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REPEGGING OF THE LATS TO THE EURO: IMPLICATIONS FOR THE FINANCIAL SECTOR

WORKING PAPER

1/2005

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RIGA 2005

ABSTRACT

The paper is a generalisation of L. E. O. Svensson's simplest test of target zone credibility and the drift-adjustment method in the context of anticipated planned repegging. In 1994, the Latvian lats was pegged to the SDR basket of currencies but on 30 December 2004 the lats was pegged to the euro maintaining the existing exchange rate and fluctuation band of ±1% around the peg rate. Three currencies and two time intervals have been used leading to the generalisation of uncovered interest parity and necessitating the use of forward interest rates.

Key words: *planned repegging, exchange rate target zone, credibility, market interest rate, arbitrage opportunities*

JEL classification codes: *D84, E43, E58, F31, G15*

Fragments of the painting Alchemy by Frančeska Kirke have been used in the design.

ISBN 9984–676–15–3

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INTRODUCTION

For a central bank (CB) to succeed in its pursuit of monetary policy, it should be aware of the expectations of economic agents. The views of financial market participants regarding credibility of the CB monetary policy, e.g. the fixed exchange rate corridor maintenance policy, are also significant. Confidence of the financial market participants, in turn, implies that they do not expect changes in the currency peg rate or any other unexpected exchange rate realignments.

Information about prices of diverse financial assets is useful in evaluation of the financial market participants' expectations. In order to test the expectations in respect of eventual exchange rate realignments, L. E. O. Svensson's simplest test of target zone credibility is used.(10) It is based on uncovered interest rate parity and the assumption that there are no arbitrage opportunities in the market. For the absence of arbitrage, a free capital flow is a prerequisite. Provided that these conditions are satisfied, possible interest rates of the domestic currency are confined within a definite domain known as the interest rate corridor. The simplest test of target zone credibility has a few drawbacks, a very wide interest rate corridor for a short term and disregard for potential peg rate realignments within the initial exchange rate target zone among them. In order to avoid such drawbacks, the drift-adjustment method of G. Bertola and L. E. O. Svensson is used, by which market participants' expectations in respect of the exchange rate parity realignments are estimated via econometric models.(3) The estimation is based on the exchange rate forecasts resulting from the assumption that, within the target zone, the exchange rate tends to return to its long-term mean.

Financial market participants may know beforehand about certain changes in the currency exchange rate regime, e.g. that a shift from the fixed exchange rate regime to a freely floating one, or vice versa, is to be expected, or that the domestic currency peg may change. Since 1994, the lats had been pegged to the SDR basket of currencies with the passive intervention target zone $\pm 1\%$. For Latvia to get ready for a full-fledged participation in the Economic and Monetary Union (EMU) in good time, the lats peg rate to the euro was set on December 30, 2004, by applying the exchange rate formula of the SDR basket of currencies and maintaining the existing exchange rate fluctuation band of $\pm 1\%$ around the peg rate. It requires transformation of the exchange rate credibility testing methods so that they include planned changes in the exchange rate regime at time $t + \tau_1$.

The study is a generalisation of the simplest test of target zone credibility and drift-adjustment method in a situation where a shift in the exchange rate regime is projected. For uncovered interest rate parity estimation purposes, three currencies and two provisional intervals have been used.

Chapter 1 reviews the theoretical foundation of the simplest test of target zone credibility and drift-adjustment method. These methods are applied when a preannounced repegging (i.e. the change of the peg currency) of the domestic currency is planned. Chapter 2 presents the analysis of the Latvian financial market data drawing on the theoretical framework examined in Chapter 1. A novel methodology for calculating precise SDR interest rates, which differs from the one recommended by the IMF, is proposed by the authors and enclosed in the Appendix.

1. FINANCIAL MARKET PARTICIPANTS' EXPECTATIONS FOR EXCHANGE RATE REALIGNMENT UNDER PRE-ANNOUNCED EXCHANGE RATE REPEG

1.1 The Simplest Test of Target Zone Credibility Under Pre-Announced Exchange Rate Repeg

We shall now examine the simplest method of testing exchange rate target zone, adjusting it to the situation where, at a definite moment of time, the exchange rate realignment via repegging is planned.

In the study, t_0 denotes the initial moment of time, τ_1 stands for the time period from t_0 to $t_0 + \tau_1$ when the peg currency is changed, whereas τ_2 is the period of time from the moment of repegging to maturity $t_0 + \tau_1 + \tau_2$.

As to other denotations, d indicates the domestic currency, c_1 is the currency to which the domestic currency was originally pegged but c_2 stands for the currency to which the domestic currency is pegged at time $t_0 + \tau_1$. $S^t_{i/j}$[1] denotes respective exchange rates at time t, with i/j showing units of currency j per one unit of currency i ($i, j = d, c_1, c_2$). Simple interest rates of currencies d, c_1 and c_2 at time t are denoted as $i_t^{d,\tau}$, $i_t^{c_1,\tau}$ and $i_t^{c_2,\tau}$, with the period of time τ expressed in years.

First, the formation of the interest rate corridor is examined in the situation where the currency or the basket of currencies to which the domestic currency is pegged is changed at a definite pre-announced moment of time. We start with exchanging one unit of the domestic currency d for foreign currency c_1 at the exchange rate $\left(\frac{1}{S^{t_0}_{c_1/d}}\right)$; the amount obtained in currency c_1 at time t is invested at the annual interest rate $i_{t_0}^{c_1,\tau_1}$ for term τ_1. Consequently, at the end of term τ_1, $\left(\frac{1}{S^{t_0}_{c_1/d}}\right)\cdot\left(1+i_{t_0}^{c_1,\tau_1}\cdot\tau_1\right)$ units of currency c_1 will be obtained; a subsequent conversion of the latter at rate $\left(\frac{1}{S^{t_0+\tau_1}_{c_2/c_1}}\right)$ produces $\left(\frac{1}{S^{t_0}_{c_1/d}}\right)\cdot\left(1+i_{t_0}^{c_1,\tau_1}\cdot\tau_1\right)\cdot\left(\frac{1}{S^{t_0+\tau_1}_{c_2/c_1}}\right)$ units of currency c_2. When this amount is invested for the remaining term τ_2 at the future interest rate $i_{t_0+\tau_1}^{c_2,\tau_2}$, we obtain $\left(\frac{1}{S^{t_0}_{c_1/d}}\right)\cdot\left(1+i_{t_0}^{c_1,\tau_1}\cdot\tau_1\right)\cdot\left(\frac{1}{S^{t_0+\tau_1}_{c_2/c_1}}\right)\cdot\left(1+i_{t_0+\tau_1}^{c_2,\tau_2}\cdot\tau_2\right)$. Finally, reconverting the resulting amount of money back into the domestic currency, we obtain

[1] The currency rate is given according to the financial market principle instead of the mathematical principle.

$$\left(\frac{1}{S_{c_1/d}^{t_0}}\right)\cdot\left(1+i_{t_0}^{c_1,\tau_1}\cdot\tau_1\right)\cdot\left(\frac{1}{S_{c_2/c_1}^{t_0+\tau_1}}\right)\cdot\left(1+i_{t_0+\tau_1}^{c_2,\tau_2}\cdot\tau_2\right)\cdot S_{c_2/d}^{t_0+\tau_1+\tau_2}$$ units of the domestic currency. In terms of the domestic currency, the return on such transactions can be calculated using the following equation:

$$\left(1+R_{t_0}^{\tau_1+\tau_2}\cdot\left(\tau_1+\tau_2\right)\right)=\left(\frac{1}{S_{c_1/d}^{t_0}}\right)\cdot\left(1+i_{t_0}^{c_1,\tau_1}\cdot\tau_1\right)\cdot\left(\frac{1}{S_{c_2/c_1}^{t_0+\tau_1}}\right)\cdot\left(1+i_{t_0+\tau_1}^{c_2,\tau_2}\cdot\tau_2\right)\cdot S_{c_2/d}^{t_0+\tau_1+\tau_2},$$

where $R_{t_0}^{\tau_1+\tau_2}$ is the annual return on the domestic currency d, written as:

$$R_{t_0}^{\tau_1+\tau_2}=\frac{1}{\left(\tau_1+\tau_2\right)}\cdot\left(\left(\frac{1}{S_{c_1/d}^{t_0}}\right)\cdot\left(1+i_{t_0}^{c_1,\tau_1}\cdot\tau_1\right)\cdot\left(\frac{1}{S_{c_2/c_1}^{t_0+\tau_1}}\right)\cdot\left(1+i_{t_0+\tau_1}^{c_2,\tau_2}\cdot\tau_2\right)\cdot S_{c_2/d}^{t_0+\tau_1+\tau_2}-1\right) \qquad [1.1.1].$$

The next level of the expected future central parity $S_{0,\,c_2/d}$ depends on the market exchange rate on a respective date $t_0+\tau_1$:

$$S_{0,\,c_2/d}=S_{0,\,c_1/d}\cdot S_{c_2/c_1}^{t_0+\tau_1} \qquad [1.1.2],$$

where $S_{0,\,c_1/d}$ is the parity at which the national currency is pegged to currency c_1, but $S_{0,\,c_2/d}$ is its peg rate to currency c_2 after the moment of time $t_0+\tau_1$.

The market rate at the moment of pegging $S_{c_2/c_1}^{t_0+\tau_1}$ is expressed as the ratio of the two fixed exchange rates:

$$S_{c_2/c_1}^{t_0+\tau_1}=\frac{S_{0,\,c_2/d}}{S_{0,\,c_1/d}} \qquad [1.1.3].$$

The obtained equation is substituted into equation [1.1.1]:

$$R_{t_0}^{\tau_1+\tau_2}=\frac{1}{\left(\tau_1+\tau_2\right)}\cdot\left(\left(\frac{1}{S_{c_1/d}^{t_0}}\right)\cdot\left(1+i_{t_0}^{c_1,\tau_1}\cdot\tau_1\right)\cdot\left(\frac{1}{\frac{S_{0,\,c_2/d}}{S_{0,\,c_1/d}}}\right)\cdot\left(1+i_{t_0+\tau_1}^{c_2,\tau_2}\cdot\tau_2\right)\cdot S_{c_2/d}^{t_0+\tau_1+\tau_2}-1\right)=$$

$$=\frac{1}{\left(\tau_1+\tau_2\right)}\cdot\left(\left(\frac{1}{S_{c_1/d}^{t_0}}\right)\cdot\left(1+i_{t_0}^{c_1,\tau_1}\cdot\tau_1\right)\cdot\left(\frac{S_{0,\,c_1/d}}{S_{0,\,c_2/d}}\right)\cdot\left(1+i_{t_0+\tau_1}^{c_2,\tau_2}\cdot\tau_2\right)\cdot S_{c_2/d}^{t_0+\tau_1+\tau_2}-1\right) \qquad [1.1.4].$$

By fixing the lats exchange rate to the euro and preserving the target zone width at ±1%, the market exchange rate at time $t_0+\tau_1+\tau_2$ could possibly be within the following band:

$$0.99 \cdot S_{0,\,c_2/d} = \underline{S} \le S_{c_2/d}^{t_0+\tau_1+\tau_2} \le \overline{S} = 1.01 \cdot S_{0,\,c_2/d}.$$

When the upper and lower margins of the exchange rate band are inserted in equation [1.1.4] we obtain a corridor inside which interest rates of the domestic currency should be kept, if the condition of free capital mobility is satisfied and any concerns about eventual devaluation or revaluation of the domestic currency are absent:

$$\underline{R}_{t_0}^{\tau_1+\tau_2} \le R_{t_0}^{\tau_1+\tau_2} \le \overline{R}_{t_0}^{\tau_1+\tau_2},$$

where

$$\overline{R}_{t_0}^{\tau_1+\tau_2} = \frac{1}{(\tau_1+\tau_2)} \cdot \left(\left(\frac{1}{S_{c_1/d}^{t_0}} \right) \cdot \left(1 + i_{t_0}^{c_1,\tau_1} \cdot \tau_1\right) \cdot \left(\frac{S_{0,\,c_1/d}}{S_{0,\,c_2/d}} \right) \cdot \left(1 + i_{t_0+\tau_1}^{c_2,\tau_2} \cdot \tau_2\right) \cdot \overline{S} - 1 \right) =$$

$$= \frac{1}{(\tau_1+\tau_2)} \cdot \left(\left(\frac{1}{S_{c_1/d}^{t_0}} \right) \cdot \left(1 + i_{t_0}^{c_1,\tau_1} \cdot \tau_1\right) \cdot \left(\frac{S_{0,\,c_1/d}}{S_{0,\,c_2/d}} \right) \cdot \left(1 + i_{t_0+\tau_1}^{c_2,\tau_2} \cdot \tau_2\right) \cdot 1.01 \cdot S_{0,\,c_2/d} - 1 \right) =$$

$$= \frac{1}{(\tau_1+\tau_2)} \cdot \left(\frac{1.01 \cdot S_{0,\,c_1/d} \cdot \left(1 + i_{t_0}^{c_1,\tau_1} \cdot \tau_1\right) \cdot \left(1 + i_{t_0+\tau_1}^{c_2,\tau_2} \cdot \tau_2\right)}{S_{c_1/d}^{t}} - 1 \right) \qquad [1.1.5],$$

$$\underline{R}_{t_0}^{\tau_1+\tau_2} = \frac{1}{(\tau_1+\tau_2)} \cdot \left(\left(\frac{1}{S_{c_1/d}^{t_0}} \right) \cdot \left(1 + i_{t_0}^{c_1,\tau_1} \cdot \tau_1\right) \cdot \left(\frac{S_{0,\,c_1/d}}{S_{0,\,c_2/d}} \right) \cdot \left(1 + i_{t_0+\tau_1}^{c_2,\tau_2} \cdot \tau_2\right) \cdot \underline{S} - 1 \right) =$$

$$= \frac{1}{(\tau_1+\tau_2)} \cdot \left(\left(\frac{1}{S_{c_1/d}^{t_0}} \right) \cdot \left(1 + i_{t_0}^{c_1,\tau_1} \cdot \tau_1\right) \cdot \left(\frac{S_{0,\,c_1/d}}{S_{0,\,c_2/d}} \right) \cdot \left(1 + i_{t_0+\tau_1}^{c_2,\tau_2} \cdot \tau_2\right) \cdot 0.99 \cdot S_{0,\,c_2/d} - 1 \right) =$$

$$= \frac{1}{(\tau_1+\tau_2)} \cdot \left(\frac{0.99 \cdot S_{0,\,c_1/d} \cdot \left(1 + i_{t_0}^{c_1,\tau_1} \cdot \tau_1\right) \cdot \left(1 + i_{t_0+\tau_1}^{c_2,\tau_2} \cdot \tau_2\right)}{S_{c_1/d}^{t}} - 1 \right) \qquad [1.1.6].$$

The market exchange rate $S_{c_1/d}^{t_0}$ can also be expressed as its position inside the target zone:

$$S_{c_1/d}^{t_0} = S_{0,\,c_1/d} + \Delta S_{t_0} = S_{0,\,c_1/d} \cdot \left(1 + \frac{\Delta S_{t_0}}{S_{0,\,c_1/d}}\right) = S_{0,\,c_1/d} \cdot \left(1 + \delta S_{t_0}\right) \qquad [1.1.7],$$

where $\delta S_{t_0} = \frac{\Delta S_{t_0}}{S_{0,\, c_1/d}}$ is the relative deviation of the exchange rate from the parity. Substituting equation [1.1.7] into equations [1.1.5] and [1.1.6], the equations determining the interest rate corridor may be further simplified:

$$\overline{R}_{t_0}^{\tau_1+\tau_2} = \frac{1}{(\tau_1+\tau_2)} \cdot \left(\frac{1.01 \cdot S_{0,\, c_1/d} \cdot \left(1+i_{t_0}^{c_1,\tau_1} \cdot \tau_1\right) \cdot \left(1+i_{t_0+\tau_1}^{c_2,\tau_2} \cdot \tau_2\right)}{S_{0,\, c_1/d} \cdot \left(1+\delta S_{t_0}\right)} - 1 \right) =$$

$$= \frac{1}{(\tau_1+\tau_2)} \cdot \left(\frac{1.01 \cdot \left(1+i_{t_0}^{c_1,\tau_1} \cdot \tau_1\right) \cdot \left(1+i_{t_0+\tau_1}^{c_2,\tau_2} \cdot \tau_2\right)}{1+\delta S_{t_0}} - 1 \right) \qquad [1.1.8],$$

$$\underline{R}_{t_0}^{\tau_1+\tau_2} = \frac{1}{(\tau_1+\tau_2)} \cdot \left(\frac{0.99 \cdot S_{0,\, c_1/d} \cdot \left(1+i_{t_0}^{c_1,\tau_1} \cdot \tau_1\right) \cdot \left(1+i_{t_0+\tau_1}^{c_2,\tau_2} \cdot \tau_2\right)}{S_{0,\, c_1/d} \cdot \left(1+\delta S_{t_0}\right)} - 1 \right) =$$

$$= \frac{1}{(\tau_1+\tau_2)} \cdot \left(\frac{0.99 \cdot \left(1+i_{t_0}^{c_1,\tau_1} \cdot \tau_1\right) \cdot \left(1+i_{t_0+\tau_1}^{c_2,\tau_2} \cdot \tau_2\right)}{1+\delta S_{t_0}} - 1 \right) \qquad [1.1.9].$$

The resulting equations [1.1.8] and [1.1.9] show that the interest rate corridor does not depend on future exchange rates but rather on the initial exchange rate $S_{c_1/d}^{t}$ or its deviation from the parity, the initial interest rate $i_t^{c_1,\tau_1}$ and the future interest rate $i_{t+\tau_1}^{c_2,\tau_2}$. The latter is not known at time t_0, but as the euro derivatives market is broad and liquid, the future interest rates can be fixed via futures and forward interest rate contracts. As for calculations, not only futures and forward interest rates quoted in the financial market but also implied forward interest rates of the money market can be used as interest rates $i_{t_0+\tau_1}^{c_2,\tau_2}$.

The forward interest rates implied by the money market interest rates can be calculated as follows:

$$f_{t_0,\tau_1}^{c_2,\tau_2} = \frac{\dfrac{\left(1+i_{t_0}^{c_2,\tau_1+\tau_2} \cdot (\tau_1+\tau_2)\right)}{\left(1+i_{t_0}^{c_2,\tau_1} \cdot \tau_1\right)} - 1}{\tau_2} = \frac{i_{t_0}^{c_2,\tau_1+\tau_2} \cdot (\tau_1+\tau_2) - i_{t_0}^{c_2,\tau_1} \cdot \tau_1}{\tau_2 \cdot \left(1+i^{c_2,\tau_1} \cdot \tau_1\right)} \qquad [1.1.10].$$

Substituting this equation into equations [1.1.8] and [1.1.9] instead of $i_{t+\tau_1}^{c_2,\tau_2}$, the margins of the interest rate corridor are obtained:

$$\overline{R}_{t_0}^{\tau_1+\tau_2} = \frac{1}{(\tau_1+\tau_2)} \cdot \left(\frac{1.01 \cdot (1+i_{t_0}^{c_1,\tau_1} \cdot \tau_1) \cdot (1+i_{t_0}^{c_2,\tau_1+\tau_2} \cdot (\tau_1+\tau_2))}{(1+\delta S_{t_0}) \cdot (1+i_{t_0}^{c_2,\tau_1} \cdot \tau_1)} - 1 \right) \qquad [1.1.11]$$

and

$$\underline{R}_{t_0}^{\tau_1+\tau_2} = \frac{1}{(\tau_1+\tau_2)} \cdot \left(\frac{0.99 \cdot (1+i_{t_0}^{c_1,\tau_1} \cdot \tau_1) \cdot (1+i_{t_0}^{c_2,\tau_1+\tau_2} \cdot (\tau_1+\tau_2))}{(1+\delta S_{t_0}) \cdot (1+i_{t_0}^{c_2,\tau_1} \cdot \tau_1)} - 1 \right) \qquad [1.1.12].$$

Due to interest rates and δS_{t_0} being small values that are added to or subtracted from number 1, a good approximation can be obtained using Taylor's first-order series. If the money market interest rates are known at time t_0, the following interest rate corridor is obtained:

$$\overline{R}_{t_0}^{\tau_1+\tau_2} = \frac{1}{(\tau_1+\tau_2)} \cdot \left(i_{t_0}^{c_2,\tau_1+\tau_2} \cdot (\tau_1+\tau_2) + 0.01 - \delta S_{t_0} + (i_{t_0}^{c_1,\tau_1} - i_{t_0}^{c_2,\tau_1}) \cdot \tau_1 \right) =$$

$$= \left(i_{t_0}^{c_2,\tau_1+\tau_2} + \frac{0.01 - \delta S_{t_0}}{(\tau_1+\tau_2)} \right) + \frac{(i_{t_0}^{c_1,\tau_1} - i_{t_0}^{c_2,\tau_1}) \cdot \tau_1}{(\tau_1+\tau_2)} \qquad [1.1.13]$$

and

$$\underline{R}_{t_0}^{\tau_1+\tau_2} = \frac{1}{(\tau_1+\tau_2)} \cdot \left(i_{t_0}^{c_2,\tau_1+\tau_2} \cdot (\tau_1+\tau_2) - 0.01 - \delta S_{t_0} + (i_{t_0}^{c_1,\tau_1} - i_{t_0}^{c_2,\tau_1}) \cdot \tau_1 \right) =$$

$$= \left(i_{t_0}^{c_2,\tau_1+\tau_2} - \frac{0.01 + \delta S_{t_0}}{(\tau_1+\tau_2)} \right) + \frac{(i_{t_0}^{c_1,\tau_1} - i_{t_0}^{c_2,\tau_1}) \cdot \tau_1}{(\tau_1+\tau_2)} \qquad [1.1.14].$$

The terms in large parenthesis of the obtained equations [1.1.13] and [1.1.14] are similar to those in the equations that are derived for testing exchange rate target zone in the situation where no changes in the exchange rate regime are to be expected.(1) In this case, the upper margin of the interest rate corridor depends on the interest rate for the currency to which the domestic currency will be pegged in the future plus the relative differential between the exchange rate and the CB's foreign currency selling rate applicable at time $\tau_1 + \tau_2$. The lower margin of the interest rate corridor depends on the interest rate of the currency to which the domestic currency will be pegged in the future minus the relative differential between the exchange rate and the CB's foreign currency selling rate applicable at time $\tau_1 + \tau_2$.

If a change in the exchange rate regime is expected, interest rate corridor equations contain an additional term $\frac{\left(i_{t_0}^{c_1,\tau_1}-i_{t_0}^{c_2,\tau_1}\right)\cdot\tau_1}{\left(\tau_1+\tau_2\right)}$, which decreases (increases) the level of the interest rate corridor, if interest rates for the currency to which the domestic currency was initially pegged are lower (higher) than those for the currency to which the domestic currency is going to be pegged as a result of the expected shift in the exchange rate regime.

To make use of the forward interest rates, the interest rate corridor can be written inserting the return $i_{t_0}^{c_1,\tau_1+\tau_2}\left(\tau_1+\tau_2\right)$ in equations [1.1.13] and [1.1.14] :

$$\overline{R}_{t_0}^{\tau_1+\tau_2}=\frac{1}{\left(\tau_1+\tau_2\right)}\cdot\left(f_{t_0,\tau_1}^{c_2,\tau_2}\cdot\tau_2+i_{t_0}^{c_1,\tau_1+\tau_2}\left(\tau_1+\tau_2\right)-\left(i_{t_0}^{c_2,\tau_1+\tau_2}\cdot\left(\tau_1+\tau_2\right)-i_{t_0}^{c_1,\tau_1}\cdot\tau_1\right)+0.01-\delta S_{t_0}\right)=$$

$$=\frac{1}{\left(\tau_1+\tau_2\right)}\cdot\left(i_{t_0}^{c_1,\tau_1+\tau_2}\left(\tau_1+\tau_2\right)+f_{t_0,\tau_1}^{c_2,\tau_2}\cdot\tau_2-f_{t_0,\tau_1}^{c_1,\tau_2}\cdot\tau_2+0.01-\delta S_{t_0}\right)$$

$$\overline{R}_{t_0}^{\tau_1+\tau_2}=\left(i_{t_0}^{c_1,\tau_1+\tau_2}+\frac{0.01-\delta S_{t_0}}{\left(\tau_1+\tau_2\right)}\right)+\frac{\left(f_{t_0,\tau_1}^{c_2,\tau_2}-f_{t_0,\tau_1}^{c_1,\tau_2}\right)\cdot\tau_2}{\left(\tau_1+\tau_2\right)} \qquad [1.1.15]$$

and

$$\underline{R}_{t_0}^{\tau_1+\tau_2}=\frac{1}{\left(\tau_1+\tau_2\right)}\cdot\left(f_{t_0,\tau_1}^{c_2,\tau_2}\cdot\tau_2+i_{t_0}^{c_1,\tau_1+\tau_2}\left(\tau_1+\tau_2\right)-\left(i_{t_0}^{c_2,\tau_1+\tau_2}\cdot\left(\tau_1+\tau_2\right)-i_{t_0}^{c_1,\tau_1}\cdot\tau_1\right)-0.01-\delta S_{t_0}\right)=$$

$$=\frac{1}{\left(\tau_1+\tau_2\right)}\cdot\left(i_{t_0}^{c_1,\tau_1+\tau_2}\left(\tau_1+\tau_2\right)+f_{t_0,\tau_1}^{c_2,\tau_2}\cdot\tau_2-f_{t_0,\tau_1}^{c_1,\tau_2}\cdot\tau_2-0.01-\delta S_{t_0}\right)$$

$$\underline{R}_{t_0}^{\tau_1+\tau_2}=\left(i_{t_0}^{c_1,\tau_1+\tau_2}-\frac{0.01+\delta S_{t_0}}{\left(\tau_1+\tau_2\right)}\right)+\frac{\left(f_{t_0,\tau_1}^{c_2,\tau_2}-f_{t_0,\tau_1}^{c_1,\tau_2}\right)\cdot\tau_2}{\left(\tau_1+\tau_2\right)} \qquad [1.1.16].$$

Equations [1.1.15] and [1.1.16] lead to an assumption, that the margins of the interest rate corridor depend on the interest rates of the initial peg currency, the return on eventual exchange rate fluctuations within the target zone and the implied forward interest rate differential between the initial peg currency and the currency to which the domestic currency will be pegged at time $t_0 + \tau_1$. The first term of the equation is used in testing the exchange rate credibility in the situation where no repegging is projected (1), whereas the second term contains future interest rate differentials between the current and future peg currency.

Consequently, the significance of interest rates of the currency to which the domestic currency will be pegged in the future will increase with the moment of repegging coming closer. It is also confirmed by the equations above where, with the value of τ_2 in relation to $\tau_1 + \tau_2$ growing, the significance of interest rate differentials of the future peg currencies also increases. If shifts in the exchange rate regime are not to be expected, $\tau_2 = 0$.

Turning to equations [1.1.13], [1.1.14] and [1.1.15], [1.1.16], they are rather similar for both the upper margin calculations of the interest rate corridor

$$\overline{R}_{t_0}^{\tau_1+\tau_2} = \left(i_{t_0}^{c_2,\tau_1+\tau_2} + \frac{0.01-\delta S_{t_0}}{(\tau_1+\tau_2)} \right) + \frac{\left(i_{t_0}^{c_1,\tau_1} - i_{t_0}^{c_2,\tau_1}\right)\cdot\tau_1}{(\tau_1+\tau_2)} \text{ and}$$

$$\overline{R}_{t_0}^{\tau_1+\tau_2} = \left(i_{t_0}^{c_1,\tau_1+\tau_2} + \frac{0.01-\delta S_{t_0}}{(\tau_1+\tau_2)} \right) + \frac{\left(f_{t_0,\tau_1}^{c_2,\tau_2} - f_{t_0,\tau_1}^{c_1,\tau_2}\right)\cdot\tau_2}{(\tau_1+\tau_2)},$$

and its lower margin calculations

$$\underline{R}_{t_0}^{\tau_1+\tau_2} = \left(i_{t_0}^{c_2,\tau_1+\tau_2} - \frac{0.01+\delta S_{t_0}}{(\tau_1+\tau_2)} \right) + \frac{\left(i_{t_0}^{c_1,\tau_1} - i_{t_0}^{c_2,\tau_1}\right)\cdot\tau_1}{(\tau_1+\tau_2)} \text{ and}$$

$$\underline{R}_{t_0}^{\tau_1+\tau_2} = \left(i_{t_0}^{c_1,\tau_1+\tau_2} - \frac{0.01+\delta S_{t_0}}{(\tau_1+\tau_2)} \right) + \frac{\left(f_{t_0,\tau_1}^{c_2,\tau_2} - f_{t_0,\tau_1}^{c_1,\tau_2}\right)\cdot\tau_2}{(\tau_1+\tau_2)}.$$

The first terms of the equations differ due to distinct interest rates used in the calculations, i.e. interest rates of the currency to which the domestic currency will be pegged at time $t_0 + \tau_1$ are used in the first case, while in the second those of the current peg currency have been employed. The applied interest rate differentials, in turn, distinguish the second terms of the equations, meaning that they differ by whether a spot interest rate differential of the current and future peg currencies or their implied forward interest rate differential has been used.

1.2 Drift-Adjustment Models

Section 1.1 of the study has already dealt with a non-arbitrage interest rate corridor, which can be used to identify cases when financial market participants assume exchange rate realignment possibilities and, at the same time, to specify the margins of the interest rate corridor within which the CB can implement its independent monetary policy in the short term. However, the interest rate corridor is extremely wide for short-term contracts, and the rate of return is seldom able to move outside its margins. Be it so, the views of financial market participants regarding exchange rate credibility can be tested by a special model worked out to identify possible forecasts of the foreign exchange market participants for probable exchange rate changes.

To start with, the uncovered interest rate parity is considered:

$$\left(1+i_t^{c,\tau}\right)^\tau = \frac{S_{c/d}^t\left(1+i_t^{d,\tau}\right)^\tau}{S_{c/d}^{t+\tau}} \qquad [1.2.1],$$

where $i_t^{c,\tau}$ and $i_t^{d,\tau}$ are compounded interest rates.

Hence the return in foreign currency c corresponds to the return on investment in the domestic currency *d* for time τ, assuming that the difference in returns is offset by the expected exchange rate changes. Under conditions of a fixed exchange rate regime with a target zone, spot interest rates and those expected in the future can be written as:

$$S_{c/d}^t = S_{0,\,c/d}^t\left(1+\delta S_{c/d}^t\right) \qquad [1.2.2],$$

$$S_{c/d}^{t+\tau} = S_{0,\,c/d}^{t+\tau}\left(1+\delta S_{c/d}^{t+\tau}\right) \qquad [1.2.3],$$

where $S_{0,\,c/d}^t$ and $S_{0,\,c/d}^{t+\tau}$ are exchange rate parity levels for time *t* and time $t + \tau$, respectively, but $\delta S_{c/d}^t$ and $\delta S_{c/d}^{t+\tau}$ are relative deviations of the market exchange rate from the parity level.

Equations [1.2.2] and [1.2.3] are inserted into equation [1.2.1]:

$$\left(1+i_t^{c,\tau}\right)^\tau = \frac{S_{0,\,c/d}^t\left(1+\delta S_{c/d}^t\right)\left(1+i_{t_0}^{d,\tau}\right)^\tau}{S_{0,\,c/d}^{t+\tau}\left(1+\delta S_{c/d}^{t+\tau}\right)} \qquad [1.2.4].$$

Then we take log of [1.2.4]:

$$\tau\cdot\ln\left(1+i_t^{c,\tau}\right) = \ln S_{0,\,c/d}^t + \ln\left(1+\delta S_{c/d}^t\right) + \tau\cdot\ln\left(1+i_t^{d,\tau}\right) - \ln S_{0,\,c/d}^{t+\tau} - \ln\left(1+\delta S_{c/d}^{t+\tau}\right) \qquad [1.2.5].$$

Denoting $\ln(1 + i_t^{c,\tau})$ with $r_t^{c,\tau}$, $\ln S_{0,\,c/d}^t$ with c_t, $\ln(1 + \delta S_{c/d}^t)$ with x_t, $\ln(1 + i_t^{d,\tau})$ with $r_t^{d,\tau}$, $\ln S_{0,\,c/d}^{t+\tau}$ with $c_{t+\tau}$, and $\ln\left(1+\delta S_{c/d}^{t+\tau}\right)$ with $x_{t+\tau}$, we obtain:

$$c_{t+\tau} - c_t = \tau\cdot\left(r_t^{d,\tau} - r_t^{c,\tau}\right) - \left(x_{t+\tau} - x_t\right) \qquad [1.2.6],$$

and use Δc_t^τ for $c_{t+\tau} - c_t$ and Δx_t^τ for $x_{t+\tau} - x_t$. As neither the exchange rate in the future nor the parity rate is known beforehand, market forecasts of the respective variables are considered. Applying the mathematical expectations operator to both sides of equation [1.2.6] at time t, we arrive at the expected realignment value of the exchange parity level:

$$E_t\left(\Delta c_t^\tau\right) = \tau\cdot\left(r_t^{d,\tau} - r_t^{c,\tau}\right) - E_t\left(\Delta x_t^\tau\right) \qquad [1.2.7].$$

Thus, the only known value in equation [1.2.7] is that of the interest rate differential, with the parity level and the exchange rate deviation from it in the future remaining unknown.

In order to estimate the extent of the expected exchange rate devaluation or revaluation, the exchange rate depreciation or appreciation forecasts relative to the target zone are to be estimated. It is equivalent to the estimation of exchange rate $E_t(x_{t+\tau})$ relative to the exchange rate parity. The studies of this problem led A. K. Rose and L. E. O. Svensson to an assumption that, within the target zone, the daily exchange rate tends to a long-term mean.(8) This tendency of reverting to long-term mean values within the target zone is associated with the fact that due to CB's interventions exchange rate values are not capable of moving outside the target zone, and foreign exchange market participants, who believe in credibility of the exchange rate regime and thereby continue to engage in transactions, facilitate the return of the exchange rate to its long-term mean. In the exchange rate forecasting model developed by J. Bertola and L. E. O. Svensson, the spot exchange rate within the target zone x_t is the only factor enabling such forecasting. Though relationships of the expected exchange rate realignments within the target zone may not necessarily be linear, J. Bertola and L. E. O. Svensson argue that linear approximation could most often be the best solution. In their works, H. Lindberg, P. Söderlind and L. E. O. Svensson (7), L. E. O. Svensson (11) and A. K. Rose, and L. E. O. Svensson (8) estimated nonlinear regression models where $x_{t+\tau}$ depends on $x_t, x_{t-1}, ..., x_{t-i}, x_t^2, x_t^3, i_t^{d,\tau} - i_t^{c,\tau}$. H. Lindberg, P. Söderlind and L. E. O. Svensson came to a conclusion that, if the exchange rate forecast is to be made within the target zone, a simple regression model estimated using the ordinary least square (OLS) method with Newey-West's error (due to conditional heteroscedesticity and residual autocorrelation) produces the best result.(7)

The findings in these works indicate that a simple linear regression leads to sound and reliable results of exchange rate forecasting within the target zone, whereas the application of a variety of other functional specifications often produces results that are difficult to explain and account for.

1.3 Drift-Adjustment Model in the Context of Planned Repeg

This section examines repegging of the domestic currency from a foreign currency or a basket of foreign currencies planned for future time $t + \tau_1$ without changing the width of the target zone.

Similar to the sample situation dealt with in Section 1.1, at time t, one unit of the domestic currency d is exchanged for $\left(\frac{1}{S_{c_1/d}^t}\right)$ units of a foreign currency c_1. Investing the obtained amount of the foreign currency units for term τ_1, $\left(\frac{1}{S^t_{c_1/d}}\right)\cdot\left(1+i_t^{c_1,\tau_1}\right)^{\tau_1}$ units of foreign currency are obtained at the expiry of the term (compounded interest is used in this case). The conversion of currency c_1 into currency c_2 at time $t + \tau_1$ results in $\left(\frac{1}{S^t_{c_1/d}}\right)\cdot\left(1+i_t^{c_1,\tau_1}\right)^{\tau_1}\cdot\left(\frac{1}{S^{t+\tau_1}_{c_2/c_1}}\right)$ units of currency c_2. When the funds thus obtained are invested for the remaining term τ_2 at the future interest rate $i_{t+\tau_1}^{c_2,\tau_2}$, $\left(\frac{1}{S^t_{c_1/d}}\right)\cdot\left(1+i_t^{c_1,\tau_1}\right)^{\tau_1}\cdot\left(\frac{1}{S^{t+\tau_1}_{c_2/c_1}}\right)\cdot\left(1+i_{t+\tau_1}^{c_2,\tau_2}\right)^{\tau_2}$ units of the currency c_2 are obtained. When this final amount is re-converted, $\left(\frac{1}{S^t_{c_1/d}}\right)\cdot\left(1+i_t^{c_1,\tau_1}\right)^{\tau_1}\cdot\left(\frac{1}{S^{t+\tau_1}_{c_2/c_1}}\right)\cdot\left(1+i_{t+\tau_1}^{c_2,\tau_2}\right)^{\tau_2}\cdot S^{t+\tau_1+\tau_2}_{c_2/d}$ units of the domestic currency d are obtained. For term $\tau_1 + \tau_2$, the return resulting from this strategy should be equal to the expected return on investments made in the domestic currency:

$$\left(1+R_t^{\tau_1+\tau_2}\right)^{(\tau_1+\tau_2)}=\left(\frac{1}{S^t_{c_1/d}}\right)\cdot\left(1+i_t^{c_1,\tau_1}\right)^{\tau_1}\cdot\left(\frac{1}{S^{t_0+\tau_1}_{c_2/c_1}}\right)\cdot\left(1+i_{t+\tau_1}^{c_2,\tau_2}\right)^{\tau_2}\cdot S^{t+\tau_1+\tau_2}_{c_2/d} \qquad [1.3.1].$$

The exchange rate $S^{t+\tau_1}_{c_2/c_1}$ at the moment of repegging is expressed as the ratio of the two fixed exchange rates:

$$S^{t+\tau_1}_{c_2/c_1}=\frac{S^{t+\tau_1}_{0,\,c_2/d}}{S^{t+\tau_1}_{0,\,c_1/d}} \qquad [1.3.2].$$

The obtained equation is substituted into equation [1.3.1]:

$$\left(1+R_t^{\tau_1+\tau_2}\right)^{(\tau_1+\tau_2)}=\left(\frac{1}{S^t_{c_1/d}}\right)\cdot\left(1+i_t^{c_1,\tau_1}\right)^{\tau_1}\cdot\left(\frac{S^{t+\tau_1}_{0,\,c_1/d}}{S^{t+\tau_1}_{0,\,c_2/d}}\right)\cdot\left(1+i_{t+\tau_1}^{c_2,\tau_2}\right)^{\tau_2}\cdot S^{t+\tau_1+\tau_2}_{c_2/d} \qquad [1.3.3].$$

The market exchange rate $S^t_{c_1/d}$ is expressed as its position within the target zone:

$$S^t_{c_1/d}=S^t_{0,\,c_1/d}\cdot\left(1+\delta S_t\right).$$

Assuming that $S^t_{0,\,c_1/d}=S^{t+\tau_1}_{0,\,c_1/d}$, i.e. the parity level of the exchange rate against the SDR basket of currencies will not be changed at time $[t,\, t+\tau_1]$, the following equation is derived:

$$\left(1+R_t^{\tau_1+\tau_2}\right)^{(\tau_1+\tau_2)}=\left(\frac{1}{1+\delta S_t}\right)\cdot\left(1+i_t^{c_1,\tau_1}\right)^{\tau_1}\cdot\frac{1}{S_{0,\,c_2/d}^{t+\tau_1}}\cdot\left(1+i_{t+\tau_1}^{c_2,\tau_2}\right)^{\tau_2}\cdot S_{c_2/d}^{t+\tau_1+\tau_2} \qquad [1.3.4].$$

Taking log of both sides gives:

$$\left(\tau_1+\tau_2\right)\ln\left(1+R_t^{\tau_1+\tau_2}\right)=-\ln\left(1+\delta S_t\right)+\tau_1\ln\left(1+i_t^{c_1,\tau_1}\right)-\ln S_{0,\,c_2/d}^{t+\tau_1}+\tau_2\ln\left(1+i_{t+\tau_1}^{c_2,\tau_2}\right)+\ln S_{c_2/d}^{t+\tau_1+\tau_2} \qquad [1.3.5],$$

where

$$S_{c_2/d}^{t+\tau_1+\tau_2}=S_{0,\,c_2/d}^{t+\tau_1+\tau_2}\left(1+\delta S_{t+\tau_1+\tau_2}\right).$$

In a general case, $S_{0,c_2/d}^{t+\tau_1}\neq S_{0,c_2/d}^{t+\tau_1+\tau_2}$, i.e. changes in the parity level of the exchange rate are admissible after time $t+\tau_1$.

The notations $r_t^{\tau_1+\tau_2}=\ln\left(1+R_t^{\tau_1+\tau_2}\right)$, $r_t^{c_1,\tau_1}=\ln\left(1+i_t^{c_1,\tau_1}\right)$, $r_{t+\tau_1}^{c_2,\tau_2}=\ln\left(1+i_{t+\tau_1}^{c_2,\tau_2}\right)$, $x_t=\ln\left(1+\delta S_t\right)$, $x_{t+\tau_1+\tau_2}=\ln\left(1+\delta S_{t+\tau_1+\tau_2}\right)$, $c_{t+\tau_1}=\ln S_{0,c_2/d}^{t+\tau_1}$, $c_{t+\tau_1+\tau_2}=\ln S_{0,c_2/d}^{t+\tau_1+\tau_2}$ are introduced and substituted into equation [1.3.5]:

$$\left(\tau_1+\tau_2\right)r_t^{\tau_1+\tau_2}=-x_t+\tau_1\cdot r_t^{c_1,\tau_1}-c_{t+\tau_1}+\tau_2\cdot r_t^{c_2,\tau_2}+c_{t+\tau_1+\tau_2}+x_{t+\tau_1+\tau_2}$$

or

$$c_{t+\tau_1+\tau_2}-c_{t+\tau_1}=\left(\tau_1+\tau_2\right)r_t^{\tau_1+\tau_2}-\tau_1\cdot r_t^{c_1,\tau_1}-\tau_2\cdot r_t^{c_2,\tau_2}-\left(x_{t+\tau_1+\tau_2}-x_t\right) \qquad [1.3.6],$$

or

$$c_{t+\tau_1+\tau_2}-c_{t+\tau_1}=\tau_1\cdot\left(r_t^{\tau_1+\tau_2}-r_t^{c_1,\tau_1}\right)+\tau_2\cdot\left(r_t^{\tau_1+\tau_2}-r_t^{c_2,\tau_2}\right)-\left(x_{t+\tau_1+\tau_2}-x_t\right) \qquad [1.3.7].$$

Similar to equation [1.2.6], the operator of mathematical expectation is applied to both sides of equation [1.3.7]:

$$E\left(c_{t+\tau_1+\tau_2}-c_{t+\tau_1}\right)=\tau_1\cdot\left(r_t^{\tau_1+\tau_2}-r_t^{c_1,\tau_1}\right)+\tau_2\cdot\left(r_t^{\tau_1+\tau_2}-r_t^{c_2,\tau_2}\right)-E\left(x_{t+\tau_1+\tau_2}-x_t\right) \qquad [1.3.8].$$

Making assumptions regarding the exchange rate dynamics within the target zone on the basis of historical data, the hypothesis of unchanging parity expectations can be estimated by using the right-hand side confidence interval for mathematical expectation of equation [1.3.8].

Equation [1.3.8] is a transformed equation [1.2.7] for the case where the exchange rate repegging to another currency is planned.

2. EMPIRICAL RESULTS

2.1 The Simplest Test of Target Zone Credibility

On December 30, 2004, the Latvian national currency – the lats – was repegged from the SDR basket of currencies to the euro; hence the study uses such equations in the target zone estimation that are consistent with the situation of the domestic currency repegging.

Regarding interest rates, the study uses the money market interest rate indices LIBOR SDR (calculated from LIBOR rates of the currencies included in the SDR basket of currencies) and LIBOR EUR. The methods for computing SDR interest rates differ from those recommended by the IMF and are discussed in the Appendix to the study. RIGIBOR and RIGIBID, Latvian money market interest rate indices, are used for comparison. However, these indices include credit institutions' credit risk, which, contrary to the yield on government securities, cannot be considered risk-neutral. Due to differences in rating of those credit institutions for which LIBOR and RIGIBOR indices have been calculated, certain inconsistencies in LIBOR and RIGIBOR interest rates, which include risk premiums of credit institutions and may include CB short-term interest rate policy distinctions, may occur.[1] A number of credit institutions in Latvia have foreign-based parent companies and it is most likely that credit resources attracted by them would be cheap and consistent with the real credit risk. However, differences in interest rates may result from the state risk as well, yet quantitative estimation of such risk has not been a purpose of this study and the models discussed herein do not capture it. They do, however, include an approximate estimation of the potential risk effects, albeit only in cases where money market interest rates lie outside the theoretical interest rate corridor determined by LIBOR and RIGIBOR. Latvia's rating has been raised on several occasions recently; hence the risk premium has decreased notably. To obtain short-term data needed in calculations, the money market interest rates are more appropriate than the Treasury bill interest rates from the point of view of liquidity.

As the money market interest rates characterise the rates of unsecured transactions, liquidity is lower for such transactions of a longer term. The Latvian money market is liquid starting with overnight deals with up to 3-month maturity and does not notably differ from other money markets. Less ample liquidity of longer term money market transactions notwithstanding, quotations of the banks that might engage in real deals at the quoted rates are close to RIGIBOR and RIGIBID; hence, to assess arbitrage opportunities, money market interest rates on transactions with up to 1-year maturity are used in the study.

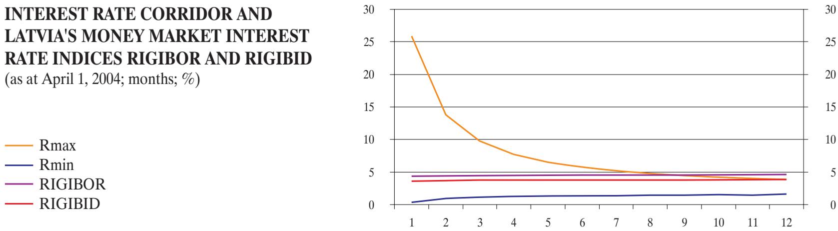
Employing equations [1.1.8] and [1.1.9], margins $\overline{R}$ and $\underline{R}$ of the interest rate corridor

[1] Under conditions of the exchange rate target zone.

are obtained using the implied forward interest rates as at April 1, 2004 as the future interest rates (see Chart 2.1.1).

Chart 2.1.1

INTEREST RATE CORRIDOR AND LATVIA'S MONEY MARKET INTEREST RATE INDICES RIGIBOR AND RIGIBID
(as at April 1, 2004; months; %)



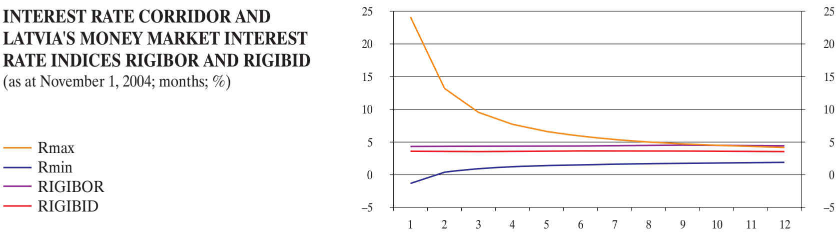
The comparison of the interest rate corridor and the Latvian money market interest rate indices RIGIBOR and RIGIBID leads to a conclusion that RIGIBOR is outside the interest rate corridor for transactions with over 9-month maturity. It is the rate at which the lats resources may be borrowed from the interbank market and, therefore, should deserve more attention if it moved below the lower margin of the interest rate corridor (see (1) for greater detail). Be it so, RIGIBID would be more significant. If it exceeds the upper margin of the interest rate corridor, a theoretical possibility to make borrowings in currencies included in the SDR basket and subsequently convert them into lats, simultaneously engaging in euro interest rate futures contracts and investing of the lats, will emerge. If, at the moment of repegging, a euro borrowing at the future interest rate is made, the SDR debt will be repaid. When, with the transaction term expiring, lats are converted into euros, there will be a safe profit – arbitrage. Under a completely credible exchange rate policy, such arbitrage would trigger large capital flows, thus pushing down the lats money market interest rates to a level that would rule out any arbitrage opportunities. The Chart shows that arbitrage opportunities are absent, notwithstanding that both RIGIBID and the upper margin of the interest rate corridor almost coincide. It indicates that market participants deem the exchange rate policy pursued by the Bank of Latvia credible.

Even shortly before repegging to the euro, the lats market interest rates did not signal an increase in arbitrage opportunities; consequently, confidence in the Bank of Latvia's foreign exchange policy remained broadly unchanged at the moment of the lats pegging to the euro (see Chart 2.1.2).

Data for April 2004 indicate that repegging of the lats to the euro would gradually widen the interest rate corridor, if the countries whose currencies are included in the SDR basket of currencies did not change their interest rate policies. It is unlikely that the differences would be pronounced, as the interest rate differential between LIBOR EUR and LIBOR SDR rates for 1-year maturity was only 16 basis points as at April 1, 2004. Hence it can be assumed that the repeg is not going to have a notable effect on lats money market interest rates. With the lats being pegged to a single currency – the

Chart 2.1.2

INTEREST RATE CORRIDOR AND LATVIA'S MONEY MARKET INTEREST RATE INDICES RIGIBOR AND RIGIBID
(as at November 1, 2004; months; %)

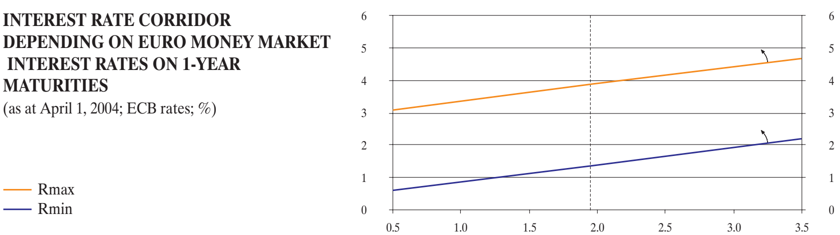


euro, the comparative computations of return will become more straightforward and the transaction costs will also fall. As a result, arbitrage opportunities will continue to diminish, unless the Bank of Latvia's exchange rate policy is mistrusted or the assessment of the bank credit risk declines.

Equations [1.1.13] and [1.1.14] show that, with repegging coming closer, the significance of the interest rates of the respective currency c_2 is growing, until at time $t+\tau_1$ the latter becomes the sole currency whose interest rates will affect the interest rate corridor of the domestic currency. Thus, with time $t+\tau_1$ approaching, the interest rate corridor is becoming steeper depending on the interest rate i^{c_2} (see Chart 2.1.3). Had the European Central Bank (ECB) changed its interest rate policy at the beginning of 2004, the impact on the lats interest rate corridor would have been proportionally weaker (see Chart 2.1.3), yet with the repegging of the lats to the euro coming closer, the impact is gradually gaining in force. At the final stage of repegging, the interest rate corridor is fully dependent on the lats exchange rate, state and bank credit risk as well as the euro money market interest rates.

Chart 2.1.3

INTEREST RATE CORRIDOR DEPENDING ON EURO MONEY MARKET INTEREST RATES ON 1-YEAR MATURITIES
(as at April 1, 2004; ECB rates; %)



2.2 Drift-Adjustment Model in the Context of Planned Repegging

In order to test market participants' assumptions regarding realignments in the lats exchange rate regime, the forecast of the exchange rate deviation from its central parity is first calculated. It is done by using daily data on differences between the lats market rate and its central parity for the period from January 2, 2002 to April 30, 2004 (608 observations).

First, the following specification of the exchange rate dynamics is used:

$$x_{t+\tau} = \beta_0 + \beta_1 x_t + u_{t+\tau} \qquad [2.2.1],$$

where $u_{t+\tau}$ is the error term.

The equation can be modified in various ways depending on the results obtained. Thus, for instance, the exchange rate could be affected by the interest rate differential between the national currency (the lats) and a foreign currency (SDR basket of currencies, later the euro), or non-linear functional specifications of the exchange rate.

Within the exchange rate target zone, the forecasting is carried out for 22, 65, 130 and 260 business day terms τ (1-, 3-, 6-month and 1-year maturities, respectively). The forecast calculation using equation [2.1.1] is complicated by the problem of "overlapping observations" (forecasting horizon overlaps the interval between observations); hence the error variables are serially correlated.(4) To solve this problem by the OLS method, the Newey-West procedure, which takes into account hetero-scedasticity and autocorrelation errors, is used. The estimation results are showed in Table 2.2.1.

Table 2.2.1

OLS RESULTS OF EXCHANGE RATE FORECASTING MODEL

τ, business days	22	65	130	260
β_0	–0.00302***	–0.004763***	–0.005831***	–0.005997***
	(0.000528)	(0.000634)	(0.000574)	(0.000439)
β_1	0.499168***	0.211040**	0.035934	0.007947
	(0.076499)	(0.091505)	(0.082422)	(0.087168)
N	608	608	608	608
R^2	0.247845	0.044412	0.001217	0.000099
Regression standard deviation	0.002645	0.002981	0.003048	0.003050
p-value (*F*-statistic)	0.000000	0.000000	0.390533	0.806436

Notes. Standard deviation using the Newey–West procedure in brackets.
*** – significant at 1% significance level;
** – significant at 5% significance level;
* – significant at 10% significance level.

For the equation obtained for the term of one month (22 business days), all the coefficients are significant at α = 1% level, while for the term of three months (65 business days), the slope coefficient β_1 is significant at the significance level α = 5%. At the same time, with the forecasting horizon extending up to 6 months (130 business days), the slope coefficient becomes insignificant. With the term growing, the constant β_0 retains a high level of significance (α = 1%), while its value is between the lats central parity and the lower boundary of the Bank of Latvia's target zone, thus confirming that on average the lats market rate is higher than the exchange rate parity set by the Bank of Latvia. All the slope coefficients of equations, in turn, are smaller than 1 and larger than 0, and, in addition, decline in line with the increasing forecast horizon. It indicates that the following condition holds: within the target zone, the exchange rate, as a rule, tends to revert to its long-term mean.

In order to assess whether any non-liner forms are applicable to exchange rate forecasts, the model is supplemented with the square and cubic forms $\beta_2 \cdot (x_t)^2$ and $\beta_3 \cdot (x_t)^3$, respectively, of the relevant variables. The equations in the square and cubic forms have the following specification:

$$x_{t+\tau} = \beta_0 + \beta_1 x_t + \beta_2 x_t^2 + \beta_3 x_t^3 + u_{t+\tau} \qquad [2.2.2].$$

The derived estimations are showed in Table 2.2.2.

Table 2.2.2

OLS RESULTS OF EXCHANGE RATE FORECASTING NON-LINEAR MODEL

τ, business days	22	65	130	260
β_0	–0.003453***	–0.004933***	–0.004933***	–0.005540***
	(0.000552)	(0.000618)	(0.000618)	(0.000430)
β_1	–0.103423	–0.417174	–0.417174	0.407108***
	(0.272703)	(0.281668)	(0.281668)	(0.150967)
β_2	–130.9499*	–174.9743*	–174.9743	
	(76.55788)	(91.96944)	(91.96944)	
β_3	–7 491.869	–11 801.04*	–11 801.04	–5 297.761***
	(5 706.045)	(6 890.332)	(6 890.332)	(1 892.090)
N	608	608	608	608
R^2	0.259694	0.059373	0.059373	0.070732
Regression standard deviation	0.002629	0.002963	0.002963	0.002942
p-value (*F*-statistic)	0.000000	0.000000	0.347384	0.000000

Notes. Standard deviation using the Newey–West procedure in brackets.
*** – significant at 1% significance level;
** – significant at 5% significance level;
* – significant at 10% significance level.

In the reviewed cases, the statistical performance of linear and non-linear models is almost analogous. Due to their comparatively simpler interpretation and the straightforwardness of needed calculations, linear models are more appropriate for the exchange rate forecasting.

Next, the discussion focuses on whether the interest rate differentials between the domestic currency and a foreign peg currency or the basket of foreign currencies to which the domestic currency is pegged can help forecast the exchange rate dynamics in the future. The following is the linear model of the exchange rate forecast supplemented with the interest rate differential:

$$x_{t+\tau} = \beta_0 + \beta_1 x_t + \beta_2 \left(i_t^{d,\tau} - i_t^{c,\tau}\right) \cdot \tau + u_{t+\tau} \qquad [2.2.3].$$

The results of equation [2.2.3] are showed in Table 2.2.3. The interest rate differential and the constant are significant for all forecasting horizons, if $\alpha = 1\%$.

Table 2.2.3

OLS RESULTS OF EXCHANGE RATE FORECASTING MODEL (INCLUDING INTEREST RATE DIFFERENTIAL)

τ, business days	22	65	130	260
τ, years	1/12	1/4	1/2	1
β_0	–0.003285***	–0.007105***	–0.008048***	–0.013617***
	(0.001052)	(0.000969)	(0.000904)	(0.000693)
β_1	0.540518***	0.335478***	0.131459	0.267292***
	(0.074915)	(0.092151)	(0.085204)	(0.066897)
β_2	0.002571***	0.005180***	0.001962***	0.005880***
	(0.006839)	(0.001564)	(0.000646)	(0.000465)
N	579	579	586	583
R^2	0.279046	0.123267	0.070152	0.540808
Regression standard deviation	0.002565	0.002879	0.002937	0.002082
p-value (F-statistic)	0.000000	0.000000	0.000000	0.000000

Notes. Standard deviation using the Newey–West procedure in brackets.
*** – significant at 1% significance level;
** – significant at 5% significance level;
* – significant at 10% significance level.

Similar to simple linear models (without the interest rate differentials), the slope coefficient β_1 is prone to decline in line with the increasing forecasting horizon. When the forecasting horizon increases, the forecasts lose some of their accuracy, i.e. the forecast confidence interval exceeds the boundaries of the target zone.

The coefficients of interest rate differentials indicate that the condition of uncovered interest rate parity holds, i.e. interest rates on the currency for which depreciation is expected are to be higher. Consequently, if the interest rate differential is positive, a future weakening of the lats within the target zone is expected.

By developing exchange rate forecasting models, it is possible to check whether the financial market expects realignments in the central parity. It can be determined by equation [1.2.7] or [1.3.8] and by testing hypothesis $H_0: E_t\left(\Delta c_t^{\tau_1+\tau_2}\right) = 0$. Closer to the lats pegging to the euro, equation [1.3.8] is to be used in producing shorter term forecasts. After the lats pegging to the euro, it is possible to return to using equation

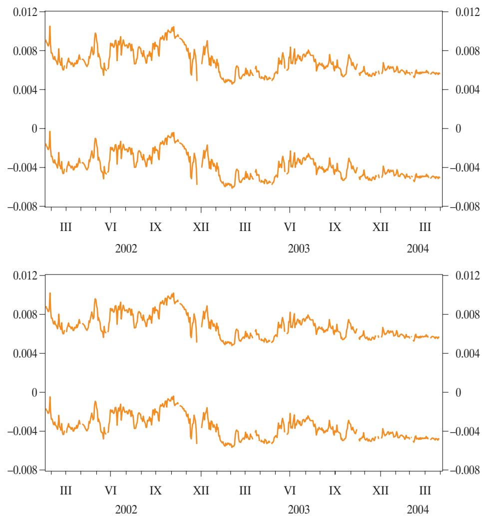
[1.2.7] again. Assuming that the repegging would not trigger any substantial changes either in the foreign exchange market or in its participants' assessment of the lats, the exchange rate data on the lats value within the target zone prior to repegging could be used also in the future, whereas in the presence of certain shifts in the exchange market, initially after repegging the number of observations could be insufficient for producing significant forecasts.

For the forecasting horizon of 1 month term (22 business days), the 95% confidence interval includes zero, implying that no realignments in the central parity are expected. On January 30 and February 5 and 6 in 2002, the confidence interval did not include zero (see Chart 2.2.1). This observation was, however, short-lived.

For the central parity forecasting horizon of 3 month term (65 business days), the 95% confidence interval did not persistently include zero on several occasions in 2002 (see Chart 2.2.2).

Chart 2.2.1

95% CONFIDENCE INTERVAL FOR CENTRAL PARITY FORECASTING HORIZON OF 22 BUSINESS DAYS



a: autoregressive model

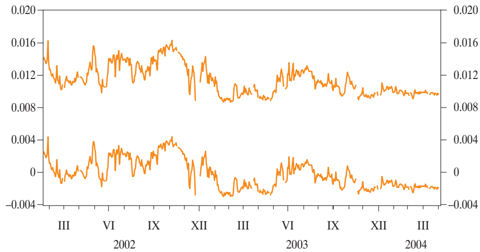
b: autoregressive model with interest rate differential

The 95% confidence interval of the central parity in the model developed by the authors of this study does not include zero (see Chart 2.2.3). Nevertheless, the conditions of the non-arbitrage interest rate corridor are not violated for 1 year maturities either, and this is a sign of the foreign exchange market participants' confidence in the exchange rate regime. Longer term forecast deviations from zero are due to the fact that Latvian banks can borrow funds from foreign investors at rates that exceed LIBOR or EURIBOR by around 20–50 basis points, because these two indices include bank interest rate quotations for prime banks, and it is usually assumed that the Latvian

Chart 2.2.2

95% CONFIDENCE INTERVAL FOR CENTRAL PARITY FORECASTING HORIZON OF 65 BUSINESS DAYS

a: autoregressive model

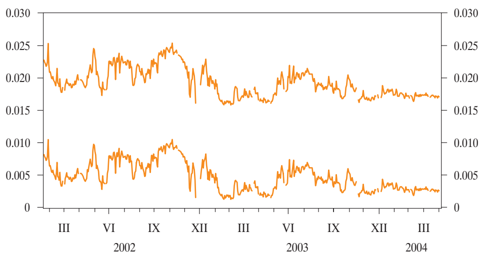


b: autoregressive model with interest rate differential

Chart 2.2.3

95% CONFIDENCE INTERVAL FOR CENTRAL PARITY FORECASTING HORIZON OF 130 BUSINESS DAYS

a: autoregressive model



b: autoregressive model with interest rate differential

banks are subject to a higher credit risk. Prices of available funds became more attractive after Latvia joined the EU. As it had been known almost for certain already since 2003 that Latvia would become an EU Member State, the Latvian bank risk assessment decreased, this being reflected also in interest rates.

Exchange rate forecasts within the target zone may be produced when no exchange rate realignments take place and also when repegging is planned beforehand. It is assumed that repegging takes place at the market rate of a particular date, which in Latvia's case was repegging of the lats from the SDR basket of currencies to the euro at the bilateral EUR/SDR rate on the respective date of repegging.

At the beginning of May 2004, equation [1.3.8] held only for terms of 9 and 12 months. In the course of 2004, the significance of euro interest rates was gradually growing. To analyse this period, 9-month interest rates and exchange rate value forecasts within the target zone are dealt with.

The following regression specification is used in forecasting:

$$x_{t+\tau} = \beta_0 + \beta_1 \cdot x_t + u_{t+\tau} \quad [2.2.4].$$

Table 2.2.4 shows that at the beginning of May 2004, the SDR interest rate for 8-month maturities (up to the moment of the lats repegging) was r^* = 1.92%, the euro implied forward interest rate for 1-month maturities expiring on January 1, 2005 was f^{**}= 2.27%, and the lats interest rate for 9-month maturities was r = 3.77%. The results indicate that the lats could have depreciated by 0.3 percentage point in the course of nine months.

Table 2.2.4

INTEREST RATES, EXCHANGE RATE FORECASTS AND CONFIDENCE INTERVAL IN 2004
(at beginning of each month)

2004	r^* (%)	f^{**} (%)	r (%)	τ_1, months	τ_2, months	$xf_{t+\tau} - x_t$	se	dc – 2*se	dc + 2*se
January	1.8274		3.58	9	0	0.28	0.003045	0.424901	1.642806
February	1.8364		3.60	9	0	0.24	0.003040	0.470526	1.686632
March	1.7822		3.60	9	0	0.30	0.003047	0.456669	1.675467
April	1.7510		3.78	9	0	0.26	0.003042	0.652695	1.869589
May	1.9246	2.26669	3.765	8	1	0.31	0.003049	0.430461	1.650061

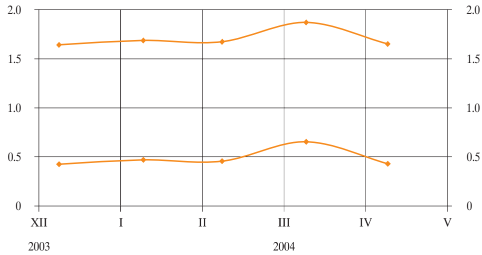
Notes. r^* – SDR interest rate for term τ_1; f^{**} – euro forward interest rate expiring on January 1, 2005 for term τ_2; r – within margins where $xf_{t+\tau} = \beta_0 + \beta_1 \cdot x_t$ is the forecast value calculated in accordance with equation [2.2.4]; se – standard error of forecast; dc – 2*se, dc + 2*se – confidence intervals of central parity alignments.

Chart 2.2.4 shows the confidence interval of central parity realignment forecasts. It does not cover zero, leading to an assumption that the hypothesis about the exchange rate parity realignments not being anticipated can be rejected with a 5% error probability. However, as has been noted before, the differential of the used interbank interest rates incorporates both the exchange and bank credit risks, i.e. credit rating of the banks for which RIGIBOR is calculated is lower than that of the banks covered by LIBOR.

The calculation of the confidence interval in the event of a bank credit risk deviation

Chart 2.2.4

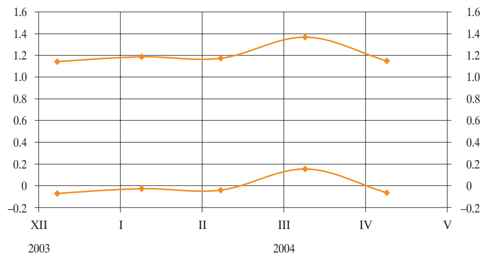
95% CONFIDENCE INTERVAL FOR CENTRAL PARITY FORECASTING HORIZON OF 9 MONTHS
(*dc* ± 2*se; %)



(see Chart 2.2.5) leads to an assumption that in the majority of cases the latter includes zero, with the only exception in March when the Bank of Latvia made an announcement on raising the refinancing rate for the purpose of restricting the excessive domestic credit growth, and the confidence interval of the parity realignment forecast temporarily exceeded zero. Later, however, interest rates reverted under the pressure of the market to a level reasonable from the market viewpoint. It is noteworthy that in a couple of months since March 2004, the Bank of Latvia had purchased foreign currencies in large amounts through passive interventions due to which an increase in the lats market resources sufficient for interest rates to recover equilibrium was observed.

Chart 2.2.5

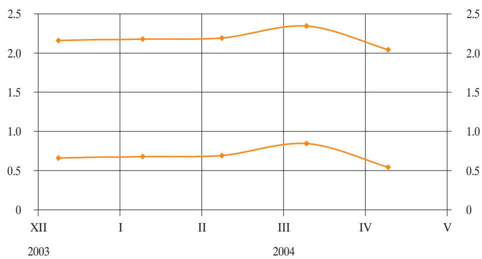
95% CONFIDENCE INTERVAL FOR CENTRAL PARITY FORECASTING HORIZON OF 9 MONTHS WITH APPROXIMATE BANK CREDIT RISK DEVIATION
(*dc* ± 2*se; %)



Regarding 1-year horizon forecasts, the 95% confidence interval of credit risk deviation from the parity does not include zero (see Chart 2.2.6).

Chart 2.2.6

95% CONFIDENCE INTERVAL FOR CENTRAL PARITY FORECASTING HORIZON OF 1 YEAR WITH APPROXIMATE BANK CREDIT RISK DEVIATION
(*dc* ± 2*se: %)



In general, it may be concluded that prior to the lats repeg to the euro, the part played by the latter currency in the financial market was continuously gaining importance, reaching the highest level at the moment of repegging. However, due to the absence of any marked differences between the euro area interest rates and those of the SDR basket of currencies, notable adjustments were not observed, and the financial market data did not give indications that any such changes should be expected either.

The lats peg to the euro simplifies the foreign exchange process relative to the peg currency and lowers the potential transaction costs, which, in turn, promote a decline in the interest rate differential of the lats and the peg currency.

CONCLUSIONS

The paper accommodates the simplest test of target zone credibility and the drift-adjustment method to suit the situation where a planned repegging is to be expected. Since 1994, the lats had been pegged to the SDR basket of currencies but on December 30, 2004, the lats was pegged to the euro maintaining its exchange rate at the central rate against the euro and with the previous fluctuation band of ±1%; hence it was important to estimate the effects of the lats repeg on money market interest rates and its potential impact on money market participants' assessment for sustainability of the exchange rate regime.

The outcomes of the simplest test of target zone credibility indicated that the financial market participants did not forecast unplanned exchange rate realignments. With the time of the lats repeg to the euro coming closer, the impact of euro interest rates on the corridor within which the lats interbank market interest rates can fluctuate without causing arbitrage opportunities constantly grew. As at the time of investigations the euro market interest rates did not differ markedly from those of the SDR basket of currencies, substantial changes were not anticipated after the repegging of the lats. With higher credit rating assigned to the Latvian banks, the lats and the euro interest rate differential might decline. In line with the lats pegging to a single currency instead of the basket of currencies, the differential may likewise be affected by a fall in potential arbitrage transaction costs, as the need to build a basket and be ensured against mutual fluctuations of its currencies would be absent; overall, it would strengthen the liquidity in the foreign exchange market.

However, the simplest test of target zone credibility does not produce convincing results for shorter horizons. The drift-adjustment method seems more appropriate for the purpose, for it allows the forecasting of potential exchange rate parity realignments. In this case, financial market data did not signal any eventual parity changes, and no risks related to the lats repegging to the euro were observed.

Finally, the methodology for SDR interest rate calculations is enclosed in the Appendix, which, in contrast to the one recommended by the IMF, enables us to estimate interest rates for a basket of currencies, which at the expiry of the transaction term would correspond to the composition of the SDR basket of currencies.

APPENDIX

Methodology for Calculating Precise SDR Interest Rates

In its SDR interest rate calculations, the IMF uses the following equation:

$$r = \alpha_{USD} \cdot r_{USD} + \alpha_{JPY} \cdot r_{JPY} + \alpha_{GBP} \cdot r_{GBP} + \alpha_{EUR} \cdot r_{EUR} \qquad \{1\},$$

where r, r_{USD}, r_{JPY}, r_{GBP} and r_{EUR} represent interest rates of the SDR basket of currencies, the US dollar, the Japanese yen, the British pound sterling and the euro, whereas α_{USD}, α_{JPY}, α_{GBP} and α_{EUR} denote the share of the respective currencies in the SDR basket of currencies at a given moment of time.

A shortcoming of this equation consists in the fact that interest rates for a currency portfolio are estimated at the beginning of a potential transaction, with the portfolio currency distribution not corresponding to the composition of the SDR basket of currencies at the end of the period. Due to mutually distinctive interest rates typical for the SDR basket component currencies, the shares of different currencies in the portfolio tend to increase disproportionately.

We begin by defining returns on assets to estimate interest rates for an SDR basket of currencies, which would correspond to the SDR basket of currencies at maturity:

$$r = \frac{F - P}{P} \qquad \{2\},$$

where F is the future asset value and P is the present asset value.

The future value of a unit of the SDR basket of currencies, expressed in US dollars, is:

$$F = 0.577 \cdot (1 + r_{USD}) + \frac{21 \cdot (1 + r_{JPY})}{S^f_{USD/JPY}} + 0.0984 \cdot (1 + r_{GBP}) \cdot S^f_{GBP/USD} + 0.426 \cdot (1 + r_{EUR}) \cdot S^f_{EUR/USD} \qquad \{3\},$$

where $S^f_{USD/JPY}$, $S^f_{GBP/USD}$ and $S^f_{EUR/USD}$ are future exchange rates of the respective currencies on a given date. To eliminate problems associated with future exchange rate uncertainties, the SDR interest rate equation is expressed using discount coefficients.

The discount coefficient d is expressed by the following equation:

$$d(t) = P(t) \qquad \{4\},$$

where $P(t)$ is the present value of one unit of an asset repayable in t year's time.

The present value of a unit of the SDR basket that will be paid after term t is a discounted value of each component of the basket. In terms of US dollars, a basket unit price on a respective date is:

$$P(t) = 0.577 \cdot d_{\text{USD}}(t) + \frac{21 \cdot d_{\text{JPY}}(t)}{S_{\text{USD}/\text{JPY}}} + 0.0984 \cdot S_{\text{GBP}/\text{USD}} \cdot d_{\text{GBP}}(t) + 0.426 \cdot S_{\text{EUR}/\text{USD}} \cdot d_{\text{EUR}}(t) \qquad \{5\},$$

where d_{USD}, d_{JPY}, d_{GBP} and d_{EUR} are the discount coefficients of the respective currencies.

In order to obtain the value in terms of SDR units, $P_S(t)$ is divided by the $S_{\text{SDR}/\text{USD}}$ rate on the respective date:

$$d(t) = P(t) = \frac{P_{\text{USD}}(t)}{S_{\text{SDR}/\text{USD}}} \qquad \{6\}.$$

1. First, the simple interest rate is calculated:

$$d(t) = \frac{1}{1 + r_t \cdot t} \qquad \{7\},$$

where r_t is the simple interest rate for term t.

By combining equations {6} and {7}, we obtain:

$$\frac{1}{1 + r_t \cdot t} = \frac{P_{\text{USD}}(t)}{S_{\text{SDR}/\text{USD}}} \qquad \{8\}$$

or

$$r_t = \frac{1}{t}\left(\frac{S_{\text{SDR}/\text{USD}}}{P_{\text{USD}}(t)} - 1\right) \qquad \{9\},$$

$$r_{t,\,\text{SDR}} = \frac{1}{t}\left(\frac{0.577 + \dfrac{21}{S_{\text{USD}/\text{JPY}}} + 0.0984 \cdot S_{\text{GBP}/\text{USD}} + 0.426 \cdot S_{\text{EUR}/\text{USD}}}{\dfrac{0.577}{1 + r_{t,\,\text{USD}} \cdot t} + \dfrac{21}{S_{\text{USD}/\text{JPY}} \cdot \left(1 + r_{t,\,\text{JPY}} \cdot t\right)} + \dfrac{0.0984 \cdot S_{\text{GBP}/\text{USD}}}{1 + r_{t,\,\text{GBP}} \cdot t} + \dfrac{0.426 \cdot S_{\text{EUR}/\text{USD}}}{1 + r_{t,\,\text{EUR}} \cdot t}} - 1\right) \qquad \{10\}.$$

2. Then, the compounded interest rate is calculated:

$$d(t) = \frac{1}{(1+r_t)^t} \qquad \{11\}.$$

By combining equations {6}and {11}, we obtain:

$$\frac{1}{(1+r_t)^t} = \frac{P_{\mathrm{USD}}(t)}{S_{\mathrm{SDR}/\mathrm{USD}}} \qquad \{12\}$$

or

$$r_t = \sqrt[t]{\frac{S_{\mathrm{SDR}/\mathrm{USD}}}{P_{\mathrm{USD}}(t)}} - 1 \qquad \{13\},$$

$$r_{t,\,\mathrm{SDR}} = \sqrt[t]{\frac{0.577 + \frac{21}{S_{\mathrm{USD}/\mathrm{JPY}}} + 0.0984 \cdot S_{\mathrm{GBP}/\mathrm{USD}} + 0.426 \cdot S_{\mathrm{EUR}/\mathrm{USD}}}{\frac{0.577}{(1+r_{t,\mathrm{USD}})^t} + \frac{21}{S_{\mathrm{USD}/\mathrm{JPY}} \cdot (1+r_{t,\,\mathrm{JPY}})^t} + \frac{0.0984 \cdot S_{\mathrm{GBP}/\mathrm{USD}}}{(1+r_{t,\,\mathrm{GBP}})^t} + \frac{0.426 \cdot S_{\mathrm{EUR}/\mathrm{USD}}}{(1+r_{t,\,\mathrm{EUR}})^t}}} - 1 \qquad \{14\}.$$

3. Next, the continuously compounded rate is calculated:

$$d(t) = e^{-r_t \cdot t} \qquad \{15\}.$$

By combining equations {6}and {15}, we obtain:

$$e^{-r_t \cdot t} = \frac{P_{\mathrm{USD}}(t)}{S_{\mathrm{SDR}/\mathrm{USD}}} \qquad \{16\}$$

or

$$r_t = \frac{1}{t} \cdot \ln \frac{S_{\mathrm{SDR}/\mathrm{USD}}}{P_{\mathrm{USD}}(t)} \qquad \{17\},$$

$$r_t = \frac{1}{t} \cdot \ln\left(\frac{S_{SDR/USD}}{0.577 \cdot e^{-r_{t,\,USD} \cdot t} + \frac{21}{S_{USD/JPY}} \cdot e^{-r_{t,\,JPY} \cdot t} + 0.0984 \cdot S_{GBP/USD} \cdot e^{-r_{t,\,GBP} \cdot t} + 0.426 \cdot S_{EUR/USD} \cdot e^{-r_{t,\,EUR} \cdot t}} \right) \quad \{18\}.$$

Equation {7} is used to transform equation {10}:

$$1 - \frac{1}{1 + r \cdot t} = \frac{r \cdot t}{1 + r \cdot t} \quad \{19\},$$

$$r_t = \frac{1}{t}\left(\frac{0.577 \cdot \frac{r_{t,USD} \cdot t}{1 + r_{t,USD} \cdot t} + \frac{21 \cdot r_{t,JPY} \cdot t}{S_{USD/JPY} \cdot (1 + r_{t,JPY} \cdot t)} + 0.0984 \cdot S_{GBP/USD} \cdot \frac{r_{t,\,GBP} \cdot t}{1 + r_{t,\,GBP} \cdot t}}{P_{USD}(t)} + \right.$$

$$\left. + \frac{0.426 \cdot S_{EUR/USD} \cdot \frac{r_{t,\,EUR} \cdot t}{1 + r_{t,\,EUR} \cdot t}}{P_{USD}(t)} \right) = \frac{1}{t}\left(\frac{0.577 \cdot r_{t,\,USD} \cdot t}{P_{USD}(t)} \cdot \frac{1}{1 + r_{t,\,USD} \cdot t} + \frac{21 \cdot r_{t,\,JPY} \cdot t}{S_{USD/JPY} \cdot P_{USD}(t)} \cdot \frac{1}{1 + r_{t,\,JPY} \cdot t} + \right.$$

$$\left. + \frac{0.0984 \cdot S_{GBP/USD} \cdot r_{t,\,GBP} \cdot t}{PU_{USD}(t)} \cdot \frac{1}{1 + r_{t,\,GBP} \cdot t} + \frac{0.426 \cdot S_{EUR/USD} \cdot r_{t,\,EUR} \cdot t}{P_{USD}(t)} \cdot \frac{1}{1 + r_{t,\,EUR} \cdot t} \right) =$$

$$= \left(\frac{0.577 \cdot r_{t,USD}}{P_{USD}(t)} \cdot \frac{1}{1 + r_{t,\,USD} \cdot t} + \frac{21 \cdot r_{t,\,JPY}}{S_{USD/JPY} \cdot P_{USD}(t)} \cdot \frac{1}{1 + r_{t,\,JPY} \cdot t} + \frac{0.0984 \cdot S_{GBP/USD} \cdot r_{t,\,GBP}}{P_{USD}(t)} \cdot \frac{1}{1 + r_{t,\,GBP} \cdot t} + \right.$$

$$\left. + \frac{0.426 \cdot S_{EUR/USD} \cdot r_{t,\,EUR}}{P_{USD}(t)} \cdot \frac{1}{1 + r_{t,\,EUR} \cdot t} \right) \quad \{20\}.$$

The IMF recommends the following equation for the estimation of SDR interest rates:

$$r_{t,\,IMF} = \left(\frac{0.577 \cdot r_{t,\,USD}}{S_{SDR/USD}} + \frac{21 \cdot r_{t,\,JPY}}{S_{USD/JPY} \cdot S_{SDR/USD}} + \frac{0.0984 \cdot S_{GBP/USD} \cdot r_{t,\,GBP}}{S_{SDR/USD}} + \frac{0.426 \cdot S_{EUR/USD} \cdot r_{t,\,EUR}}{S_{SDR/USD}} \right)$$

{21},

where $\frac{0.577}{S_{SDR/USD}}$, $\frac{21}{S_{USD/JPY} \cdot S_{SDR/USD}}$, $\frac{0.0984 \cdot S_{GBP/USD}}{S_{SDR/USD}}$, $\frac{0.426 \cdot S_{EUR/USD}}{S_{SDR/USD}}$ are the weights of respective SDR basket component currencies. Thus, the interest rate calculated in accordance with the IMF methodology is, in fact, the average weighted interest rate of currencies in the SDR basket of currencies.

Equation {20} is rewritten as follows:

$$r_t = \frac{\frac{0.577}{1+r_{t,\text{USD}} \cdot t}}{P_{\text{USD}}(t)} \cdot r_{t,\text{USD}} + \frac{\frac{21}{S_{\text{USD/JPY}} \cdot (1+r_{t,\text{JPY}} \cdot t)}}{P_{\text{USD}}(t)} \cdot r_{t,\text{JPY}} + \frac{\frac{0.0984 \cdot S_{\text{GBP/USD}}}{1+r_{t,\text{GBP}} \cdot t}}{P_{\text{USD}}(t)} \cdot r_{t,\text{GBP}} + \frac{\frac{0.426 \cdot S_{\text{EUR/USD}}}{1+r_{t,\text{EUR}} \cdot t}}{P_{\text{USD}}(t)} \cdot r_{t,\text{EUR}}$$

{22}.

In contrast to the formula recommended by the IMF, this equation calculates weights in conformity with discounted value ratios of the respective currencies in terms of US dollars at the rate on the respective date and the discounted weights of the SDR basket of currencies.

Equation [6] is used to arrive at $P_{\text{USD}}(t)$:

$$P_{\text{USD}}(t) = d(t) \cdot S_{\text{SDR/USD}} \qquad \{23\}.$$

$d(t)$ is moved to the left-hand side of the equation and substituted into equation {22}:

$$r(t) \cdot d(t) = \left(\frac{0.577 \cdot d_{\text{USD}}(t)}{S_{\text{SDR/USD}}} \cdot r_{t,\text{USD}} + \frac{21 \cdot d_{\text{JPY}}(t)}{S_{\text{USD/JPY}} \cdot S_{\text{SDR/USD}}} \cdot r_{t,J} + \frac{0.0984 \cdot S_{\text{GBP/USD}} \cdot d_{\text{GBP}}(t)}{S_{\text{SDR/USD}}} \cdot r_{t,\text{GBP}} + \right.$$

$$\left. + \frac{0.426 \cdot S_{\text{EUR/USD}} \cdot d_{\text{EUR}}(t)}{S_{\text{SDR/USD}}} \cdot r_{t,\text{EUR}} \right) \qquad \{24\}.$$

As

$$r(t) \cdot d(t) = r(t) \cdot \frac{1}{1+r(t) \cdot t} = \frac{1}{t} \cdot \left(1 - \frac{1}{1+r(t) \cdot t} \right) = \frac{1}{t} \cdot (1 - d(t)) \qquad \{25\},$$

by substituting it into equation {22}, we obtain:

$$\frac{1}{t}\cdot(1-d(t))=\left(\frac{0.577}{S_{SDR/USD}}\cdot(1-d_{USD}(t))\cdot\frac{1}{t}+\frac{21}{S_{USD/JPY}\cdot S_{SDR/USD}}\cdot(1-d_{JPY}(t))\cdot\frac{1}{t}+\right.$$

$$\left.+\frac{0.0984\cdot S_{GBP/USD}}{S_{SDR/USD}}\cdot(1-d_{GBP}(t))\cdot\frac{1}{t}+\frac{0.426\cdot S_{EUR/USD}}{S_{SDR/USD}}\cdot(1-d_{EUR}(t))\cdot\frac{1}{t}\right) \quad \{26\},$$

$$(1-d(t))=\left(\frac{0.577}{S_{SDR/USD}}\cdot(1-d_{USD}(t))+\frac{21}{S_{USD/JPY}\cdot S_{SDR/USD}}\cdot(1-d_{JPY}(t))+\right.$$

$$\left.+\frac{0.0984\cdot S_{GBP/USD}}{S_{SDR/USD}}\cdot(1-d_{GBP}(t))+\frac{0.426\cdot S_{EUR/USD}}{S_{SDR/USD}}\cdot(1-d_{EUR}(t))\right) \quad \{27\}.$$

Equation {24} shows that variables $r_i(t)\cdot d(t),\ i=\text{USD, JPY, GBP, EUR, SDR}$ are average weighted interest rates of the currencies included in the SDR basket of currencies.

The ratios are represented by $\alpha_1=\frac{0.577}{S_{SDR/USD}}$, $\alpha_2=\frac{21}{S_{USD/JPY}\cdot S_{SDR/USD}}$, $\alpha_3=\frac{0.0984\cdot S_{GBP/USD}}{S_{SDR/USD}}$ and $\alpha_4=\frac{0.426\cdot S_{EUR/USD}}{S_{SDR/USD}}$, and, taking into account that $\alpha_1+\alpha_2+\alpha_3+\alpha_4=1$, equation {26} produces:

$$1-d(t)=\alpha_1\cdot(1-d_{USD}(t))+\alpha_2\cdot(1-d_{JPY}(t))+\alpha_3\cdot(1-d_{GBP}(t))+\alpha_4\cdot(1-d_{EUR}(t)) \quad \{28\},$$

$$1-d(t)=1-(\alpha_1\cdot d_{USD}(t)+\alpha_2\cdot d_{JPY}(t)+\alpha_3\cdot d_{GBP}(t)+\alpha_4\cdot d_{EUR}(t)) \quad \{29\},$$

$$d(t)=\alpha_1\cdot d_{USD}(t)+\alpha_2\cdot d_{JPY}(t)+\alpha_3\cdot d_{GBP}(t)+\alpha_4\cdot d_{EUR}(t) \quad \{30\}.$$

In such a way, the discounted coefficient is equal to the average weighted discount coefficient for all component currencies.

To obtain differences between the interest rates by using both the equation developed in the study and the one offered by the IMF, equation {30} is rewritten:

$$\frac{1}{1+r(t)\cdot t}=\alpha_1\cdot\frac{1}{1+r_{USD}(t)\cdot t}+\alpha_2\cdot\frac{1}{1+r_{JPY}(t)\cdot t}+\alpha_3\cdot\frac{1}{1+r_{GBP}(t)\cdot t}+\alpha_4\cdot\frac{1}{1+r_{EUR}(t)\cdot t} \quad \{31\}$$

or, using 1 for the US dollar, 2 for the Japanese yen, 3 for the British pound sterling and 4 for the euro, we obtain:

$$1+r(t)\cdot t=\frac{1}{\sum_{i=1}^{4}\alpha_i\cdot\frac{1}{1+r_i\cdot t}} \qquad \{32\},$$

$$r=\frac{1}{t}\cdot\left(\frac{1}{\sum_{i=1}^{4}\alpha_i\cdot\frac{1}{1+r_i\cdot t}}-1\right)=\frac{1}{t}\cdot\left(\frac{1-\sum_{i=1}^{4}\alpha_i\cdot d_i}{\sum_{i=1}^{4}\alpha_i\cdot d_i}\right)=\frac{1}{t}\cdot\left(\frac{\sum_{i=1}^{4}\alpha_i-\sum_{i=1}^{4}\alpha_i\cdot d_i}{\sum_{i=1}^{4}\alpha_i\cdot d_i}\right)=$$

$$=\frac{1}{t}\cdot\left(\frac{\sum_{i=1}^{4}\alpha_i\cdot(1-d_i)}{\sum_{i=1}^{4}\alpha_i\cdot d_i}\right)=\frac{1}{t}\cdot\left(\frac{\sum_{i=1}^{4}\alpha_i\cdot\left(1-\frac{1}{1+r_i(t)\cdot t}\right)}{\sum_{i=1}^{4}\alpha_i\cdot d_i}\right)=\frac{1}{t}\cdot\left(\frac{\sum_{i=1}^{4}\alpha_i\cdot r_i(t)\cdot t\cdot d_i}{\sum_{i=1}^{4}\alpha_i\cdot d_i}\right)=$$

$$=\frac{\sum_{i=1}^{4}\alpha_i\cdot r_i(t)\cdot d_i}{\sum_{i=1}^{4}\alpha_i\cdot d_i}=\sum_{i=1}^{4}\alpha_i\cdot r_i\cdot\left(\frac{d_i}{\sum_{j=1}^{4}\alpha_j\cdot d_j}\right) \qquad \{33\}.$$

In equation {33}, the term in partenthesis is:

$$\frac{d_i}{\sum_{j=1}^{4}\alpha_j\cdot d_j}=\frac{d_i}{\sum_{j=1}^{4}\alpha_j\cdot d_j}-1+1=1+\frac{d_i-\sum_{j=1}^{4}\alpha_j\cdot d_j}{\sum_{j=1}^{4}\alpha_j\cdot d_j}=1+\frac{\sum_{j=1}^{4}\alpha_j\cdot d_i-\sum_{j=1}^{4}\alpha_j\cdot d_j}{\sum_{j=1}^{4}\alpha_j\cdot d_j}=$$

$$=1+\frac{\sum_{j=1}^{4}\alpha_j\cdot(d_i-d_j)}{\sum_{j\neq 1}^{4}\alpha_j\cdot d_j} \qquad \{34\}.$$

Equation {34} is substituted into equation {33}:

$$r(t)=\sum_{i=1}^{4}\alpha_j\cdot r_j\left(1+\frac{\sum_{j\neq 1}^{4}\alpha_j\cdot(d_i-d_j)}{\sum_{j=1}^{4}\alpha_j\cdot d_j}\right)=\sum_{i=1}^{4}\alpha_j\cdot r_j+\sum_{i=1}^{4}\alpha_j\cdot r_j\cdot\frac{\sum_{j\neq 1}^{4}\alpha_j\cdot(d_i-d_j)}{\sum_{j=1}^{4}\alpha_j\cdot d_j} \qquad \{35\}.$$

The first sum obtained is formula $r_{\mathrm{SVF}}(t)$ recommended by the IMF; taking into account that

$$d_i-d_j=\frac{1}{1+r_i(t)\cdot t}-\frac{1}{1+r_j(t)\cdot t}=\frac{(r_j(t)-r_i(t))\cdot t}{(1+r_i(t)\cdot t)\cdot(1+r_j(t)\cdot t)} \qquad \{36\},$$

the second sum obtained is as follows:

$$\frac{t}{\sum_{j=1}^{4}\alpha_j\cdot d_j}\cdot\sum_{i=1}^{4}\alpha_j\cdot r_j(t)\cdot\sum_{j\neq 1}^{4}\frac{(r_j(t)-r_i(t))\cdot\alpha_i}{(1+r_i(t)\cdot t)\cdot(1+r_j(t)\cdot t)}=\frac{t}{\sum_{j=1}^{4}\alpha_j\cdot d_j}\cdot$$

$$\cdot\sum_{i=1}^{4}\sum_{j\neq i}\alpha_i\cdot\alpha_j\cdot d_i(t)\cdot d_j(t)\cdot r_i\cdot(r_j-r_i)=\frac{t}{\sum_{j=1}^{4}\alpha_j\cdot d_j}\cdot\sum_{i=1}^{4}\sum_{j>i}\alpha_i\cdot\alpha_j\cdot d_i(t)\cdot d_j(t)\cdot$$

$$\cdot(r_i\cdot(r_i-r_j)+r_j\cdot(r_j-r_i))=\frac{t}{\sum_{j=1}^{4}\alpha_j\cdot d_j}\cdot\sum_{i=1}^{4}\sum_{j>i}\alpha_i\cdot\alpha_j\cdot d_i(t)\cdot d_j(t)\cdot(r_i-r_j)^2 \qquad \{37\}.$$

Finally, we obtain:

$$r(t)-r_{\mathrm{SVF}}(t)=-\frac{t}{\sum_{j=1}^{4}\alpha_j\cdot d_j}\cdot\sum_{i=1}^{4}\sum_{j>i}\alpha_i\cdot\alpha_j\cdot d_i(t)\cdot d_j(t)\cdot(r_i-r_j)^2 \qquad \{38\}.$$

Equation {38} shows that the application of different interest rate calculation methods – one suggested by the authors of this study and the other recommended by the IMF – leads to the interest rate difference of the second order (e.g. if the interest rate differential of component currencies in a currency basket is 0.01 (or 1 percentage point), interest rates calculated by each of the aforementioned methods will differ by approximately $0.01^2 = 0.0001$ (or 0.01 percentage point)). The method recommended by the IMF raises the SDR interest rate slightly, for the right-hand side of equation

{38} is always negative. As interest rate differentials of various currencies tend to differ more for longer terms, equation {38} allows to assume that the currency basket interest rates calculated by using either the new SDR interest rate methodology or the IMF methodology may display larger disparities for a longer term than the ones for a shorter term.

This difference may be essential for countries that make borrowings from the IMF in SDR. The proposed interest rate calculation methodology can be applied to any basket of currencies.

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