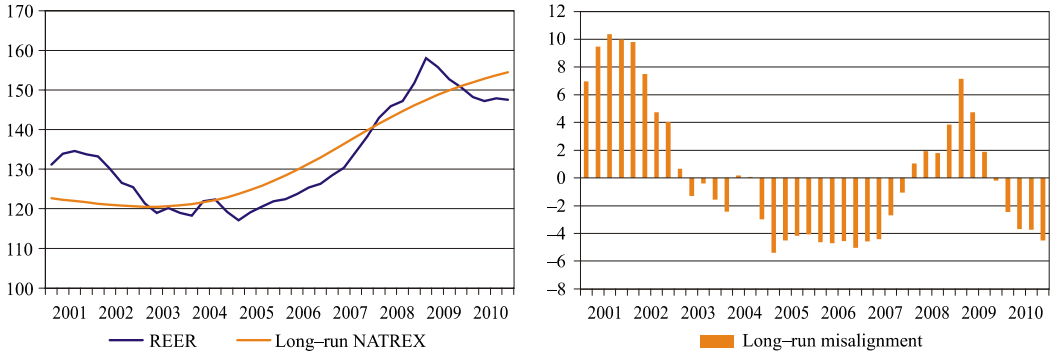


Source: Authors' estimates.

To obtain long-run NATREX in addition to solving the system of equations [16]–[19], one should assume that capital stock and net foreign debt have reached their steady state levels, as represented by equations [20] and [21]. These steady state levels are derived from the dynamic equations of capital and net foreign debt accumulation. Following Detken et al. (2002), the equation for steady state stock of net foreign debt is derived assuming that the net factor income ratio to GDP is exogenous.

The REER and long-run NATREX are depicted in Figure 10. The long-run NATREX shows a similar pattern if compared to the medium-term NATREX with larger deviations from the actual REER and bigger misalignment at the beginning of the sample, and smaller misalignment thereafter, including the period of pre-crisis overvaluation of Latvian REER. Nevertheless, it points to a similar path of misalignment over the period under consideration with the period of initial overvaluation (from the first quarter of 2001 to the first quarter of 2003), undervaluation in the middle of the first decade of the 2000s (from the fourth quarter of 2004 to the third quarter of 2007), and overvaluation of the pre-crisis and early crisis period (from the first quarter of 2008 to the third quarter of 2009).

Figure 10
REER, long-run NATREX and long-run misalignment



Source: Authors' estimates.

One should take into consideration high sensitivity of the long-run NATREX estimates to the assumed steady state rate of real and nominal GDP growth and the

rate of capital depreciation. Therefore the long-term NATREX estimates should be interpreted with considerable caution.

4.2 The SVAR approach

In this section, we will follow Clarida and Gali (1994) approach using SVAR model to decompose the real exchange rate into permanent and temporary components by identifying long-run structural shocks using the method by Blanchard and Quah (1989) (for details see Appendix 5). In particular, Clarida and Gali (1994) construct trivariate SVAR to estimate the relative importance of different types of macroeconomic shocks for changes in relative output (domestic output relative to that of trading partners), relative GDP deflator, and the REER. The long-run triangular identification scheme of Blanchard and Quah is used, in which money or nominal shocks are assumed not to influence the REER and the relative output in the long-run, but are likely to raise the price level; supply shocks, in turn, are deemed to affect all three variables in the long-run, whereas demand shocks are designed not to affect relative output. Therefore only supply shocks influence relative output in the long run, prices adjust completely to all three shocks, but the *REER is affected by both supply and demand shocks*. These identifying restrictions are based on the modified version of the Mundell-Fleming-Dornbusch model proposed by Obstfeld (1985). Clarida and Gali (1994) use SVAR estimates for historical decomposition of the REER to extract the contribution of each structural shock to the deviation of REER from its baseline projection.

Empirical results

The VAR model consists of the first differences of relative output levels, the real effective exchange rate and relative GDP deflators; all variables are in logarithms and calculated relative to Latvia's main trading partners. The VAR system is estimated over the full sample period, i.e. from the first quarter of 1997 to the third quarter of 2011.

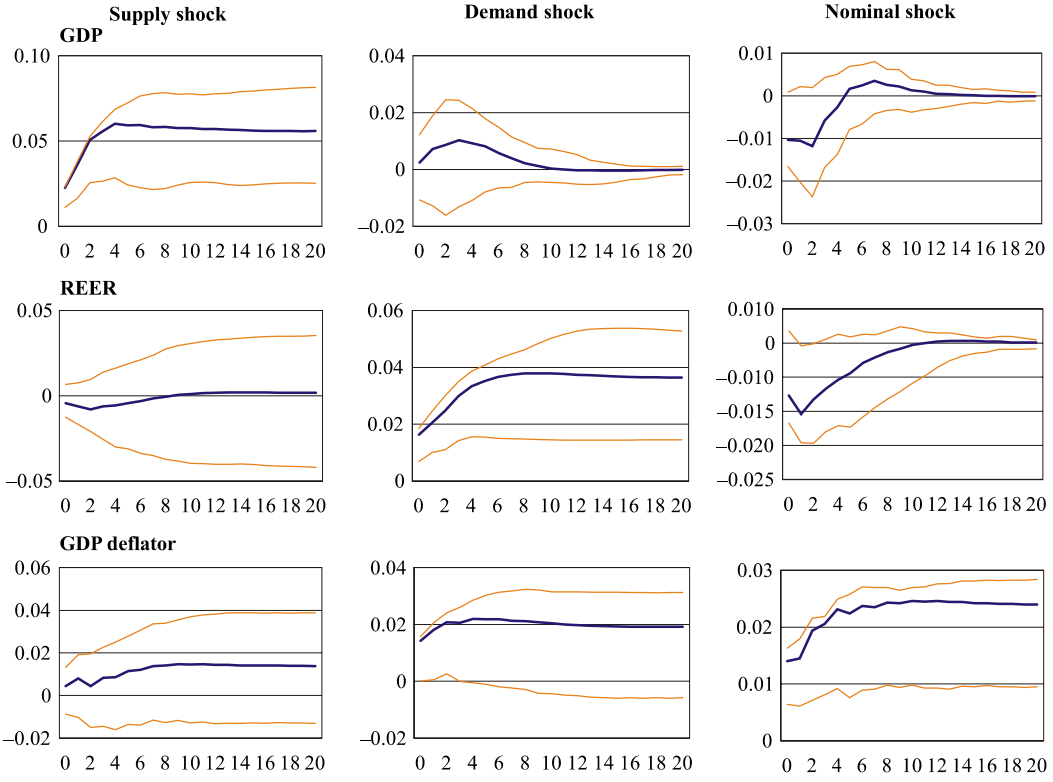
In order to choose an appropriate number of lags in the model, we use a number of lag length criterions. Consistently with the sequential modified LR test statistic criteria, we include three lags in the model, which also allows for passing through all residual diagnostic tests (autocorrelation, normality and heteroskedasticity).

The accumulated impulse responses of REER, relative output and GDP deflator to each of the three structural shocks are computed from the estimated VAR coefficients and are presented in Figure 11. As we use relative measures for output and prices, the shocks are thought of as relative supply shocks, relative demand shocks and relative nominal shocks. All shocks are equal to one standard deviation. To take into account the uncertainty surrounding point estimates of impulse responses, we construct confidence intervals using the Hall's bootstrap percentile confidence interval method (Hall, 1992).

The signs of obtained impulse responses are primarily consistent with theoretical priors. A positive supply shock results in a minor depreciation of REER in the short-run (albeit statistically insignificant) over the first five quarters and then the effect fades. The short-run responses of both output and the REER to one standard deviation *supply shock* are in line with the theory, because a positive supply shock creates a rise in output; to stimulate the foreign demand for extra output, an

improvement in competitiveness is required. It can be achieved by REER depreciation, but in our study this effect is almost negligible. At the same time, the absence of significant, long-run impact of the supply shock on REER is not something unique in this paper and resembles the findings of Clarida and Gali (1994), Detken et al. (2002), and MacDonald and Swagel (2000). The accumulated relative output increases by 6% in the long-run. A positive supply shock generates an increase in relative GDP deflator, which, in a way, contradicts the theory. This can be explained by the fact that the theoretical impact of the supply shock rests upon two assumptions: first, it affects all sectors of the economy equally; second, the effect of the supply shock outweighs any derived wealth (demand) effect. The former assumption rules out the possibility of Balassa-Samuelson type effects, which could lead to higher inflation.

Figure 11
Accumulated impulse responses to shocks



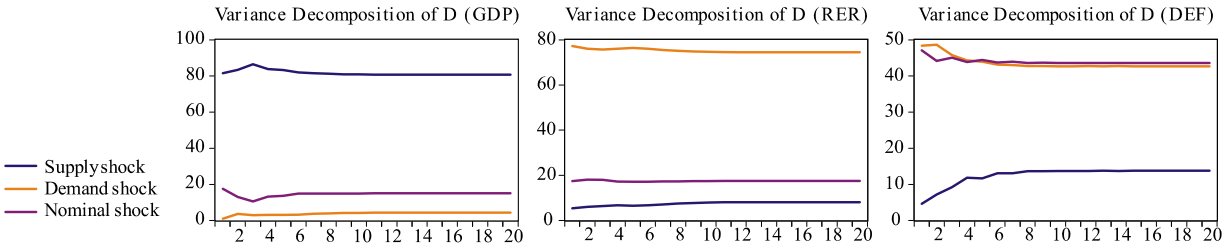
Source: Authors' estimates.

The results also show that the responses of relative output, REER and relative GDP deflator to the *demand shock* are positive in the short run. In the long run, the real exchange rate appreciates by 3.6% and relative GDP deflator increases by 2%. Overall, the signs of impulse responses match our expectations.

As regards the impact of the *nominal shock*, the relative GDP deflator goes up permanently above the 2% level. The REER depreciates initially, but the effect gradually disappears and the REER returns to its baseline projected value. Output drops by 1% over the first three quarters.

Figure 12 presents the forecast error *variance decomposition* of variables at different forecast horizons, which can be attributed to each shock in the model. Demand shocks do not explain much of the variance in forecasting the changes in relative output. Only 4% of the variance of forecasting changes in relative output at a 20-quarter horizon is attributed to demand shocks. The demand shock accounts for a substantial fraction of the variance of change in the REER. After 20 quarters, 75% of variation is explained by demand shocks. About 17% of the variance is attributed to nominal shocks. Supply shocks play a very weak role in explaining movements in the REER, accounting for only 8% of the variance at a 20-quarter horizon. Demand and nominal shocks are the main driving forces of this variable, both contributing more than 90% of the forecast error variance. The shocks that cause most of the variation in relative output do not seem to be major contributors to the movements in the real exchange rate. The results are similar to those reported by Detken et al. (2002). At a 20-quarter horizon, the demand and nominal shocks almost equally contribute (about 43%) to the forecast error variance of relative inflation. This result contradicts somewhat Detken et al. (2002), who find that the relative GDP deflator is explained mainly by supply and nominal shocks in the euro area. Unlike the euro area, the demand shock was one of the most important driving forces behind the GDP deflator in Latvia.

Figure 12
Variance decompositions



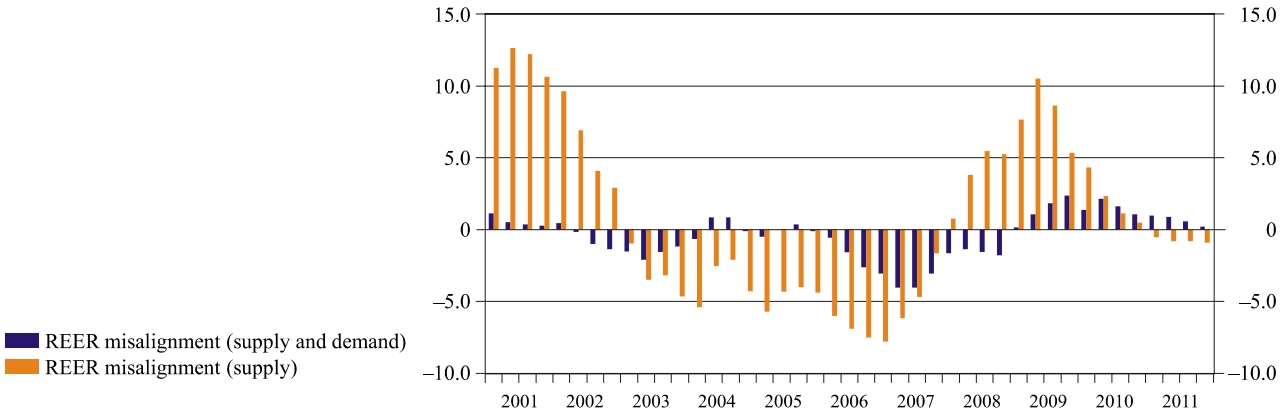
Source: Authors' estimates.

The equilibrium exchange rate can be defined as historical component of the real exchange rate driven by the identified real supply and demand shocks, because these shocks are deemed to influence the REER in the long run. The result is presented in Figure 13 and indicates that the real exchange rate follows very closely the equilibrium exchange rate. The maximal misalignment over the whole time span is about 4%. The results also indicate that from the fourth quarter of 2008 to the third quarter of 2011, the actual REER was slightly overvalued (maximum overvaluation of 2.4%) if compared with the SVAR-based equilibrium REER. In the third quarter of 2011, the REER and equilibrium REER were almost equivalent.

MacDonald and Swagel (2000) suggest that the permanent component of movements in the real exchange rate is solely on account of the contribution by supply shocks, thus stripping out the influence of the demand and nominal shocks. Detken et al. (2002) also exclude the demand-driven shocks by noting that they do not appear to be related to the underlying fundamentals of the economy. In a sense, we can refer to the medium-run exchange rate equilibrium resulting from the contribution of demand and supply shocks, whereas the long-run equilibrium solely depends on the contribution of supply shocks, i.e. the situation when the impact of demand shock on output dies completely out. Consequently, one could see the

similarity between the medium and long-run NATREX on the one hand and SVARs on the other. Taking into account that a substantial growth in demand in Latvia was caused by credit expansion bringing about rapid appreciation of the REER, we have estimated an alternative measure of misalignment, whereby only the supply shock is supposed to exert impact on the equilibrium REER. According to these estimates, Latvia's REER was clearly overvalued in the period from the fourth quarter of 2007 to the third quarter of 2010, reaching its maximum in the first quarter of 2009; however, similarly to previous results where both shocks were taken into account, the misalignment has already vanished.

Figure 13
REER misalignment according to SVAR approach (%)



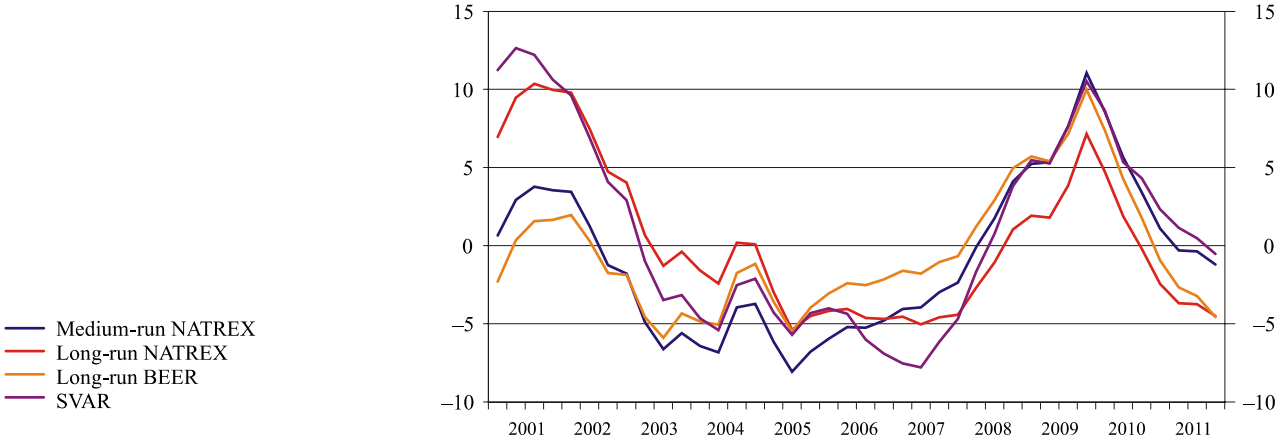
Source: Authors' estimates.

5. COMPARISON OF ESTIMATES

Finally, we compare the results of four estimates that assess the dynamics of misalignment obtained by using three different approaches: the average of long-term BEER estimates, medium and long-term NATREX, and SVAR driven by supply shocks. As a benchmark, we also refer to the two point estimates of misalignment obtained by MB and ES approaches. All four estimates that assess the dynamics of misalignment point to a pretty similar path of misalignment despite the fact that all three methodologies differ significantly in terms of theoretical background and macroeconomic time series used. All four estimates of misalignment pointed to the peak overvaluation in the first quarter of 2009 and a subsequent adjustment towards equilibrium (see Figure 14). Differences arise with regard to the timing of switching from overvaluation to undervaluation and their extent. The highest swings measured by standard deviation are shown by the SVAR estimates of misalignment. This stems from the fact that the SVAR misalignment is measured with respect to supply-shock-generated equilibrium REER, which does not exhibit significant fluctuations. The smallest swings occur in the long-term BEER misalignment. This, in turn, is the result of estimating the long-term BEER directly from the reduced-form equation. If we look at the pairwise correlations between different estimates of the REER misalignment during 2001–2010, we can conclude that the estimates are indeed correlated. The highest correlation is observed between the long-run BEER and medium-term NATREX, and between the SVAR and long-run NATREX. As regards the latter two, both are of a long-run nature indeed, as demand shocks die out only after a considerable lapse of time, and the convergence of capital stock and

net foreign debt to their long-run steady state values can be accomplished over a long time span as well.

Figure 14
REER misalignment by four approaches



Source: Authors' estimates.

Table 8
Pairwise correlation between different misalignment estimates

	Medium-run NATREX	**Long-run NATREX**	**Long-run BEER**	**SVAR**
Medium-run NATREX	1.00	0.66	0.92	0.84
Long-run NATREX	0.66	1.00	0.52	0.91
Long-run BEER	0.92	0.52	1.00	0.65
SVAR	0.84	0.91	0.65	1.00

Source: Authors' estimates.

Referring to point estimates of misalignment derived by the MB and ES approaches, both point to closeness of REER to its equilibrium level in 2011 that fits rather well into the overall picture. The MB approach using different estimates of equilibrium current account and price elasticities for industrial countries displays the misalignment in the range of +0.5%––6.5%, a result apparently rather consistent with the outcomes derived by the three above mentioned approaches at the end of the sample period, i.e. the end-2010. Also, the misalignment derived by the ES approach using the current level of NFA as a benchmark (–1.9%) fits well into this range, and only more conservative assumptions on equilibrium NFA level produced a small positive misalignment of up to +3.9%.

CONCLUSIONS

The aim of this study is to estimate the equilibrium real effective exchange rate of Latvia, which was done by using different methodologies, including those developed by the IMF, and the NATREX and SVAR approaches. The CGER methodology used by the IMF implies the application of three different approaches: the macroeconomic balance approach, the external sustainability approach and the reduced-form equilibrium real exchange rate approach.

Our estimates derived from both the *macroeconomic balance* and the *external sustainability* approach show that Latvia's REER was overall close to its equilibrium in 2011. Depending on different specifications used, small misalignments on both ends (under-evaluation and overvaluation) were derived. At the same time, these results are rather sensitive to the assumptions and coefficients used.

In three out of four VECMs employed in the framework of the e*quilibrium real exchange rate* approach, the productivity differential was found to be statistically significant and to have a positive impact on the REER. Openness, NFA, terms of trade and fiscal balance appear significant in one (NFA) or two (openness, terms of trade, fiscal balance) specifications. Our estimates show that the gap between the current BEER and REER is not closed by the adjustment in the REER itself in any of the VECMs, which is in line with Latvia's fixed exchange rate regime. At the same time, the current BEER is much more volatile than the REER due to large fluctuations in regressors. By applying the HP filter to fundamental determinants for extracting their long-term values, we derived a long-term BEER. According to this estimate, Latvia's REER was found to be almost in equilibrium at the end of 2009 and slightly undervalued after the downward adjustment from the overvalued level before the recent crisis. It should be taken into account that the estimates of long-term BEER for the last four quarters of the sample should be interpreted with caution, as they suffer from the end-point problem inherent to the HP filter.

The three behavioural equations determining investment, consumption and trade balance were estimated in the framework of *NATREX approach* by means of VECMs. The medium-run NATREX has been derived by solving the system of equations and using estimated coefficients. In addition, the long-run NATREX has been evaluated by assuming that capital stock and net foreign debt have reached their steady state ratios. Both medium-run and long-run NATREXs indicate that there has been an overvaluation of Latvia's REER during the pre-crisis period, but the gap has disappeared thereafter. However, the long-run NATREX estimates are highly sensitive to assumptions regarding the GDP growth, inflation and depreciation rate and therefore should be interpreted with caution.

By means of SVAR estimates, we have decomposed the REER developments as driven by the demand shock, supply shock and money (or nominal) shock. Initially, the supply and demand shocks were regarded as permanent, but later on it was assumed that only the supply shock impacts the REER in the long run. According to this estimate, the gap between the supply-driven equilibrium REER and the actual REER has also been closed shortly after the period of currency overvaluation prior to the recent recession.

Given that equilibrium exchange rate estimates are subject to substantial uncertainty and are sensitive to different assumptions, it is important to employ a broad set of

methodologies that differ considerably in terms of the underlying theoretical background and macroeconomic time series before any definitive conclusions on REER misalignment are made. All in all, the results of all approaches used in this study indicate that Latvia's REER does not appear to be significantly misaligned at the current juncture, and the real exchange rate of Latvia, after the appreciation during boom years and the subsequent adjustment, remains close to its equilibrium level.

Appendix 1
THE ERER ESTIMATE FOR LATVIA USING IMF CGER COEFFICIENTS

In this Appendix, we assess the equilibrium REER of Latvia using the ERER approach by applying IMF CGER coefficients to Latvia's data. More specifically, we use the coefficients estimated by Lee et al. (2008) for a panel of 48 countries (subsequent refinements using CEE-specific coefficients have been made to account for country-specific effects in Central and Eastern Europe). We infer the country's "fixed effect" directly from the data and the other estimated coefficients by equalising the average prediction error (i.e. the average misalignment) to zero for 2001–2010. The results are summarised in Table 1A1, in which the first column gives values of coefficients estimated by Lee et al. (2008), the second column presents the actual values of regressors (at end-2010), and the last column reports the contribution of each regressor to the equilibrium real exchange rate. This approach indicates that Latvia's REER was at its equilibrium at the end of 2010. However, it is important to emphasise that the real exchange rate is weakly explained by fundamentals in this approach and it is mostly accounted for by the fixed effect. Besides, Latvia is out-of-sample in the IMF panel estimations. Therefore we use single-country (time series) estimation in the main text of this study to extend the ERER calculations based on IMF CGER coefficients.

Table 1A1
ERER estimates using IMF CGER coefficients

	Coefficients	**Value of regressors**	**Contribution**
Productivity gap	1.42	–0.56	–0.80
NFA	0.04	–0.96	–0.04
Government consumption	0.00	0.17	0.00
Commodity terms of trade index	0.39	4.64	1.81
Share of administered prices/1	–0.02	2.00	–0.04
Fixed effect/2	4.06	1.00	4.06
log of actual REER			4.99
log of ERER			4.99
REER misalignment			0.0

Sources: Lee et al. (2008), Eurostat and authors' calculations.

Appendix 2
DATA USED IN ERER APPROACH

Table 2A2
Description of data

Variable	Description
Net foreign assets	Latvia's international investment position is scaled by the sum of exports and imports.
Fiscal balance to GDP differential	This variable is defined as the difference between the ratio of the general government budget balance to GDP in Latvia and the weighted average of budget balance of Latvia's major trading partners. The variable is seasonally adjusted.
Productivity differential	This variable is defined as the logarithm of the ratio of output per employee in tradables and non-tradables sector in Latvia, constructed on the basis of six-sector classification of output and employment, relative to product of weighted productivity of Latvia's major trading partners.
Investment to GDP differential	This variable is defined as the difference between the ratio of investment as a share of GDP in Latvia and the weighted average of investment as a share of GDP of Latvia's major trading partners.
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 Latvia's total exports and imports. All of the commodity prices are estimated relative to the price of manufacturing exports of advanced countries.
Openness to trade differential	This variable is defined as the difference between the openness (exports and imports) to GDP in Latvia and the openness to GDP of the main Latvia's trading partners. The variable is seasonally adjusted.
CPI-based REER	This variable is defined as the logarithm of the CPI-based REER index (1996Q1 = 100) against Latvia's 11 main trading partners.
Government consumption to GDP differential	This variable is defined as the difference between the ratio of the government consumption to GDP in Latvia and the weighted average of the government consumption to GDP of Latvia's main trading partners. The variable is seasonally adjusted.

Appendix 3
UNIT ROOT TEST AND COINTEGRATION TEST IN ERER APPROACH

Table 3A3
Results of unit-root test

	Test for unit root in	Included in test equation	ADF	DFGLS	PP	KPSS
REER, CPI-based, in logs	Level	Intercept	–2.05	–0.32	–2.05	0.56**
		Trend and intercept	–2.12	–1.68	–2.01	0.10
		None	1.26		1.44	
	1st difference	Intercept	–5.08***	–5.01***	–5.03***	0.17
		None	–4.88***		–4.81***	
Productivity differential	Level	Intercept	–1.50	–1.50	–1.50	0.25
		Trend and intercept	–2.02	–1.83	–2.01	0.15**
		None	–0.32		–0.32	
	1st difference	Intercept	–6.65***	–5.58***	–6.69***	0.20
		None	–6.72***		–6.75***	
Commodity terms of trade	Level	Intercept	–1.96	1.91*	–1.74	0.32
		Trend and intercept	–4.33***	–2.03	–1.17	0.07
		None	0.27		0.24	
	1st difference	Intercept	–4.35***	–4.32***	–4.35***	0.20
		None	–4.41***		–4.40***	
Openness to trade	Level	Intercept	–1.25	–1.22	–1.39	0.42*
		Trend and intercept	–2.16	–1.68	–2.21	0.14*
		None	–0.65		–0.68	
	1st difference	Intercept	–6.50***	–5.98***	–6.51***	0.20
		None	–6.59***		–6.58***	
Investment as a share of GDP	Level	Intercept	–0.94	–0.93	–1.13	0.20
		Trend and intercept	–1.04	–0.96	–0.94	0.19**
		None	–0.54		–0.57	
	1st difference	Intercept	–7.04***	–2.22**	–7.01***	0.39*
		None	–7.13***		–7.08***	
NFA	Level	Intercept	–1.67	–1.59	–1.22	0.69**
		Trend and intercept	–3.33*	–3.67**	–1.71	0.14*
		None	–0.75		–0.81	
	1st difference	Intercept	–1.62	–1.82*	–1.92	0.13
		None	–1.90*		–2.14**	
Fiscal balance to GDP differential	Level	Intercept	–1.43	–1.10	–3.26**	0.46*
		Trend and intercept	–2.72	–1.49	–4.28***	0.19**
		None	–1.43		–3.11***	
	1st difference	Intercept	–7.60***	–9.42***	–13.72***	0.05
		None	–7.71***		–13.92***	
Government consumption to GDP differential	Level	Intercept	–1.51	–1.04	–1.58	0.51**
		Trend and intercept	–2.27	–2.33	–2.44	0.07
		None	–0.47		–0.44	
	1st difference	Intercept	–7.49***	–3.38***	–7.42***	0.06
		None	–7.40***		–7.33***	

Sources: Authors' calculations, Bank of Latvia and Eurostat.

Note: Three/two/one asterisk(-s) stand for rejection at 1%/5%/10%.

Table 4A3
Results of cointegration test

Hypothesis	**Trace**	**Trace 95%**
	VECM 1	
None	33.388*	29.797
At most 1	16.413*	15.495
At most 2	3.766	3.841
	VECM 2	
None	45.322*	29.797
At most 1	16.755*	15.495
At most 2	3.478	3.841
	VECM 3	
None	56.919*	47.856
At most 1	27.947	29.797
At most 2	8.672	15.495
	VECM 4	
None	51.362*	47.856
At most 1	28.645	29.797
At most 2	10.362	15.495

Note: An asterisk implies rejection of null hypothesis at 5% level.

Appendix 4
UNIT ROOT TEST AND COINTEGRATION TEST IN NATREX APPROACH

Table 5A4
Results of unit-root test

	Test for unit root in	Included in test equation	ADF	DFGLS	PP	KPSS
Consumption ratio	Level	Intercept	–0.38	–1.12	–2.93**	0.74***
		Trend and intercept	–4.87***	–1.66	–4.89***	0.08
		None	–0.90		–1.62*	
	1st difference	Intercept	–9.69***	–9.28***	–15.62***	0.14
		None	–9.69***		–12.19***	
Capital ratio	Level	Intercept	0.74	–0.15	–0.29	0.72**
		Trend and intercept	–3.05	–1.55	–1.80	0.16**
		None	1.86		1.85	
	1st difference	Intercept	–2.61*	–2.53**	–1.85	0.13
		None	–1.93*		–1.68*	
Net foreign debt ratio	Level	Intercept	–1.31	–0.06	–1.56	0.78***
		Trend and intercept	0.06	–0.85	0.09	0.11
		None	1.05		1.83	
	1st difference	Intercept	–3.72***	–3.84***	–3.70***	0.31
		None	–3.39***		–3.32***	
Trade balance ratio	Level	Intercept	–1.00	–1.03	–1.28	0.27
		Trend and intercept	–1.47	–1.27	–1.57	0.18**
		None	–0.70		–0.79	
	1st difference	Intercept	–5.84***	–5.87***	–5.91***	0.21
		None	–5.90***		–5.97***	
Absorption ratio	Level	Intercept	–0.97	–0.96	–0.97	0.32
		Trend and intercept	–1.42	–1.47	–1.34	0.18**
		None	–0.73		–0.79	
	1st difference	Intercept	–7.19***	–6.52***	–7.22***	0.18
		None	–7.20***		–7.22***	
Foreign consumption ratio	Level	Intercept	–2.53	–2.56**	–1.98	0.12
		Trend and intercept	–2.62	–2.69	–2.06	0.10
		None	0.36		0.19	
	1st difference	Intercept	–3.95***	–3.69***	–3.85***	0.06
		None	–3.97***		–3.89***	
Investments ratio	Level	Intercept	–1.10	–1.12	–1.35	0.20
		Trend and intercept	–1.23	–1.19	–1.41	0.18**
		None	–0.33		–0.35	
	1st difference	Intercept	–6.79***	–2.41**	–6.93***	0.17
		None	–6.87***		–7.00***	
Marginal productivity and interest rate differential	Level	Intercept	–0.39	–0.39	–1.12	0.58**
		Trend and intercept	–2.18	–1.21	–1.92	0.13*
		None	–1.00		–1.01	
	1st difference	Intercept	–1.72	–1.75*	–3.48**	0.11
		None	–1.68*		–3.49***	

Sources: Authors' calculations, Bank of Latvia and Eurostat.

Note: Three/two/one asterisk(-s) stand for rejection at 1%/5%/10%.

Table 6A4
Results of cointegration test

Hypothesis	**Trace**	**Trace 95%**
	Consumption equation	
None	49.575*	42.915
At most 1	13.100	25.872
At most 2	4.333	12.518
	Investment equation	
None	49.157*	42.915
At most 1	23.817	25.872
At most 2	6.453	12.518
	Trade balance equation	
None	80.813*	63.876
At most 1	33.950	42.915
At most 2	9.574	25.872

Note: An asterisk implies rejection of null hypothesis at 5% level.

Appendix 5
ESTIMATION AND IDENTIFICATION OF SVAR MODEL

The first stage is to estimate a reduced–form VAR of first differences of the vector of endogenous variables $X_t=[\Delta y_t, \Delta q_t, \Delta p_t]'$, where y_t is relative output, q_t is real exchange rate, and p_t stands for relative GDP deflators. This VAR can be written as follows:

$$X_t = B_1X_{t-1} + B_2X_{t-2} + \ldots + B_pX_{t-p} + e_t = \sum_{i=1}^{p} B_i L^i X_t + e_t = B(L)X_t + e_t \quad [1]$$

$var(e_t) = \Omega$,

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

Inverting this VAR gives moving average representation:

$$X_t = (I - B(L))^{-1}e_t = (I + B(L) + B(L)^2 + \ldots)e_t = e_t + R_1e_{t-1} + R_2e_{t-2} + \ldots,$$

where $R_i = \begin{bmatrix} r_{11i} & r_{12i} & r_{13i} \\ r_{21i} & r_{22i} & r_{23i} \\ r_{31i} & r_{32i} & r_{33i} \end{bmatrix}$.

The model can be represented by the following structural infinite vector moving average representation:

$$X_t = C_0\varepsilon_t + C_1\varepsilon_{t-1} + C_2\varepsilon_{t-2} + \ldots = \sum_{i=0}^{\infty} C_i\varepsilon_{t-i} = \sum_{i=0}^{\infty} C_i L^i \varepsilon_t, \quad [2]$$

where ε_t denotes structural shocks, which have certain effects on the level endogenous variables and are distinct economic phenomena (mutually uncorrelated, i.e. $var(\varepsilon_t) = I$).

Following Clarida and Gali (1994), we assume that there exists a non–singular matrix S that kinks the structural shocks ε_t and reduced–form disturbances e_t, i.e. $e_t = S\,\varepsilon_t$.

Comparing equations [1] and [2] gives:

$$C_0 = S,\ C_1 = R_1S,\ C_2 = R_2S,\ldots, \quad [3],$$

$$\text{i.e. } C(L) = R(L)S \quad [4].$$

Thus

$$e_t = C_0\varepsilon_t \quad [5].$$

Taking into account that structural shocks are mutually orthogonal and that each has unit variance, and using equation [5] gives:

$$C_0C_0' = \Omega \quad [6].$$

Taking into consideration that C_0 is a 3x3 matrix, nine parameters are needed to identify C_0 and, thus, recover time series of structural shocks ε_t from equation [5]. Six parameters are given by the elements of Ω (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, additional assumptions about the structural shocks should be made. To do that, we follow the Blanchard and Quah approach, which implies the use of long–run theory–based restrictions to the effects of certain shocks on the levels of certain endogenous variables. The effect of a shock on the level of an endogenous variable is determined by the sum of structural moving average coefficients, i.e. by matrix

$$C(1) = C_0 + C_1 + C_2 + \dots .$$

Consequently, the restriction that shock j has zero long–run effect on the level of endogenous variable i means that $C_{ij}(1) = 0$ is imposed. Following Clarida and Gali (1994), we impose the following restrictions on shocks. First, demand shocks $\varepsilon_t^d \equiv \varepsilon_{2t}$ do not affect the level of relative output in the long run: $C_{12}(1) = 0$. Nominal shocks do not affect either relative output or real exchange rate in the long run: $C_{13}(1) = 0$ and $C_{23}(1) = 0$. This provides lower triangulation of matrix C(1). Namely, it can be written as

$$\sum_{i=0}^{\infty} R_i = \sum_{i=0}^{\infty} \begin{bmatrix} r_{11i} & r_{12i} & r_{13i} \\ r_{21i} & r_{22i} & r_{23i} \\ r_{31i} & r_{32i} & r_{33i} \end{bmatrix} = \begin{bmatrix} c_{11}(1) & 0 & 0 \\ c_{21}(1) & c_{22}(1) & 0 \\ c_{31}(1) & c_{32}(1) & c_{33}(1) \end{bmatrix}.$$

It follows from equations [3] and [4] that

$$R(1) = C(1)C_0^{-1} \qquad [7].$$

Taking into account equation [6], the following matrix is formed:

$$R(1)\,\Omega R(1)' = C(1)C_0^{-1}\Omega\, C_0^{-1'}\, C(1)' = C(1)C_0^{-1}\, C_0 C_0^{'}\, C_0^{-1'}\, C(1)' = C(1)C(1)'.$$

Now, we can compute the lower triangular Cholecki decomposition of $R(1)\,\Omega R(1)'$, which is denoted as H:

$$HH' = R(1)\,\Omega R(1)'.$$

C(1) may be equated to H, since it is also triangular:

$$C(1) = H \qquad [8].$$

From equation [7] it follows that

$$C_0 = R(1)^{-1}C(1) = R(1)^{-1}H.$$

Given estimate of C_0, structural system dynamics can be recovered from equation [3]:

$$C_i = R_i C_0 \,,\ i = 1,2,3,...$$

The time series of structural shocks could also be obtained:

$$\varepsilon_t = C_0^{-1} e_t.$$

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