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Introduction to the Series "Monetary Transmission Mechanism in Estonia" [1]

The traditional view on monetary policy transmission mechanism is that monetary policy decisions affect liquidity and yields in financial markets, and these ultimately influence consumption and investment decisions. Understanding those mechanisms is essential for understanding the impact of monetary authority decisions and actions on the economy. However, even today there is no consensus about how monetary policy exactly transmits to monetary policy ultimate targets. The theoretical mechanisms of monetary transmission are still under ongoing debate. Moreover, the empirical estimations are usually difficult to implement even in advanced economies, not to mention transition economies.

This series is concerned with surveying some intuitive aspects that affect the monetary transmission process in Estonian currency board arrangement (CBA) and with empirical estimation of the monetary transmission mechanism in Estonia. Note that we prefer the phrase *monetary transmission* rather than *monetary policy transmission* in the context of CBA. The reason is straightforward – the scope for active monetary policy is rather limited in the context of CBA. The lack of active monetary policy does not necessarily mean that some important links or channels are missing in the economy using currency board system. However, the strength of particular links or channels can differ across monetary systems.

In the first paper of the series, brief overview about the currency board policy was given and factors that probably affect the monetary transmission process are introduced. In the current paper, empirical model of monetary transmission process is specified and estimated. Special emphasis is put on foreign debt capital supply and formation of domestic lending rates. On the total, the model specified and estimated consists of 10 behavioural equations and 11 identities, including approximately 21 endogenous and 11 exogenous variables. In the last part of the paper, most important simulations are carried out and results are commented. The last section is followed by conclusion and discussion about future perspectives.

After current publication of the first two papers, the series stays open for further contribution and discussion. Especially considering the growing interest on MTM in the accession countries and ongoing process of Estonian accession to EU and EMU.

[1] The series consists currently of two papers: the paper discussing theoretical setup and implications of monetary transmission mechanism in the framework of currency board (see Lättemäe 2001); and the current paper estimating the empirical model.

1. Introduction

Usually, three different approaches are used for quantitative studies of monetary transmission: Vector Auto Regressive (VAR) models, small structural macromodels and big macroeconometric models. VARs and small macromodels need just a few time series but are clearly oversimplified. Generally, these methods are used to study transmission of monetary policy operations through separately specified monetary transmission channels. These models ignore systematic components in monetary policy and, as a rule, assume that monetary policy actions are unanticipated. Big macroeconometric models usually specify all the most important relationships in the economy and are more likely to be specified by different markets and links in transmission. However, these big models are far more data-intensive and not transparent; some sectors can rely on too strong theoretical assumptions and misspecification in one part of the model can lead to the failure of the whole model.

In the current work, a decision is made in favour of specification between small structural and big macroeconometric models. At first, a model had to be constructed for the study, as there were no macro models with good short-run dynamics and clear monetary transmission channels that would work for Estonia. Therefore, a lot of energy is currently spent in order to build a model that can be used for simulating monetary transmission. Fortunately, impressive amount of research work has been done on separate sectors of Estonian economy that, in its turn, has also offered good background information for the current paper (especially regarding prices and foreign trade).

The current model relies mostly on *ad hoc* specification and tries to cover most important and obvious relationships in the economy. Unfortunately, there are some blocks that are still ignored under current specification (for example, labor market and formation of assets prices). The current model relies partially also on very strong assumptions concerning competitiveness of domestic banking sector and easy substitution between domestic and foreign liabilities of commercial banks.

In the next two sections of the paper the idea behind the model is introduced and some issues special for Estonia are discussed. In the fourth section the model is specified and in the fifth empirical estimates to specified equations are derived. The model constructed here consists of 10 behavioural equations and 11 identities (in aggregate 21 endogenous and 11 exogenous variables). Most of the equations are estimated using ordinary least squares (OLS) method on error correction model (ECM) specifications. In the sixth section monetary transmission through estimated transmission model is studied using external shocks' generation. Last section is left for conclusions and discussion about further prospects.

2. The Idea of the Model

2.1. Blocks

The model estimated to study monetary transmission in Estonia can be divided into four blocks. First of them can be labeled as foreign monetary block. It connects official rates of anchor currency (ECB's rate of main refinancing operations) and conditions on foreign money markets. The second domestic monetary sector block is the heart of monetary transmission and deals with domestic lending rate and with bank lending. Special attention is paid to credit rationing as one form that credit channels of monetary transmission can take. Real sector's part of the model specifies transmission of interest rates and banks' lending activity to domestic demand aggregates and specifies production function of the economy (as the last is only needed to estimate GDP gap, an alternative opportunity is to use some simple time functions instead of specification of production function). The formation of current account balance is also included in this block. Last block included in the model deals with inflation expectations. Expected inflation is specified as a mix of adaptive and forward-looking expectations.

2.2. Channels, Links and Signals

Balance sheet channels, asset price channel and direct interest rate channel are presented in the current model[2]. Bank lending channel has been ignored meaning that banks' liabilities are treated as easily substitutable both domestically and internationally (see discussion about bank credit supply below). Interest rate channel is specified directly from interest rate to demand aggregates and indirectly through credit demand. Because of the lack of detailed and credible data for credit contracts and assets prices (other than traded stocks), general credit channel is specified in the form of credit rationing[3]. In the current specification credit rationing is carried out by commercial banks only, meaning that commercial banks themselves always have the opportunity to change freely their net foreign assets position (or that they will never be discriminated by foreign creditors or debtors).

Even if the different channels of monetary transmission are distinguishable in the specifiable model, specification by links is used instead of channels (the approach also used, for example, by Bank of England, 1999 and ECB, 2000). As we are interested in the overall transmission process and not in testing the existence of some specific transmission channel, the approach by links will be more useful to help us avoid partial overlapping between different channels.

Monetary signals transmitting through the model that is specified and estimated later are ECB official rate and foreign and domestic monetary shocks. Depending on the

[2] For more complex discussion about standard approaches to monetary transmission see Romer and Romer (1990); Bernanke and Gertler (1995); Mishkin (1996); Vlaar and Schuberth (1999) and Benhabib and Farmer (1999) to name but a few from enormous amount of research done on this field. In the context of transition economies, BIS (1996) consists of a number of valuable experiences of different countries dealing with monetary transmission and of excellent comparative conclusion by Kamin, Turner and Van't dack.

[3] Usually credit rationing is defined as condition on loan markets where lenders supply less funds than borrowers demand at the quoted contract terms (Newman, Milgate and Well 1998 pg 719).

definition of monetary transmission (or monetary impulses), transmission of changes in nominal effective exchange rate can also be taken into account. But, as it was concluded in the first paper of the series (Lättemäe 2001), commercial banks do not have significant exposure to changes in non-euro currencies, nominal effective exchange rate will affect economy only through competitiveness as component of real effective exchange rate.

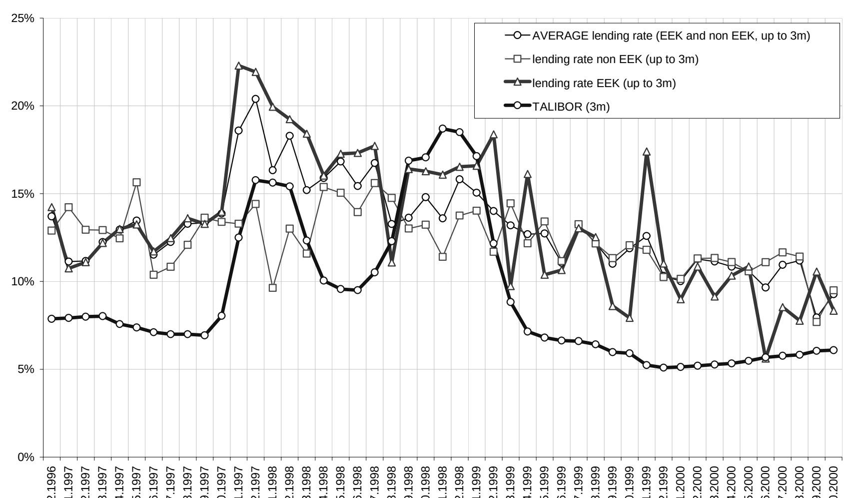
3. Special Issues

Lättemäe (2001) gives a complex overview of CBAs with special emphasis on the system used in Estonia. However, some additional theoretical and empirical problems related to domestic interest rates, banks' credit supply and monetary signals have still remained and need closer explanation.

3.1. Measuring Domestic Interest Rates

The first problem is related to domestic money market and to the fact that domestic money market is too shallow to play an important role as transmitter of monetary signals. As a proof, Figure 1 is constructed. One can observe the clearly unstable relationship between local 3months inter-bank money market rate TALIBOR and rate on loans issued by local commercial banks to private sector (with maturity up to three months as well). Then, in the end of 1997, the increase in money market rates was accompanied by clear and sharp increase in short term lending rates, in the end of 1998 increase in short term bank lending rates was much more moderate than increase in TALIBOR. There existed even a few months period where inter-bank money market rate was few percentage points higher than rate asked by commercial banks from private sector.

Figure 1. Different interest rates in Estonia



Source: Bank of Estonia

The second problem related to interest rates is the lack of tradable government bonds. Estonian general government has a relatively low level of debt outstanding (~5% of

GDP, see table A.1. in Appendix 1) and this is mostly financed through direct borrowing from commercial banks or international financial institutions (such as EBRD, WB etc), not through bonds and T-bills. The reason behind low level of debt lies in privatization receipts that have allowed running budget deficit without financing it externally.

These two points make it difficult to measure country risk and domestic financial sector risk premiums. The first adequately measurable interest rates describing domestic economy are commercial banks' deposit rates and lending rates.

Another problem closely related to the current topic is the lack of any close substitute for money. As there is no secondary market for government bonds and no liquid and easily accessible market for corporate bonds, alternative asset for money is hard to find. This makes the estimation of money demand function extremely challenging, as money stock should be divided between holdings of money as medium of exchange (related to transaction motive and precautionary motive of demand) and as financial asset (wealth accumulation and income earning aspects of demand).

3.2. Form of Bank Credit Supply Function Under CBA

The form of bank credit supply function under CBA may be the most critical question raised in the paper. This question can be both theoretical and current model-specifically technical. The question is currently important in the process of domestic interest rate determination, as in the traditional economic theory the price of goods is derived as equalizing factor of demand and supply. If one of them has extremely high sensitivity to price changes (high price elasticity), the concept changes significantly making prices close to constantly predetermined (see simple textbook-style Figure A.1 in Appendix 1).

In the case of interest rate determination, both closed and open economies should be examined. First, considering closed economy and using traditional IS-LM framework, balancing interest rates are derived from predetermined amount of money in the economy and from real sector demand aggregates. The same can also be derived using micro-level intertemporal optimization. Every economic agent will choose an optimal level of expenditure (and through current income also corresponding level of net savings) according to time preferences interest rates and expected future incomes. But as economic agents may have different time preferences and different level of current income (i.e. they are in the different phase of life cycle meaning that income level is also currently different from its' life-time average), some agents will find themselves in the position where they need to borrow additional funds to finance current expenditure or save for the future (or repay old debt). If, on given rates, there are more agents in the economy who have a need for external financing to finance their negative savings than agents who need to save their funds, interest rates will rise till the demand for external financing equals with the supply of funds. Of course, both of these oversimplified concepts look at the demand side of the economy only, totally ignoring investment demand as a part of supply side. Nonetheless, given that all investment projects have higher net present value on lower interest rates, exclusion of supply side will not harm the overall concept. As an outcome, equilibrium interest rates can be derived for every moment of time by summing up all individual net saving positions and equalizing it with zero (as the economy is assumed to be closed). The addition of banking sector[4] should not harm the concept as well; it can just change the shape of aggregate credit demand and credit supply functions (but not a sign of slope).

However, let us assume the world with two countries- one relatively large and another relatively small and open economy with open trade and financial account and with credibly fixed exchange rate; equalizing the sum of domestic net saving positions does not make any sense, as this small open economy is now firmly connected with another huge economy. Summing net saving position all over the two-country-world is necessary for delivering equilibrium interest rates. But, if our economy is really relatively small compared to the other counterpart, domestic factors can hardly make any difference in interest rate determination, supposing that for our small economy interest rates are predetermined.

Another way to explain predetermined interest rates under CBA is to use a little higher level of aggregation and deal with international capital flows. Let us assume again two different size of countries, fixed exchange rate and free balance of payment transactions, uncovered interest parity (UIP) condition can be applied. Now, according to UIP, the difference between domestic and foreign rates should be determined by domestic risk premium (containing default risk, liquidity risk etc) and by expected changes in exchange rate. If peg is totally credible (for example unilateral adoption of foreign currency), this part of the premium will vanish leaving only domestic risk premium to determine the spread between domestic and foreign interest rates. Under CBA, expected changes in exchange rate can be put to the same part with country risk or domestic political risk because very deep economic recession with banking crisis or extremely strong political consensus is needed to abandon the peg. It was mentioned already by Lättemäe (2001) that CBA monetary rule assures that central bank can never run out of reserves. Thus, under the current specification it could be defined that domestic interest rates are specified as in (S0):

$$i = i^* + \delta + \varepsilon \qquad \text{(S0)}$$

where
- i — domestic rate of interest
- i^* — foreign rate
- δ — domestic risk premium
- ε — deviation from parity condition

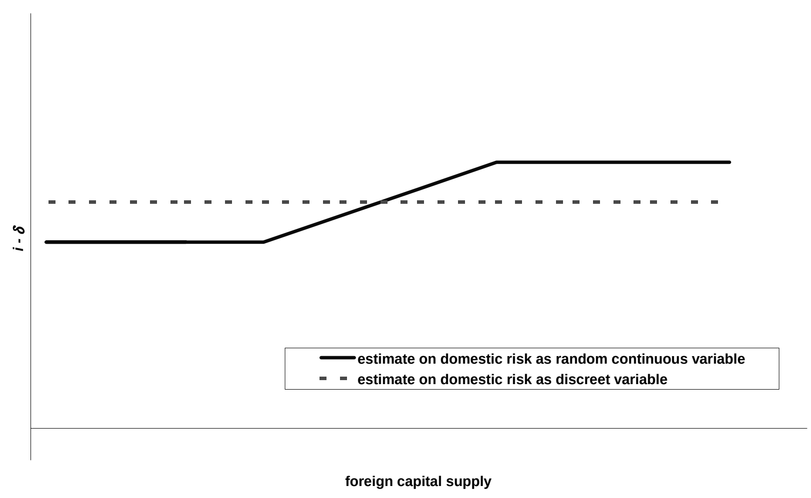
If domestic rates will deviate from the predetermined level, both domestic and foreign economic agents will have arbitrage opportunity (as already mentioned, financial account is assumed to be totally free) to gain unreasonably high incomes. Arbitrage opportunity will be available as long as generated international financial and capital flows will balance domestic rates with interest parity conditions. Now, there are number of factors that may disrupt the work of arbitrage conditions. Firstly, information about creditworthiness of different economic agents may not be available as freely as needed and may cause misjudgment of specific risks. Secondly, price of risk is threaded here as symmetric, but in actual life and, especially in the case of transition economies, pricing the risk and the will to bear the risk may be asymmetric. It means that domestic agents may prefer higher risk with higher expected yields than do foreign agents and they may also price low risk higher than foreigners. It may cause

[4] Here notation banking sector captures all kind of financial intermediation.

situations where interest rate adjustments that need contraction in net foreign debt position (if domestic rates are lower from parity condition) may differ from the ones where net foreign debt should be increased (if domestic rates are higher than suggested by parity condition)[5]. The last point worth to note here is fact that domestic risk premium was so far treated as exact discreet value. In real life, risks and representative premiums are not actual values, but estimates subjectively given by many economic agents. Like any estimate, there is a certain amount of uncertainty attached to it here as well (and this is one reason why error term was added to the parity condition above). I.e. a slight deviation from parity condition will not necessarily cause instant balancing of capital flows, but flows will occur if parity condition is violated by more than some subjective interval.

Under the above specifications, it is possible to draw directly that foreign (debt) capital supply function is a positive function of risk premium δ and deviation from parity condition ε. If the estimate of risk premium is not a single discreet value (but has its constant mean and deviation $\varepsilon \sim (0,\sigma^2)$), supply will have slight positive slope around parity condition (see Figure 2). If risk premium estimate is a single discreet value (ε=0), foreign capital supply will be a horizontal line meaning that any little deviation from parity condition will cause immediate infinite capital flows that, in turn, will reestablish immediately parity condition through changes in domestic rates. This specification draws a link between domestic risk premium ($i = i^* + \delta + \varepsilon$) and capital supply, but not between domestic rates and foreign capital supply. If δ is assumed to be constant, domestic factors (including domestic rates defined as $i = i^* + \delta + \varepsilon$) cannot influence foreign capital supply in the long run.

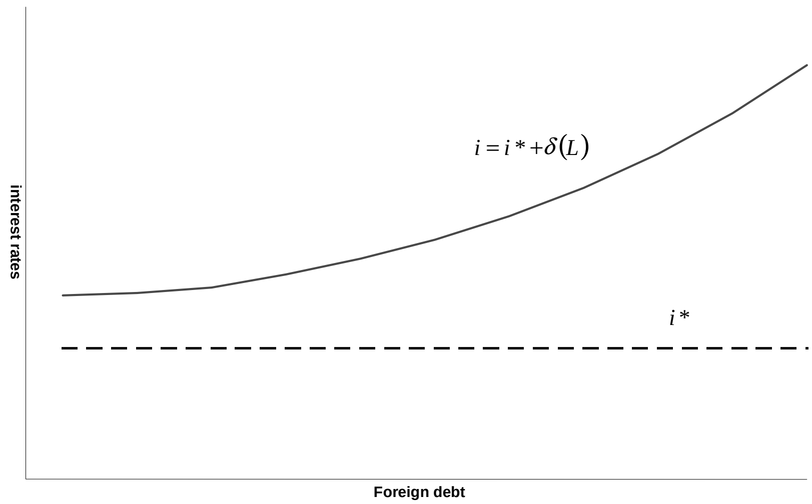
Figure 2. Foreign capital supply depending on specification of risk premium



[5] In empirical part, ECM like specification was tested where positive and negative deviations from long-run levels were included separately. As a result, it was impossible to state that these parameters were statistically significantly different. Parameters were respectively -0.76 for adjustment from too low and –0.60 for adjustment from too high domestic rates.

Now, the only way to connect foreign capital supply with domestic interest rates (set by equation S0) is to specify domestic risk premium as a positive function of foreign debt (or a level of debt relative to some income variable; see Figure 3). Still, it is arguable whether this derived relationship is actually a reverse foreign debt capital supply function or just indirect predetermination of domestic interest rates. The latter position is supported by the fact that the function defines domestic risk and domestic interest rates on given level of foreign debt, not on the level of loans foreign investors are willing to lend out on given rates. In this framework, if demand shifts to the right, more loans are demanded, foreign investors will supply the demanded loans, but gradually will increase the price asked as domestic risk increases.

Figure 3. Domestic lending rate, foreign rate and domestic risk premium as function of loans outstanding.



Another factor confusing current specification is a missing distinction between short run and long run. Intuitively, significant change in indebtedness is needed to change domestic risk premium that cannot be achieved over few periods. It means that in short run specification, domestic risk premium may not be a function of indebtedness giving horizontal supply functions. At the same time, in the short run ε may be not discretely equal to zero, as well, and positive slope of supply function can be derived even in the short run (as demonstrated earlier).

A technical problem for specification of the overall model comes from distinguishable interest rate spread (i-i^*) and indistinguishable domestic risk premium $\delta(L)$. In real life, domestic risk premium often is defined as interest rate spread, as actual risk premium cannot be measured. To solve the problem, an introduced reverse supply function-like function will be used (with other possible long-run risk premium factors) in the domestic interest rate determination, and demand for foreign debt capital by banks will be indirectly included through bank credit demand. This specification takes into account the fact that higher indebtedness calls for higher risk premium, but it fails to derive direct foreign capital supply function. Additionally, this specification assumes that at least in the medium-run, commercial banks can substitute their domestic liabilities with changes in their net foreign assets position.

Current specification stays rather simple and assumes that the environment is stable and that foreign investors' behaviour is homogenous over the entire time horizon. Intuitively, in real life there can be periods when this specification holds (more or less). Yet, there can be also shock periods when foreign debt capital supply is contracted or can be even cut to zero. This kind of situation can arise when international financial turmoil occurs and actual risks in the global economy (or in the transition economies) are not easy to estimate. Then, foreign investors can find that it may be cheaper not to supply any funds before the end of the turmoil, or to introduce additional requirements to the borrowers (or to domestic financial intermediaries)[6]. To some extent, the latter can be very similar to the credit rationing effect that is usually recognised and studied on commercial banks level. But, as we cannot technically derive direct foreign capital supply function (as mentioned, we cannot distinguish between interest spreads and domestic risk premium), we also cannot add credit rationing to the function. To solve the problem, probably the second best solution is used in the current paper and credit rationing is introduced as an instrument on commercial banks' arsenal. Under this specification average lending rate is predetermined for commercial banks (through reverse foreign debt capital supply function) and under "normal" situations commercial banks will deliver entire amount of loans demanded by domestic economic agents on given real rates. Still, when problems arise in the economy, commercial banks can slightly increase the lending rates and also rationalize the amount of credit derived to real sector of the economy.

4. Specification of the System

Most of the equations in the current system are specified on *ad hoc* basis with intuitive desire to cover all most important processes specific to the countries in the transition. This does not mean that all the specified equations are strictly atheoretical. In most cases, conventional economic theories are kept in mind with extensions related to aspects of small and open economies and to transition processes (such as nominal and real convergence[7])

4.1. Interest Rates

Conditions on foreign money market

It is found that shocks on foreign monetary policy and conditions on international money markets are transmitted to transition economies as amplified factors. For example, Arora and Cerisola (2000) have found that both the increase in U.S. federal funds target rate (as proxy for stance of U.S. monetary policy) and U.S. money market turbulence (spread between yield on three-months U.S. Treasury bills and U.S. federal funds target rate was used as proxy) have positive impact on developing countries' country risk. Country risk was measured as a difference between yields on sovereign bonds of developing countries and U.S. Treasury securities with similar maturities.

[6] See Pikkani (2000) for some longer discussion about possible behavior of foreign capital supply.
[7] For discussion about the real convergence in Estonia see Randveer (2000)

Frankel, Schmukler and Servén (2000) studied global transmission of interest rates under different currency regimes and found that under fixed regimes, transmission of U.S. rates to other countries was amplified. They used rather simple regression between domestic and U.S. T-bill rates for the analysis and found that parameter of U.S. rates was, in most cases, bigger than one (especially in the cases of fixed exchange regimes over last decades). Of course, some additional country-specific variables were added to regression models in this analysis.

In the current model both official rate of base currency and indicator of condition on international money markets are included in the system. For this, unexpected changes in inter bank money market rates are separated from expected ones. For this, a simple auto-regressive model between foreign money market rate and official rate is estimated (and residuals are treated as unanticipated shocks). In this model it is assumed for simplicity that monetary policy decisions are perfectly foreseen.

$$\Delta\left(i^*_t\right) = \alpha_{10} \cdot \left[i^*_{t-1} - \overline{i^*}_{t-1} - \beta_{10}\right] + \Phi_1(L) \cdot \Delta\overline{i^*}_t + \varepsilon_t^{i^*} \qquad \text{(S1)}$$

$$\Phi_1(L) = \phi_{11}L^{-3} + ... + \phi_{14} + ... + \phi_{17}L^3$$

where $\overline{i^*}$ rate of interest on foreign money markets
i^* foreign official interest rate
ε^{I^*} unanticipated shocks on foreign monetary sector, residual

Domestic Rate of Interest

In the current model, it is assumed that the spread between domestic bank lending rate[8] and foreign rate consists of two separate parts. At first, there is a part that afterwards will be referred to as “normal risk premium”. This part of the risk premium is strictly function of fundamentals and cannot vary significantly over a short period of time. The second part of the spread is more volatile and is an outcome of short-run shocks (both domestic and foreign). What makes this specification more complicated is that some economic fundamentals are, at the same time, function of domestic interest rates, making the specified system a simultaneous one.

[8] If simply notation of domestic interest rate is used in the current paper, domestic lending rate is always borne in mind.

$$\Delta(i_t) = \alpha_{20} \cdot \left[i_{t-1} - \overline{i^*_{t-1}} - \mu_{t-1}(\underline{Y}) \right] + \alpha_{21} \cdot \Delta \overline{i^*_{t-1}} + \Phi_2(L) \cdot \varepsilon_t^{i^*} + \varepsilon_t^{i} \tag{S2}$$

$$\Phi_2(L) = \phi_{21} + \phi_{22} L + ... + \phi_{27} L^6$$

where
- i domestic rate of interest
- $\overline{i^*}$ foreign official interest rate
- $\mu(\underline{Y})$ normal risk premium being function of vector of variables $\underline{Y}$ (partially endogenous to the whole system)
- L lag operator
- ε^{I^*} unanticipated shocks on foreign monetary sector (coming from equation S1)
- ε^{I} unanticipated shocks on domestic interest rates, residual

4.2. Demand for Bank Credit and Credit Rationing

Formation of the amount of actually delivered bank loans is specified in two separate parts. The first part covers the demand for bank loans and the second specifies the extent of credit rationing conducted by commercial banks. The reason behind this specification was explained under the topic of special issues (see 3.2., *Special issues – Form of bank credit supply function under CBA*).

First, credit demand is specified as a function of real *ex-ante* interest rate and economic activity (both current and expected one – equation S3.1). The extent of credit rationing is set to be a function of unanticipated shocks and of assets prices (equation S3.2). In turn, these two can be reduced to the amount of actually delivered credit. This specification will assure that afterwards we can derive estimations on both credit demand and credit rationing.

$$L^D{}_t = f_{L^D}\left(i_t; E_t(\pi_{t+1}); E_t(\underline{Y}_{t+1}); \underline{Y}_t\right) \tag{S3.1}$$

$$L^D{}_t - L_t = f_{L^D - L}\left(\underline{Y}_t; q; \varepsilon_t^{i^*}; \varepsilon_t^{i}\right) \tag{S3.2}$$

reduced form equation:

$$L_t = f_L\left(i_t; E_t(\pi_{t+1}); E_t(\underline{Y}_{t+1}); \underline{Y}_t; q; \varepsilon_t^{i^*}; \varepsilon_t^{i}\right) \tag{S3.3}$$

where
- L^D demand for bank credit
- L actually delivered amount of bank credit
- i domestic lending rate
- $E_t(\underline{Y}_{t+1})$ expectations of vector of variables $\underline{Y}$
- $E_t(\pi_{t+1})$ inflation expectations (inflation is presented y-o-y basis)
- q assets prices
- ε^{I} unanticipated shocks on domestic interest rates (coming from equation S2)
- ε^{I^*} unanticipated shocks on foreign monetary sector (coming from equation S1)

4.3. Inflation Expectations

The formation of inflation expectations is divided into two equal parts. The first part of expectations is strictly backward looking and the second part assumes forward-looking behaviour. In the formation of forward looking expectations current GDP gap, current relative price level (compared to EU or world average), current and future changes in world prices with changes in respective nominal effective exchange rate and future changes in administrative prices are considered as important indicators.[9]

$$E^{A}{}_{t}(\pi_{t+1}) = \frac{1}{n+1}(\pi_t + \pi_{t-1} + ... + \pi_{t-n}) \quad \text{(S4.1)}$$

$$E^{F}{}_{t}(\pi_{t+1}) = f_{E^{F}{}_{t}(\pi_{t+1})}\left(\pi^{*}{}_{t}; \pi^{*}{}_{t+1}; \pi^{A}{}_{t+1}; gap_t; P/P^{*}; NEER\right) \quad \text{(S4.2)}$$

$$E_t(\pi_{t+1}) = \frac{1}{2}\left[E^{A}{}_{t}(\pi_{t+1}) + E^{F}{}_{t}(\pi_{t+1})\right] \quad \text{(S4.3)}$$

Where
$E^{A}{}_{t}(\pi_{t+1})$ adaptive inflation expectations
$E^{F}{}_{t}(\pi_{t+1})$ forward looking inflation expectations
$E_t(\pi_{t+1})$ average inflation expectations
π rate of domestic inflation (y-o-y)
$\pi^{*}{}_{t}$ rate of foreign inflation (y-o-y)
π^{A} changes in administrative prices (y-o-y)
gap GDP gap relative to potential output
P domestic price level
P^{*} foreign price level
$NEER$ nominal effective exchange rate

GDP gap presents short (or medium) run domestic price pressure, relative price level compared to foreign world prices indicates the speed of nominal convergence (assuming that the farther we are from the point we are converging to, the faster we should move to the direction of that point) and foreign inflation adjusted by change in nominal effective exchange rates (preferably on import weights) stands for imported inflation.

4.4. Domestic Demand Aggregates

For domestic demand, equations for private consumption expenditure and private fixed capital formation are specified. For these aggregates both, income and external financing impacts are included. It is important to note already here that to avoid overidentification, only interest rates with the extent of credit rationing or the amount of actually delivered credit alone can be used in specification. For example using actually delivered credit in the same equation with interest rates can cause a situation where interest rate information is doubled: once directly through interest rates and, secondly, through bank credit demand.

[9] For Estonian inflation model see Sepp, Vesilin and Kaasik (2000)

$$C = f_C\left(Y; r; \Delta(L^D - L)\right) \quad \text{(S5.1)}$$

or

$$C = f_C(Y; \Delta L) \quad \text{(S5.2)}$$

$$I^P = f_{I^P}\left(Y; r; \Delta(L^D - L)\right) \quad \text{(S6.1)}$$

or

$$I^P = f_{I^P}(Y; \Delta L) \quad \text{(S6.2)}$$

Where C private consumption expenditure
I^P private fixed capital formation (with changes in inventories)
Y gross domestic product
r real interest rate
L^D demand for bank credit
L actually delivered amount of bank credit

4.5. Trade and Service Balance

Knowing that a relatively low level of value is added in the Estonian export[10], current account balance is estimated instead of separate equations for import and export volumes[11]. Because of this, both factors behind export demand and import demand should be included. Also competitiveness should be included in the form of relative productivity and prices.

In the current model net export is set to be a function of real effective exchange rate, relative productivity (relative real GDP is used as proxy), foreign income and domestic demand.

$$NX = f_{NX}\left(REER; Y / Y^*; Y^*; DD\right) \quad \text{(S7)}$$

Where NX net export of goods and services
$REER$ real effective exchange rate
Y real gross domestic product
Y^* real gross domestic product abroad
DD domestic demand

4.6. Fixed Capital and Production Function

As common to economies in transition, measuring the amount of capital in the economy is a challenging task, making estimation of production function complicated. As only GDP gap is needed in the current transmission model, one possibility is to estimate potential GDP by simple time trend. At the same time, extremely volatile private fixed capital formation (fluctuating between 20 and 30 per cent of GDP, for background see figure A.2 in Appendix 1) may have had an impact on economy's potential over observation period. It is usually argued that changes in monetary

[10] Trade turnover (export + import of goods and services) made up 150% of GDP on 2000.
[11] For modeling Estonian export see Vesilind and Ehrlich (2001) and for early works on import demand see Sepp (1999).

conditions do not have long run effects; here, however, the question is about the definition of the long run. It seems that in the case of Estonia long run may be far above the horizon of the current model (or above the length of time period covered with data) and, instead, long-run medium-term reactions should be included into the model. In the current setup both simple time trend and estimation of production function have been considered as alternatives.

For production function the simplest Cobb-Douglas form is used. For capital stock simple (constant) amortization rate is assumed and for technological process different functions of time trends are tested.

$$K_t = (1-\sigma)\cdot K_{t-1} + I_t \quad \text{(S8.1)}$$

$$\overline{Y}_t = \alpha_{30}\cdot K_t^{\alpha 31}\cdot L_t^{(1-\alpha 31)}\cdot T_t \quad \text{(S8.2)}$$

or equally

$$\ln(\overline{Y}_t) = \alpha_{33} + \alpha_{31}\cdot \ln\left[K_0\cdot(1-\sigma)^t + \sum_{n=1}^{t} I_n\cdot(1-\sigma)^{t-n}\right] + (1-\alpha_{31})\cdot\ln(L_t) + \ln(T_t) \quad \text{(S9)}$$

$$\alpha_{33} = \ln(\alpha_{31})$$

where

$\overline{Y}$	potential output
K	capital stock
I	fixed capital formation
L	employment
T	neutral technological progress
σ	constant rate of amortization
Y	domestic potential output

4.7. Public Sector

Public expenditure (sum of public consumption expenditure and public fixed capital formation) makes up around 25-30 per cent of GDP (see figure A.2 in Appendix 1) and value added in public sector makes up 12-16 per cent from the total. This makes public sector a relatively important agent in the economy. As the shares of government spending to total GDP vary significantly over time, an assumption of constant shares cannot be employed. There are two alternative ways: (1) inclusion of public sector as totally exogenous; or (2) estimation of some rather simple reaction functions for public sector expenditure. Although, keeping public sector as exogenous (control variable) could allow us to run different simulations assuming changes in public sector behaviour, it can lead us to inconsistent results when simulating shocks for monetary sector over medium-run. As monetary shocks and impulses are most important in the current model, estimation of simple reaction function is a more favourable way.

As the goal of Estonian fiscal policy is to achieve fiscal balance in the medium-run, public sector expected revenues are the most important variable driving public expenditure (expected ones as budgetary plans are done in advance). Expected revenues in turn can be estimated using previous periods' GDP (as a maximum information available for the period when budgetary plans are formed). Budget balance is needed only in medium-run and budget deficit can be allowed over periods of slow economic growth balancing it with collection of reserves over periods with higher than average growth. As mentioned above, thanks to previously collected privatization revenues, running a low budget deficit can easily be managed even without issuing public debt (using reserves or current receipts from privatization).

Value added in public sector has been rather stable over the observation period, and can be estimated using simple time trend or equivalently using some constant or changing growth rates. Also, inclusion of public value added as exogenous variable is maybe not the biggest possible violations in the model specification (especially considering that value added in public sector is measured indirectly).

$$\ln(G_t) = \alpha_{40} + \alpha_{41} \ln\left(\frac{1}{n}\sum_{n=1}^{m} Y_{t-n}\right) - \alpha_{42} \cdot g_t \qquad \text{(S10)}$$

$$Y^G = f_{Y^G}(t) \qquad \text{(S11)}$$

where G public expenditure (public consumption expenditure + public fixed capital formation)
Y gross domestic production
Y^G value added by public sector
g rate of annual economic growth [g = d(Y)/Y - 1]

4.8 Additional Identities

To close the system some additional identities are needed.

$$DD_t = C_t + I_t + G_t \qquad \text{(S12)}$$

$$Y_t = DD_t + NX_t \qquad \text{(S13)}$$

$$gap_t = \left(\overline{Y}_t - Y_t\right) / \overline{Y}_t \qquad \text{(S14)}$$

$$r_t = [i_t + 1] / [E_t(\pi_{t+1}) + 1] - 1 \qquad \text{(S15)}$$

where DD domestic demand
C private consumption expenditure
I private fixed capital formation
G public expenditure (public consumption + public fixed capital formation)
NX net export (export - import)
Y gross domestic production
gap GDP gap relative to potential output
Y domestic output
$\overline{Y}$ potential output
$E_t(\pi_{t+1})$ average inflation expectations
i domestic rate of interest
r *ex ante* real interest rate

5. Specification and Estimation of the Empirical Model

To capture both long-run relationship and dynamic adjustment, in most cases, error correction model (ECM) specification is used[12]. But there are a number of problems related to the estimation of ECMs that one should be aware of. First, it is a well-known fact that unit root tests suffer from low power on finite samples and pre-testing variables for order of integration can lead to misclassification of the variables. The second problem is related to the same unit root tests and two-stage estimation procedure derived by Engle and Granger (1987). Namely, to test the existence of cointegrating relationship, residual from long-run relationship should also be tested for order of integration. However, in this stage of tests adjusted coefficients should be used depending on the number of parameters estimated in the cointegrating relationship. These test statistics are derived by Engle and Yoo (1987), but similar to traditional unit root tests, low power of test on small samples stays here as potential danger, as well.

Also, if more than one explanatory variable is used in a cointegrating relationship (and Engle-Granger methodology is strictly followed), cointegration in all possible sets of variables should be tested. This meaning that while grouping the variables by order of integration and testing for number of cointegrating relationships, great number of false decisions may be made just because of the low power of unit root tests. Additionally, estimating cointegration model in two-stage, static cointegrating relationship and dynamic adjustment procedure are estimated separately. On large samples there would probably raise no harm from that separation, but if the sample is small and time series are volatile, a possible mix-up between long-run and short-run signals can occur.

For the current model all the ECMs are estimated using single equation instead of estimating separate long-run cointegrating equation and dynamic adjustment process. To minimize number of violations in the empirical estimation procedure, time series (and their fist differences) are first visually inspected and grouped by their *most probable* order of integration. In most cases variables were found to be most likely I(1). Knowing possible inconsistencies of parameters and estimated standard deviations, a lot of attention is put on parameters' stability tests (mostly in the form of recursive tests) in the estimation procedure. Also, for a background check, traditional two stage procedures were carried out (without additionally testing for order of integration and number of cointegrating equations) which gave results broadly consistent with the ones derived using single equations.

To capture very short-run adjustments and to increase (to some extent artificially) the degree of freedom, all empirical equations are estimated on monthly time series. If there are no problems with monthly data about monetary sector's indicators, then national account statistics are presented only on quarterly basis. To solve this problem, all quarterly time series are interpolated to monthly time series using a simple linear interpolation method[13]. One should be aware that if this procedure will be used, no accurate monthly dynamics are derived. Because of this, instead of monthly

[12] For quick catch-up in technical aspects see for example Enders (1995), Ch 6 or Gujarati (1995) Ch. 21.

[13] Depending on the nature of time series (stock or flow) average or 1/3 of respective time series was imported to the monthly work-file. After this, series were smoothed using three period moving average (using current, leading and lagging observation).

differences, changes over three months are used in dynamic parts of domestic demand and net export equations[14].

5.1. Condition on International Money Markets

London inter-bank 3month Euro offer rate was used as an indicator of conditions on international money markets. For official rate European Central Bank (ECB) rate on main refinancing operations was used (before January 1999 instead of EUR Libor DEM Libor was used and instead of ECB rate on main refinancing operations Deutche Bundespank repo rate was used). ECB main refinancing operations' maturity is two weeks only, being considerably lower than the estimated money market rate. To solve the problem, it is assumed that all monetary policy operations are perfectly foreseen over the next three months. Simple ECM type of model estimated gave the following result[15]:

D(EURIBOR_3M) = -0.45*[EURIBOR_3M(-1)-ECB_REF(-1)-0.003] + 0.54*D(ECB_REF(1)) + 0.90* D(ECB_REF) + 0.13*D(ECB_REF(-1))+ 0.13*D(ECB_REF(-2)) + SH_EURIBOR_ 3M (EQ1)

Estimated equation indicates one-to-one long-run relationship between ECB official rate and money market rate on the given spread of 30 bp. In dynamic part, ECB official rates were usable as indicators with two period lags and only one period lead. For later shock simulations residual SH_EURIBOR _3M is presented here explicitly.

5.2. Domestic Interest Rates

The spread between domestic average lending rate and ECB rate on main refinancing operations is divided between two groups of factors. The first is defined as so-called "normal" or long run spread and the second specifies short-run volatility around this normal spread. For long-run spread traditional fundamentals like level of external debt, private sector indebtedness, government budget position, current account balance and official reserves in weeks of imports were tested. Most of these fundamentals should have impacts on spreads when equilibrium in the economy is achieved or when economy is moving by equilibrium path. For a country in transition like Estonia, there are long-run trends in many variables that cannot be expressed with these fundamentals or with traditional macro variables. In this long-run adjustment process, qualitative changes may be even more important than quantitatively measurable changes. Bearing interest spreads in mind, credit ratings (or invitations to accession negotiations with EU in the first round), for example might be more important than changes in relatively low government debt. To get proxy for increase in stability and credibility of domestic financial sector, share of foreign ownership in banking industry was estimated with different types of time trends. This estimated trend, in turn, was used as an explanatory variable (labeled later as F_OWNERSHIP) to estimate long run normal risk premium. This machination does not apply for the reflection of causal linkages in the economy. The only goal is to get proxy to show growing stability and trust in the sector (knowing that behind domestic commercial banks there are big international financial institutions will

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[14] Expressed as D3(x)= x_t - x_{t-3}

[15] For explanations of the variables and mathematical operators see the *List of Variables* at the end of the paper. And please note that all variables on lowercase, here and afterwards, present natural logarithms of respective variables.

lower risks and vice versa, it can be assumed that without belief in stability of the market, foreign financial institutions are not eager to gain ownership in the domestic banking industry).

To explain short-run volatility in interest rate spread, anticipated and unanticipated spread between three month EURIBOR and ECB official rate is used and sharp falls in domestic assets prices and external monetary shock indicator (residual SH_EURIBOR_3M from eq1) as credit channel effect were tested. Like in EURIBOR_3M equation above, residual is explicitly presented here, as well (SH_IL_AV).

D(IL_AV-ECB_REF) = -0.64*[(IL_AV(-1)-ECB_REF(-1)) - 0.43*F_INDEBTEDNESS(-1)
+0.10*f_ownership(-1) + 0.08]
- 0.04* F_SH_ASSETSP + 0.49*D(EURIBOR_3M-ECB_REF)
+ 1.22*D(EURIBOR_3M(-1)-ECB_REF(-1)) - 0.20*D(IL_AV(-1)-ECB_REF(-1)) + SH_IL_AV (EQ2)

As a result, long run (or normal) risk premium was found to be a function of synthetic variable F_OWNERSHIP and variable F_ INDEBTEDNESS reflecting indebtedness of domestic real sector (defined as annual average of the level of private sector loans outstanding relative to GDP). Additionally autoregressive term and spreads on foreign monetary sector were found to have explanatory power on domestic interest spread. Impact from the difference between ECB official rate and 3month EURIBOR was found to be strongest with one period lag (yielding to multiplier equal to 1.22).

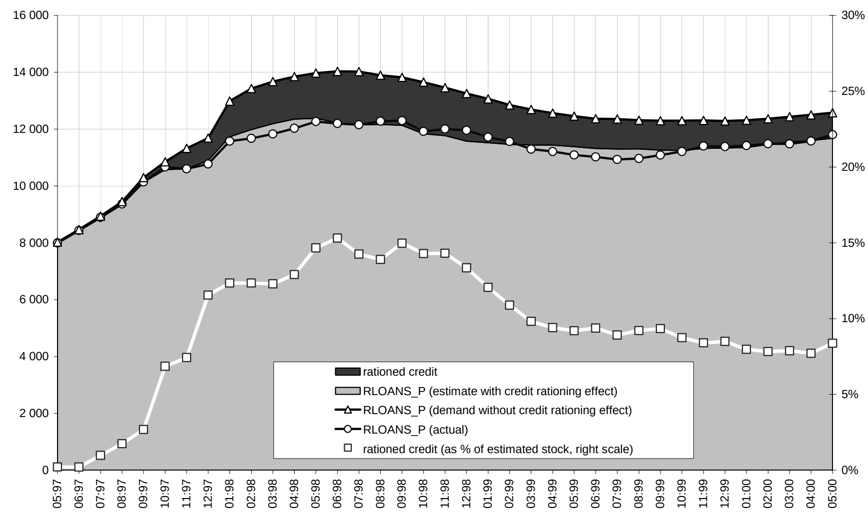
5.3. Bank Credit

A change in the real bank credit is estimated as reduced form equation from credit demand and credit rationing. For credit demand real lending rate and moving average of real GDP are used. To describe credit rationing, unanticipated upside shocks in domestic lending rate and falls in assets prices are used. Additionally, historical ratio between loans outstanding and GDP is used as a measure of distance from prospective equilibrium. The farther we are from that equilibrium, the faster we should probably move to the direction of the equilibrium (similar to price convergence).

D(rloans_p,2) = -0.87*[D(rloans_p(-1)) - 0.014*LOG(@MOVAV(RSKP_P_SAS(-1),3))
+ 0.025*(RLOANS_P(-2)/(RSKP_P_SAS(-2))) + 0.39*RL_AV6(-1)]
+ 0.08* F_SH_ASSETSP - 0.02*F_SH_IL_AV^(1/4)) + 0.03*DMS_9709 + 0.08*DMS_9801 (EQ3)

Estimated equation is on a reduced form capturing both demand and credit rationing factors. To get estimates about the extent of credit rationing the following procedure was carried out. Firstly, the estimate to the amount of loans outstanding was derived using simple dynamic *ex post* forecast. After this, variables used to describe credit rationing where removed from the equation and new series was estimated. If our equation is adequate, last time series should present the credit demand without credit rationing and difference between these two should present extent of credit rationing. Somewhat problematic is the interpretation of derived time series as the starting value of rationed credit is unknown. However, dynamics of the time series should follow actual credit rationing and should be usable for further estimations of domestic demand aggregates. Derived values for credit demand, credit rationing and actual bank credit are presented on Figure 4.

Figure 4. Estimated credit demand, credit rationing and amount of actually delivered loans.



Source: Bank of Estonia and own estimations

5.4. Private Consumption Expenditure

To estimate private consumption, value added in private sector (excluding taxes on production and imports) was used as a proxy for income and real lending rate and the amount of rationed credit where used as monetary indicators.

D3(rcons_sas) = -0.7728124282*[rcons_sas(-3) - 0.95*rgdp_p_sas(-3) - 0.19*@MOVAV(RL_AV6(-3),3)] - 0.01*D3(rloans_p_rat) + 0.86D3(rgdp_p_sas) (EQ4)

In the long-run income elasticity 0.95 and in the short-run 0.86 were found. Between monetary aggregates it can be concluded that real lending rates have influence in the long run only and the extent of credit rationing in the short-run (consistent with belief that credit rationing is a short-run phenomenon only).

5.5. Private Fixed Capital Formation

Similar set of explanatory variables to private consumption expenditure was used for estimation of private investment, but a slightly different set was finally chosen.

D3(rinv_p_sas) = -1.06*[rinv_p_sas(-3) - 1.63*rskp_p_sas(-3) - 0.00026*D3*(RLOANS_P(-3)) + 6.48] + 0.00013*D3(RLOANS_P,2) + 1.68*D3(rgdp_p_sas) (EQ5)

Unlike private consumption expenditure, actually delivered amount of loans was found to be better indicator for investment than separate use of interest rate and rationed credit.

5.6. Trade and Service Balance

D3(RNX_SAS) = -0.99[RNX_SAS(-3) + 217.79*REER_SCAND(-3) - 2370.14*RGDP_ SCAND_SAS(-3) - 6652085*(RGDP_ SCAND_SAS(-3)/RGDP_SAS(-3)) + 0.32*RDD_SAS(-3) +1759]- 0.37*D3(RDD_SAS) - 273.1912578*D3(REER_SCAND) (EQ6)

Trade and service balance is estimated to be a function of real domestic demand, Scandinavian real GDP (as proxy for foreign demand), domestic real GDP relative to the Scandinavian one (as proxy for relative productivity) and real effective real exchange rate compared to Scandinavia (also as proxy for competitiveness). As net export is a value that can change its sign, equation is not estimated on logs but on levels, making interpretation of estimated parameters difficult. The only parameter that can be easily interpreted is the parameter in front of domestic demand indicating that approximately 2/3 of domestic demand can be met domestically and another 1/3 has to be imported.

5.7. Public Sector

To keep the overall model as simple as possible, no additional (new) variables were included in estimation of public sector components (for example, some variable reflecting tax revenues could be useful to add, but it would need also additional equations explaining tax collection).

For public expenditure, moving average real GDP with one-year lag was used to describe budgetary planning process and real economic growth with short lag added as stabilising factor.

rdd_g_sas = 0.48*@MOVAV(rgdp_p_sas(-12),12) + 3.16 - 0.25*(@PCH(RGDP_P_SAS(-1),12)) (EQ7)

Value added in public sector is estimated as a simple function of trend and the overall real economic activity.

rgdp_g_sas = 0.00076*@TREND + 0.11* @MOVAV(rgdp_p_sas(-1),3) + 5.21 (EQ8)

5.8. Inflation Expectations

Forward-looking horizon in inflation expectations forming real *ex ante* interest rates is chosen to be six months. This choice is made subjectively according to the model's overall specification (for example, it was found that inflation is affected by output cap with 6 and 5 months lag and that it takes 3 to 5 months for foreign prices to have impact on domestic inflation) and inflation performance so far.

In forward-looking part of expectations imported inflation and domestic demand side pressures are used as explanatory variables. As the rate of inflation has decreased significantly, formation of inflation expectations (or estimation of future inflation by economic agents) has got simpler. To capture this change, GARCH models or weighted least squares models could be used. In the current case, parameters' estimates by GARCH and weighted least squares (where inverse value of past inflation was used as weights) were not significantly different and the results from weighted least squares were included to the model and are reported here.

```
EXP_INFL_FL6 = 0.27*@PCH(REGPI_BM(6),12) + 0.37*@PCH(CPI_BM_W(2)/NEER_W(2),12)        (EQ9)
        -2375.3*(@MOVAV(CPI_BM/(CPI_BM_W / NEER_W),12)
        - 0.53*@MOVAV(RGDP_P_GAP/RGDP_P_SAS,3) + 0.28
```

Secondly, backward looking part of expectations is defined as annual moving average of actual inflations

```
EXP_INFL_AD6 = @MOVAV(@PCH(CPI_BM(-6),12),12)        (EQ10)
```

and average expected inflation is defined as simple average from these two.

```
EXP_INFL_AVG6 = (EXP_INFL_FL6 + EXP_INFL_AD6)/2        (EQ11)
```

Specified system assumes that for forward-looking expectations changes in world price level, nominal effective exchange rates and in administrative prices are perfectly anticipated.

To close the system, actually occurred inflation is needed. Under the current specification inflation actually taking place is set to be equal to forward looking expectations (as the best inflation forecast).

```
CPI_BM = CPI_BM(-12)*(1+EXP_INFL_FL6(-6))        (EQ12)
```

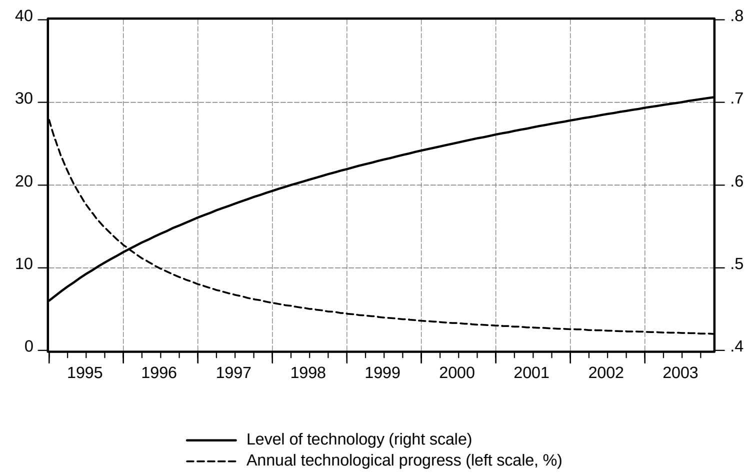
5.9. Potential Output

In the current case, a simple Cobb-Douglas form of production function is used (as defined in (S9)). For initial capital stock, indirectly measured stock was used (Rõõm, unpublished manuscript) and for rate of amortization, 2% per quarter was assumed (equally ≈0.6712% per month or ≈8.24% per year). To describe neutral technological progress, simple log-linear time trend was used.

```
rgdp_p_pot_sas = (1-0.73)*rk_p+0.73*l_psa + 0.144*trend        (EQ13)

RK_P = RK_P (-1)*(1-0.006712) + RINV_P_SAS        (EQ14)
```

Estimated annual improvement in technology is presented on Figure 5. If estimated annual technological progress was in the beginning of 1995 close to 15%, then for the beginning of new century, progress has slowed down to 2% and will slow down to 1.2% for the end of 2005. Unrealistically high level of technological progress in the beginning of the sample period can be caused by miss-estimated initial capital or by some other statistical problems common for economies in transition. For the time periods after 1997, level of progress seems to be on a reasonable level.

Figure 5. Estimated technological progress



Source: Own estimations

5.10. Getting the Model Together

After putting all estimated equations mechanically together into a model, some problems with models' stability raised when *ex ante* simulations were carried out. The increased oscillation that occurred could have been caused by estimation method (ignoring the fact that system is simultaneous) or by misspecification. After studying the system, formation of inflation expectation turned out to be the biggest subject of discredit, especially the part specifying domestic demand pressures on inflation. This does not mean, explicitly, that forward-looking equation is the problematic one as the problem can also be in specifying potential output.

To solve the problem, a decision was made in favour of calibration of inflation expectation's equation. A reasonably stable system was achieved after lowering GDP gap's parameter below –0.5. A further lowering to -0.3 was needed to abolish excess fluctuation (average of most important endogenous variables from *ex ante* forecast did not change significantly after this).

The full system of estimated equations and identities is presented in Appendix 2.

5.11. Biggest Shortcomings of the Current Specification

Although the current model has 11 behavioural equations, there are number of shortcomings in the model that should be kept in mind when the model is used and that could be subject to future revisions.

1. Currently missing the links between ECB rate and …
   1.1. foreign (EMU11) GDP
   1.2. foreign (EMU11) inflation
   1.3. Euro exchange rate against others currencies

These can cause problems, because currently simulated increase in ECB official rate does not take into account actually (in medium-run) lowering inflation and GDP growth rate in euro zone.

2. The model ignores growing share of leasing financing in the economy and direct external borrowing option available for the number of domestic economic agents (for background information see Figure A.3 in Appendix 1).

3. Calibration of inflation expectations' equation. May underestimate domestic pressures on consumer price inflation.

4. Missing direct link between potential output and demand aggregates. Most easily can cause problems if the model is used for longer than short-run forecasting exercise. The most important link currently missing from this system is the link between prices and domestic demand aggregates. This comes from the fact that the model is estimated on real values only, ignoring any changes in relative prices.

5. Another problem that, to some extent, is related to the relative prices concerns stock of loans outstanding. The demand for the real stock of loans outstanding is currently estimated directly as real value. This means that current system does not take into account income effect coming from higher prices and lower real level of debt outstanding.

5.12. Adequacy of the Model.

To test the adequacy of the overall model, both *ex post* and *ex ante* forecasts were used. Additionally reactions to temporary shocks in domestic demand and inflation expectations were studied. These two were chosen, as these were the most important variables channeling endogenous impacts.

Dynamic *ex post* forecasts were carried out and forecasted series where compared with actual series (see Appendix 3). It came out that model's *ex post* forecast is far more volatile than actual time series. The reason behind this higher volatility is probably the interpolation of quarterly time series into monthly ones. Using as simple interpolation procedures as was currently in the use, unrealistically stable monthly SNA data (originally quarterly ones) were faced with monthly monetary and price data that still had their actual volatility. In the case of arbitrary *ex ante* forecast (under fixed exogenous variables) much lower volatility was observed.

As mentioned, reactions to different endogenous shocks were also studied (using *ex ante* forecasts') to test the stability and convergence of the overall system. Variables under study were chosen as domestic demand (excluding government) and inflation expectations. Shocks with amplitude of 10% and 10pp respectively are presented in Appendix 4. From these figures it can be concluded that after relatively huge temporary shocks in domestic demand (+10%) and in forward-looking part of inflation expectations (+10 pp), old pre-shock values will be reached in both cases in less than two years. Near to pre-shock level in inflation expectations will be reached already in the second period after the shock. It might be interesting to note that, in the case of domestic demand, 10% temporary shock will be amplified through multiplier effects to 36% during the shock period (worsening also net export position in the extent of 9.7%

of GDP and increasing GDP by 26%). This only 9.7% worsening in current account balance and huge multiplier reflect high importance of domestically produced goods in domestic consumption. Analyzing other time series generated by the same simulation it was founded that, after domestic demand shock, only 36% from additional domestic demand (resulted by shock) will be channeled to import demand (this is consistent with net export equation analyses done in single equation level above in section 5.6.).

6. Simulations of Monetary Impulses through Estimated Transmission Model.

To study monetary transmission, *ex ante* simulation was carried out for base scenario. For the base simulation following assumptions were made:

1. ECB rate on main refinancing operations is equal to 4%;
2. Scandinavian GDP grows on constant rate of 2% per annum;
3. the world price level grows with constant annual rate of 2%;
4. no changes in the nominal exchange rates (constant NEERs);
5. no decreases on domestic assets prices (i.e. no credit rationing based on this factor for base case)
6. constant level of employment
7. no increase in administratively adjusted prices

After base-simulation, adjustments in the variable reflecting the monetary signal under study were made and second round of simulations were carried out. To analyze impacts, changes on most important endogenous variables were plotted (depending on the nature of variable, % or pp differences were used).

6.1. Changes in the ECB Main Refinancing Rate

Impacts from 1 pp permanent change in ECB main refinancing rate are presented in Appendix 5.1. These figures present a rather big amount of information; therefore, some additional verbal explanation should be given.

First, according to estimated equations, high initial impact on domestic lending rate (peaking at ~1.5 pp) was expected. As changes in inflation expectations take some time, almost as high initial change in real rates will occur. So, high differences in real and nominal rates will stay only for one month and after three months level around 0.9 pp in nominal and around 1 pp in real rates will be achieved till the end of the first after-shock year. As a result of higher rates, average level of indebtedness will decrease, lowering external risk premiums and domestic lending rates slowly after this.

Higher real rates in the beginning of adjustment process will lead to lower domestic demand and to lower credit demand. Contraction will peak at 1.6% in private consumption expenditure and at more than 6.5% (!) in private fixed capital formation, making domestic demand decline around 2.2%. As a marginal stabilizing factor, public expenditure will rise around 0.5%. Caused mainly by the fall in domestic demand (price competitiveness should play a small role, as well), external balance will improve in the extent close to 1% of GDP, making aggregate domestic output to decline by slightly less than 1.5% (value added in private sector will decline slightly more than

1.5%). The highest peaks in real sector values will be archived in half a year after ECB rate change.

A peak in impacts on inflation will take a little longer and will be achieved in one year, reaching its top with the decline by 0.2 pp. For the end of the second after-shock year, initial rate of inflation will be achieved again and the slight over-adjustment to the positive side will occur, as well. The last phenomenon can be explained through the overall price convergence process. According to this, slower growth in some period is needed to be made up over the following periods (at least to some extent).

As a side effect coming from lower fixed capital formation (as mentioned, labor market is not included to the system making the overall system to rely on the assumption of constant potential employment), domestic potential output will fall during first 18 after-shock months, peaking with 0.23 %.

In two or three years, all the domestic demand aggregates and external balance have turned back to the close neighborhood of their pre-change values. Both nominal and real lending rate will stay on the level of 0.6 pp higher than before the changes in ECB rate. Also, real stock of loans outstanding and potential output will not move back to their original levels and stay on the levels respectively 3.2 and 0.16 per cent lower than initially.

As the estimated model is neither strictly linear nor log-linear, some (very low) trends will remain in deviations. More worrying is that the occurred fluctuation stays on relevant level till the end of simulations.

6.2 Foreign Money Market Shock

Impacts from temporary 1 pp size foreign money market shock SH_EURIBOR_3M (residual in EQ1) are presented in Appendix 5.2.

As the beginning of shock transmission is, in its nature, similar to the transmission of permanent change in ECB official rate, deeper explanation of reactions is not needed here. One can see from the figures that transmission of external monetary shock is faster and all the variables have regained their pre-shock values in less than two years. Readjustment in lending rates takes even less than half a year.

What makes current transmission process different from the reaction to changes in ECB rate is that the adjustments done in the first half of the adjustment process are equalised almost as extensive reverse reactions to the other side. For example, contraction in consumption over the first 6 months is followed by extension in almost the same amounts over the next 6 to 8 months, making net effect close to zero (in the previous case cumulative losses in demand aggregates occurred), because this also domestic output potential will not be affected significantly (old level is regained after short term decline by 0.2%).

6.3. Domestic Interest Rate Shock

As domestic interest rate shock is a variable affecting domestic credit rationing, its transmission is slightly different from the transmission of external monetary shocks, even the initial impact on lending rate is approximately in the same size (see Appendix 5.3. for the figures).

Adding credit rationing to the process, contraction in domestic demand aggregates is wider compared to foreign monetary shock (according to the model's specification, when credit rationing did not occur), but the contraction path stays rather similar. For example, under current simulation decline in consumption expenditure peaked at 1.4% (0.38% in the previous case), in investment demand with 4.4% (compared to 1.3% in the previous case) and in aggregate GDP with 1.3% (0.5% in the earlier case).

The behaviour of credit rationing itself is extremely interesting. During the first three months, credit to private sector was cut by more than 0.8% (additionally to demand side contraction caused by higher lending rates). Arbitrarily, it can be claimed that from 1.6% total decline in the real stock of loans outstanding half (0.8%) was caused by demand factors and the other half (also 0.8%) was caused by banks' behaviour in the form of credit rationing[16].

6.4. Nominal Effective Exchange Rate Shocks

It is rather complicated to analyze impacts coming from changes in nominal effective exchange rate. A problem arises because two different NEERs are included in the model. One of them is weighted together using import basket of goods (NEER_W) and another on foreign trade volumes with Finland and Sweden (NEER_SCAND). To connect these two with traditional NEER calculated on total trade volumes, average share of floating (or non-euro currencies) in these three different NEERs were calculated. As a result, it came out that 1% increase in traditional NEER is consistent with 0.6% increase in NEER_SCAND and with 0.9% increase NEER_W (assuming that all non-euro currencies depreciate in the same amount). Shocks lower than 1% mean that in both self-combined NEER indices (in NEER_SCAND and NEER_W) share of non-euro currencies is lower than in traditional NEER.

According to the above calculations, in order to simulate 1% increase in traditional NEER, NEER_SCAND and NEER_W were needed to be shocked at the same time (respectively by 0.6% and 0.9%) in order to simulate 1% increase in traditional NEER. Under this simulation exercise, rather different channels start to work compared to the last three different interest rate shocks (for results see Appendix 5.4).

The first of the two distinguishable nominal effective exchange rate transmission channels is related directly to imported prices and to real *ex ante* interest rate. The second channel is related to the competitiveness of domestic products on export markets, but is partially also connected with the first channel through domestic prices.

[16] In the case where model specification without assets prices in credit rationing was used, total decline in the stock of loans outstanding was 1.9% and from that 1.1% was arbitrarily related to credit rationing.

Impact from imported inflation is easy to track. With four months lag domestic inflation rate will decline by 0.4 to 0.6 pp for one year. After this, pre-shock inflation rate will be achieved again with some volatility in it. As a direct outcome, real lending rates start to increase already before actual increase in inflation (as it is assumed in the model that changes in foreign prices and nominal exchange rates are perfectly foreseen). Real rates will have direct impact on domestic demand aggregates and domestic demand has in turn direct impact on net export (lower import for final consumption = higher net export).

From the other side, net export has negative relationship with nominal effective exchange rate calculated on Finnish and Swedish currencies. That is, stronger value of kroon against Scandinavia means lower competitiveness on these markets. As Appendix 5.4 indicates, current shocks of NEERs sum up positive impact on net export. This means that contraction in import demand (because higher real rates cause lower domestic demand) exceeds contraction in export demand (that is caused by the loss of competitiveness). This outcome can be considered as contradictory to traditional beliefs. According to traditional view in the economy, it is believed that, for example, stronger dollar has helped to increase Estonian export that, in turn, has boosted Estonian economic growth.

There is one problem related to the current simulations that can make the results unreliable. Namely, the assumption that ALL non-euro currencies have to depreciate by the same amount. At least to some extent, NEER_W consists of US dollar, Russian rouble, Latvian lat (pegged to SDR) and Lithuanian litas (pegged to USD) that have historically shown higher volatility against euro and DEM than Swedish crone and Finnish mark[17]. This, in turn, can lead to actually inconsistent assumption. Yet, assumptions of depreciation of all non-euro currencies to the same extent is probably the best assumption one can make without studying the relationships between different currencies any deeper.

Conclusion and Future Perspectives

Currency board arrangement sets rather strict rules on the conduction of monetary policy operations and the environment. Central bankers' hands are tied up with the full base money backing requirement and, in most cases, adjustment processes needed in the economy and reactions to domestic and external shocks are left to be managed by the private sector. Some help from fiscal policy can be hoped, but currency board arrangement sets strict financing conditions also here. Namely, government cannot be financed by central bank's (unbacked) money creation and, in the long run, government has to bear in mind strict balancing budget constraints.

Another important aspect coming directly from fixed exchange rate policy is domestic interest rate convergence to the one in EMU area. To cover this, interest rate formation in the current model was divided into two parts. First, long run specification that

[17] In the first half of year 2000 traditional NEER calculated on trade volumes had on average following shares: USD – 2.7%, Russian ruble – 14.8%, Latvian lat – 7.2% and Lithuanian litas – 3.2%. NEER_W calculated on import volumes had following average weights: USD – 2.5%, Russian ruble – 17.8%, Latvian lat – 5.0% and Lithuanian litas – 2.3%.

covers economic transition and growing credibility aspects and second, short-run specification that deals with transmission of external and domestic shocks.

To study impacts from foreign and domestic monetary shocks, a monthly monetary transmission model was constructed. The model consists of 11 behavioural equations and covers hopefully all most important sectors engaged into transmission process. In *ex-ante* simulations the model showed some signals of instability, but after a slight calibration of inflation expectations equation satisfying level of stability was archived.

Estonian economy's reactions to four different shocks were generated (section 6.1-6.4 and Appendix 5). All simulations showed surprisingly fast absorption of the shocks and movements back to pre-shock levels. Only in the case of permanent change in ECB official rate new levels in domestic average lending rate, stock of loans outstanding and level of potential output (not in the potential growth rate) were achieved. To compare the results of shock in domestic monetary sector with the ones derived by Walsh (1998, pg 473)[18], a consistence of the results was found (see figure A.4. and A.5. in Appendix 1). Adjustment process derived by the model estimated on Estonian data has considerably faster adjustment process. The latter can be caused by both, different specification of formation of domestic interest rates[19] and by relatively high openness of the economy as well as by very high wage and price flexibility in Estonia.

As a result, it was found that in the case of permanent change in ECB official rate maximum contraction in domestic demand aggregates and domestic output will be achieved in 5-6 months and maximum amplitudes will be respectively around 2.2 and 1.5 per cent. Total recovery will be achieved in 3 years from the change in official rate (section 6.1.).

Future Perspectives

For the future, three different objectives could be set. At first, some estimated relationships in the economy could be revisited and improved. Also some purely technical improvements can be borne in mind (for example, changing annual inflation with monthly one could give some additional stability for the *ex-ante* forecasts).

Secondly, some new sectors could be added to the model. The first candidate in the domestic waiting list is probably labour market (wages, labour supply and demand). In the euro-area waiting list there are ECB official rate and euro-area output and prices. Last ones are needed to generate more realistic foreign monetary shock simulations. For example, increase in ECB official rate will actually cause changes also in euro area output and price level. Also, there is probably more or less quantifiable ECB reaction function to changes in output and prices. Currently, all the three are treated as strictly

[18] Walsh (1998, pg 431-476) constructed a rather small open economy model to study impacts from domestic and foreign monetary **policy** shocks. For this they used monetary policy rule introduced by Fuhrer and More (1995).

[19] In the model used by Walsh, domestic monetary authority set official rate according to weighted average of inflation and output. Also, relatively high autoregressive term (0.84) is included. In the model constructed for Estonia, domestic monetary shocks die out fast, because the level of domestic rates rely on interest rate arbitrage condition and total absence of domestic monetary policy.

independent exogenous variables in the model’s simulations. To solve this problem, results from studies conducted on monetary policy rules can be directly included to the model.

As a last proposition for the future use of the current model, some additional simulations can be carried out. The model has currently a set of instruments to study, for example, impacts from changes in external demand, administrative prices and changes in domestic fiscal policy rule. Additional equations can change the range of questions the model can answer, at least to some extent.

References

Arora, V., Cerisola, M. (2000) *How Does U.S. Monetary Policy Influence Economic Conditions in Emerging Markets?*, IMF Working Paper 00/148

Bank of England (1999) *The Transmission Mechanism of Monetary Policy - a paper by the Monetary Policy Committee April 1999* [http://www.bankofengland.co.uk/montrans.pdf] 01.08.2000

Benhabib, J., Farmer, R. E. A. (1999) *The Monetary Transmission Mechanism,* EUI Working Paper ECO No. 99/35

Bernanke, B.S., Gertler, M. (1995) *Inside the Black Box: the Credit Channelof Monetary Policy Transmission,* The Journal of Economic Perspectives, 9, Fall

BIS (1996) *The Transmission of Monetary Policy in Emerging Market Economies*, BIS Policy papers No. 3

ECB (2000) *Monetary policy transmission in the euro area,* Monthly Bulletin, July pg. 43-58

Enders, W. (1995) *Applied Econometric Time Series,* John Wiley & Sons, Inc,

Engle, F. R., Granger, C. W. J. (1987) *Co-Integration and Error Correction: Representation, Estimation and Testing,* Econometrica 55

Engle, R., Yoo, B. (1987) *Forecasting and Testing in Cointegrated Systems*, Journal of Econometrics 35

Frankel, J., Schmucler, S., Servén, L. (2000) *Global Transmission of Interest Rates: Monetary Independence and Currency Regime,* World Bank Policy Research Working Papers No2424, August

Fuhrer, J. C., Moore, G. R. (1995) *Inflation Persistence,* Quarterly Journal of Economics, 110

Gujarati, D. N. (1995) *Basic Econometrics, 3rd ed.*, McGraw-Hill International Editions

Lättemäe, R. (2001) *Monetary Transmission in Estonia,* Working Papers of Eesti Pank, No 4

Mishkin, F. S. (1996) *The Channels of Monetary Transmission: Lessons For Monetary Policy*, NBER Working Paper Series, Working Paper No. 5464

Newman, P., Milgate, M., Well, J. E. (1998) *The New Palgrave – Dictionary of Economics.*

Pikkani, R. (2000) *The Monetary Sector under a Currency Board Arrangement: Specification and Estimation of a Model with Estonian Data,* Working Papers of Eesti Pank, No 4

Randveer, M. (2000) *Tulutaseme konvergents Euroopa Liidu ja liituda soovivate riikide vahel*, Eesti Panga Toimetised Nr. 6

Romer, C. D., Romer, D. H. (1990) *New Evidence on the Monetary Transmission Mechanism,* Brooklings Papers on Economic Activity, 1

Rõõm, M. (unpublished manuscript) *Potentsiaalse kogutoodangu hindamine tootmisfunktsioonimeetodil Kesk- ja Ida-Euroopa riikide näitel*, Bank of Estonia, Research Department

Sepp, U. (1999) *Factors of Trade-Deficit Convergence in Estonia*, Working Papers of Eesti Pank, No 1

Sepp, U., Vesilind, A. Kaasik, Ü. (2000) *Estonian Inflation Model*, Working Papers of Eesti Pank, No 1

Vesilind, A., Ehrlich, L. (2001) *Determinants of Estonian Export of Goods: An Econometric Analysis and Comparison with Latvia and Lithuania,* Working Papers of Eesti Pank, No 1

Vlaar, P.J.G., Schuberth, H. (1999) *Monetary Transmission and Controllability of Money in Europe: a structural vector error correction approach*, DNB Staff Reports 1999, No. 36

Walsh, C.E. (1998) *Monetary Theory and Policy*, MIT Press

Appendix 1. Figures and tables

Table A.1. Government debt (as of December 31, 2000)

	mln EEK	as % of GDP
General government	4323.9	5.1%
Central government	2715.6	3.2%
Domestic debt	210	0.2%
Foreign debt	2505.6	3.0%
Local governments	1836.1	2.2%
To other parts of government	227.8	0.3%
To domestic financial intermediaries	658.5	0.8%
Issued securities	684.4	0.8%
Other debt	66.4	0.1%
External debt	199	0.2%

Source: Ministry of Finance and Statistical Office

Figure A.1. Price reactions to demand shocks under supply functions with high and low price elasticity.

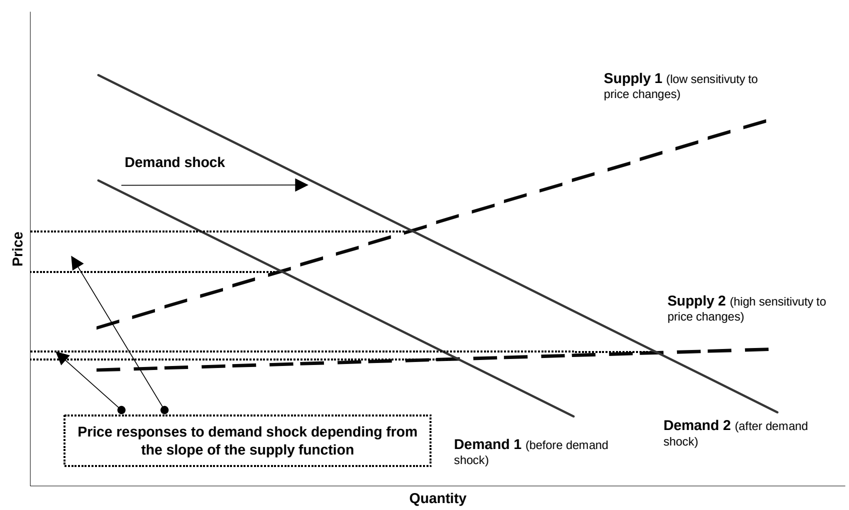
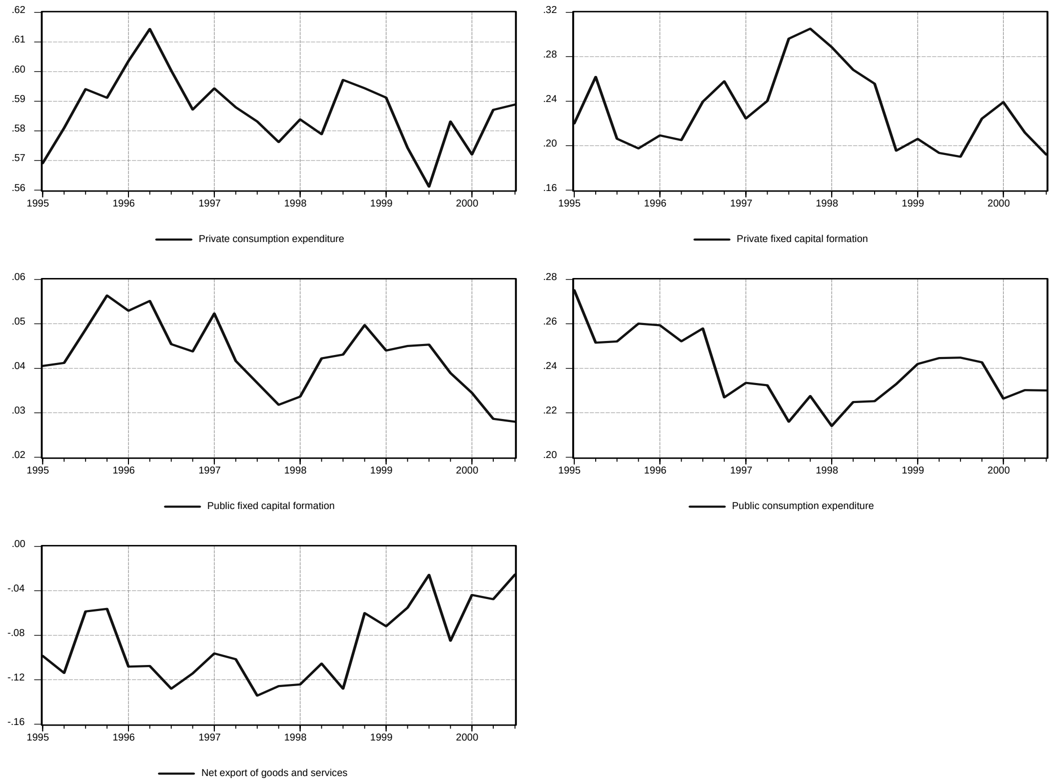
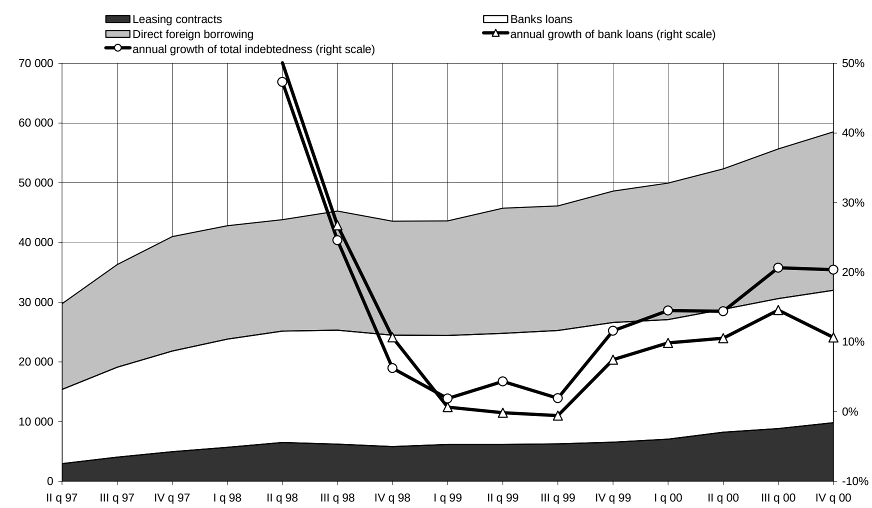


Figure A.2. Composition of GDP at current prices by demand aggregates (as % of total GDP, seasonally adjusted)



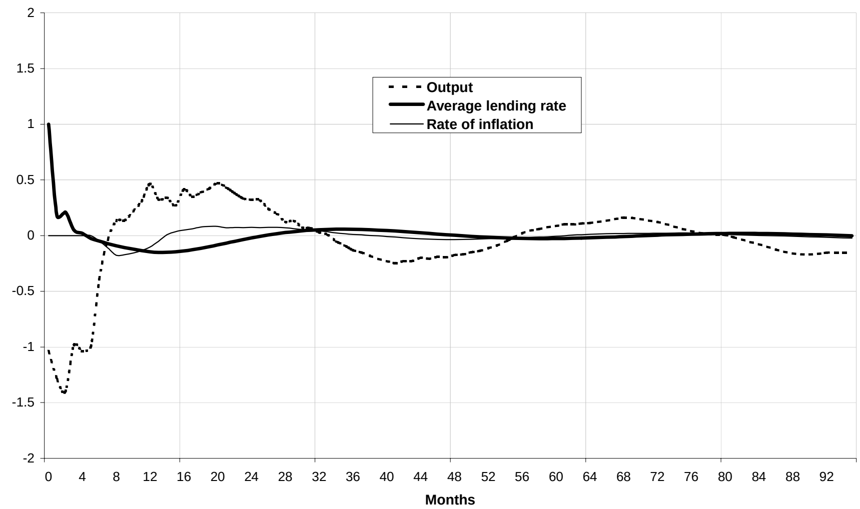
Source: Statistical office, own calculations

Figure A.3. Domestic private sectors domestic and foreign debt (mnl EEK)



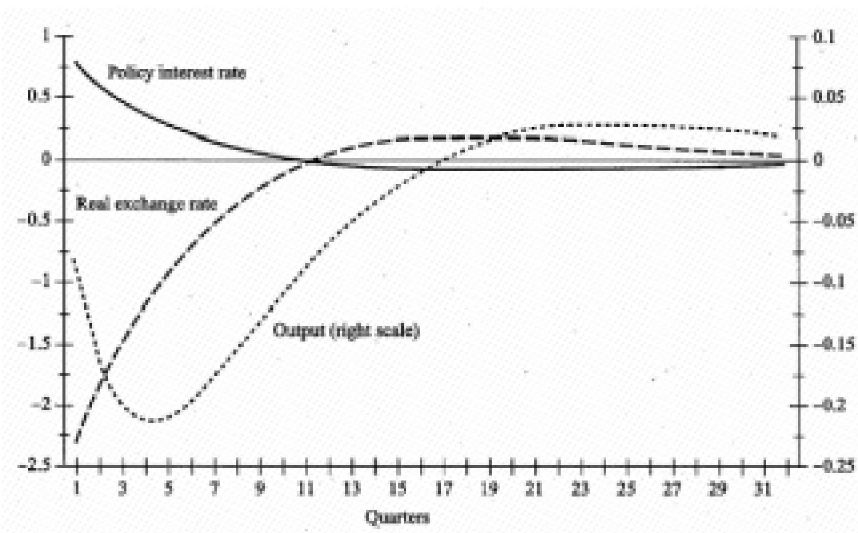
Source: Bank of Estonia

Figure A.4. Results from temporary domestic monetary shock (to residual in domestic lending rate equation)



Source: Own estimations

Figure A.5. Results from domestic monetary POLICY shock derived by Walsh (1998, pg 473, Figure 10.6)

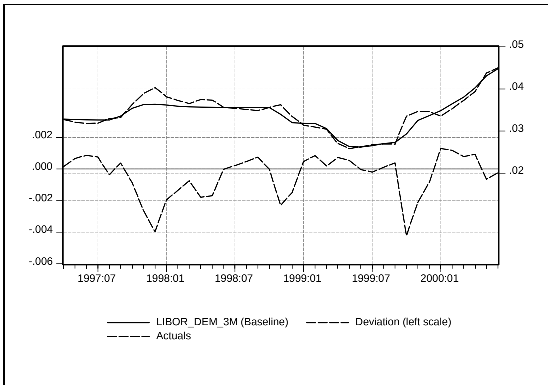


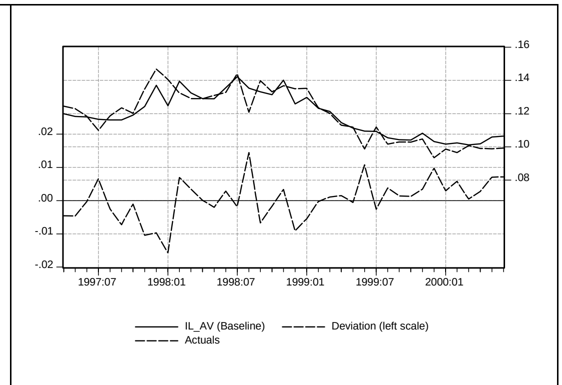
Source: Walsh (1998, pg 473)

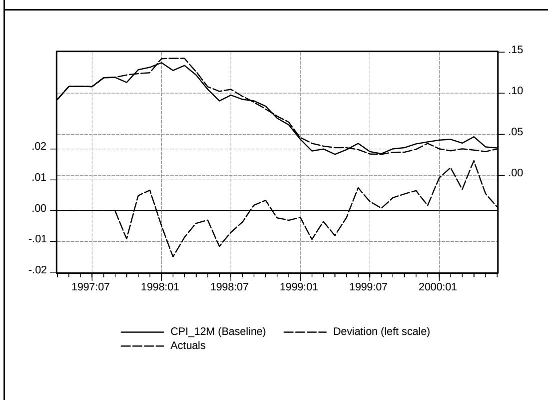
Appendix 2. Estimated model

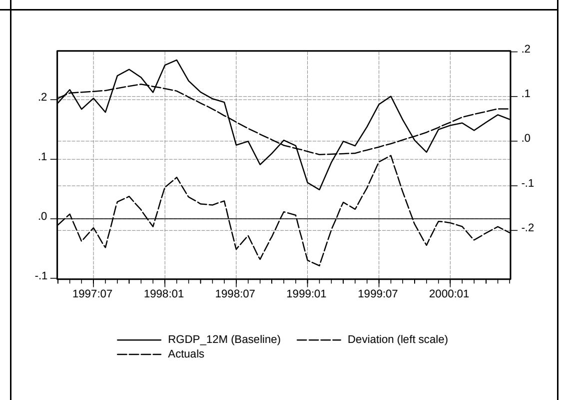
```
D(EURIBOR_3M) = -0.45*[EURIBOR_3M(-1)-ECB_REF(-1)-0.003] + 0.90* D(ECB_REF)                          (EQ1)
        + 0.13*D(ECB_REF(-1))+ 0.13*D(ECB_REF(-2)) + 0.54*D(ECB_REF(1))+ SH_EURIBOR_ 3M

D(IL_AV-ECB_REF) = -0.64*[(IL_AV(-1)-ECB_REF(-1)) -  0.43*F_INDEBTNESS(-1) + 0.10*f_ownership        (EQ2)
        + 0.08] - 0.04* F_SH_ASSETSP + 0.49*D(EURIBOR_3M-ECB_REF)
        + 1.22*D(EURIBOR_3M(-1)-ECB_REF(-1)) - 0.20*D(IL_AV(-1)-ECB_REF(-1)) +  SH_IL_AV

D(rloans_p,2) = -0.87*[D(rloans_p(-1)) - 0.014*LOG(@MOVAV(RSKP_P_SAS(-1),3))                         (EQ3)
        +  0.025*(RLOANS_P(-2)/(RSKP_P_SAS(-2))) + 0.39*RL_AV6(-1)] + 0.08* F_SH_ASSETSP
        - 0.02*F_SH_IL_AV^(1/4)) + 0.03*DMS_9709 + 0.08*DMS_9801

D(rloans_p_nr,2) = -0.87*[D(rloans_p_nr(-1))                                                         (EQ3.1)
        - 0.014*LOG(@MOVAV(RSKP_P_SAS(-1),3)) + 0.025*(RLOANS_P_NR(-2)/(RSKP_P_SAS(-2)))
         + 0.39*RL_AV6(-1)]  + 0.03*DMS_9709 + 0.08*DMS_9801

RLOANS_P_RAT = RLOANS_P_NR – RLOANS_P_RAT                                                            (EQ3.2)

D3(rcons_sas) = -0.7728124282*[rcons_sas(-3) - 0.95*rgdp_p_sas(-3) - 0.19*@MOVAV(RL_AV6(-3),3)]      (EQ4)
        - 0.01*D3(rloans_p_rat) + 0.86D3(rgdp_p_sas)

D3(rinv_p_sas) = -1.06*[rinv_p_sas(-3) - 1.63*rskp_p_sas(-3) - 0.00026*D3*(RLOANS_P(-3)) + 6.48]     (EQ5)
        + 0.00013*D3(RLOANS_P,2)  + 1.68*D3(rgdp_p_sas)

D3(RNX_SAS) = -0.99[RNX_SAS(-3) + 217.79*REER_SCAND(-3) - 2370.14*RGDP_ SCAND_SAS(-3)                 (EQ6)
        - 6652085*(RGDP_ SCAND_SAS(-3)/RGDP_SAS(-3)) + 0.32*RDD_SAS(-3) +1759]
        - 0.37*D3(RDD_SAS) - 273.1912578*D3(REER_SCAND)

rdd_g_sas = 0.48*@MOVAV(rgdp_p_sas(-12),12) + 3.16 - 0.25*(@PCH(RGDP_P_SAS(-1),12))                  (EQ7)

rgdp_g_sas = 0.00076*@TREND + 0.11* @MOVAV(rgdp_p_sas(-1),3) + 5.21                                  (EQ8)

EXP_INFL_FL6 = 0.27*@PCH(REGPI_BM(6),12) + 0.37*@PCH(CPI_BM_W(2)/NEER_W(2),12)                       (EQ9)
        -2375.3*(@MOVAV(CPI_BM/(CPI_BM_W / NEER_W),12)
        - 0.53*@MOVAV(RGDP_P_GAP/RGDP_P_SAS,3) + 0.28

EXP_INFL_AD6 = @MOVAV(@PCH(CPI_BM(-6),12),12)                                                        (EQ10)

EXP_INFL_AVG6 = (EXP_INFL_FL6 + EXP_INFL_AD6)/2                                                      (EQ11)

CPI_BM = CPI_BM(-12)*(1+EXP_INFL_FL6(-6))                                                            (EQ12)

rgdp_p_pot_sas = (1-0.73)*rk_p+0.73*l_psa + 0.144*trend                                              (EQ13)

RK_P = RK_P (-1)*(1-0.006712) + RINV_P_SAS                                                           (EQ13)

RDD_SAS = RCONS_SAS + RINV_SAS + RDD_G_SAS                                                           (EQ14)

RGDP_SAS = RDD_SAS + RNX_SAS                                                                         (EQ15)

RGDP_P_SAS = RGDP_SAS – RGDP_G_SAS                                                                   (EQ16)

RGDP_P_GAP = (RGDP_P_OPT_SAS - RGDP_P_SAS) / RGDP_P_POT_SAS                                          (EQ17)
```

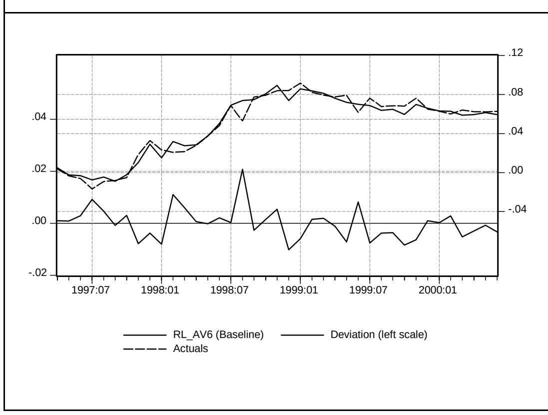
Appendix 3. Model's ex post forecast [20]

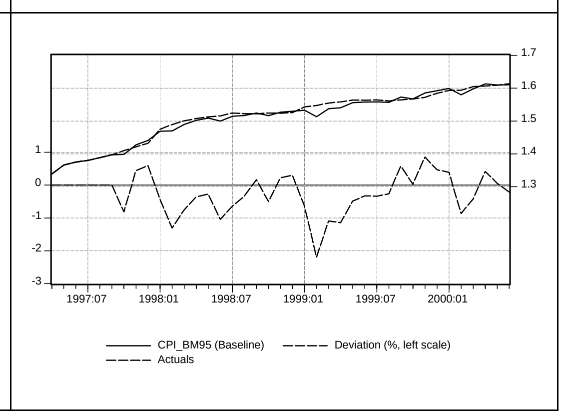




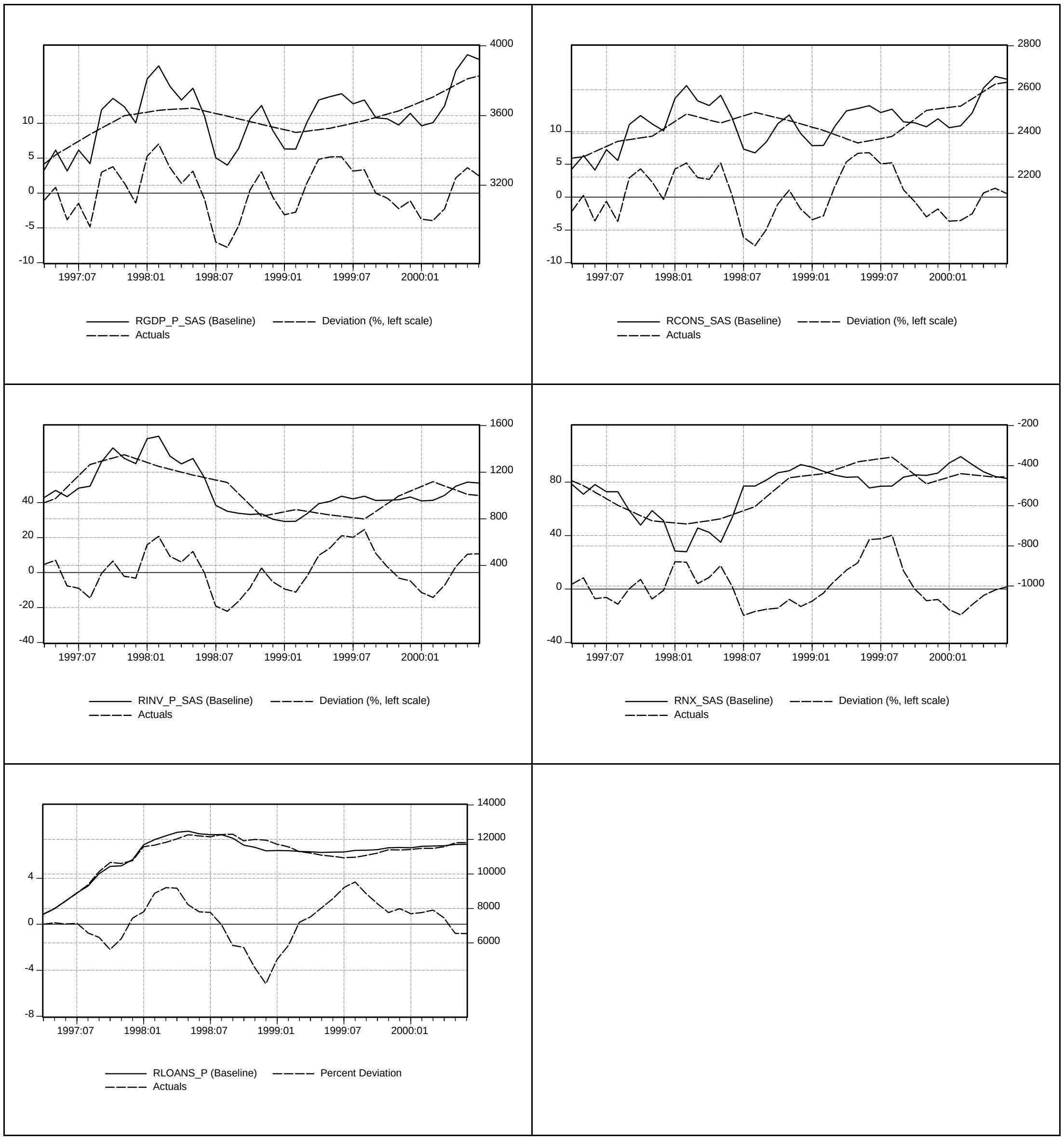






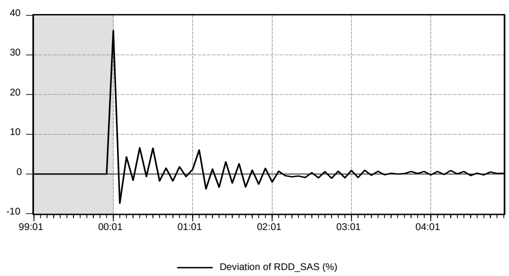


[20] Under this *ex post* forecast it is assumed that there have never been either external or internal monetary shocks (meaning that decomposed shock residuals SH_EURIBOR_3M and SH_IL_AV are ignored in equations).

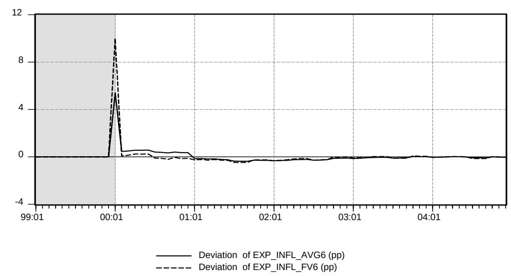

RGDP_P_SAS (Baseline)
Deviation (%, left scale)
Actuals
RCONS_SAS (Baseline)
Deviation (%, left scale)
Actuals
RINV_P_SAS (Baseline)
Deviation (%, left scale)
Actuals
RNX_SAS (Baseline)
Deviation (%, left scale)
Actuals
RLOANS_P (Baseline)
Percent Deviation
Actuals
1997:07
1998:01
1998:07
1999:01
1999:07
2000:01

Appendix 4. Results form ex ante shocking
(temporary shocks on 00:01)

10% shock to RDD_SAS



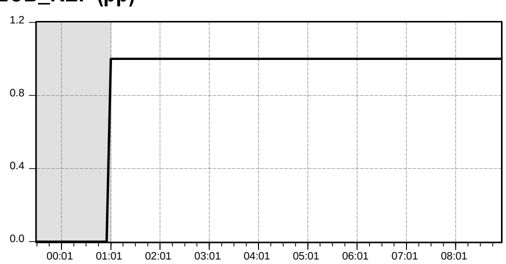
10pp shock to EXP_INFL_FV6



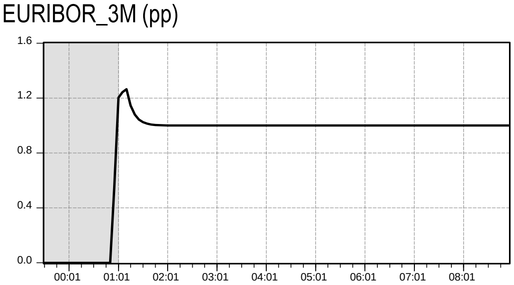
Appendix 5. Results from simulated monetary shocks

Appendix 5.1. Deviations from base-simulation after 1 pp permanent increase in ECB_REF (on 01:01)[21].

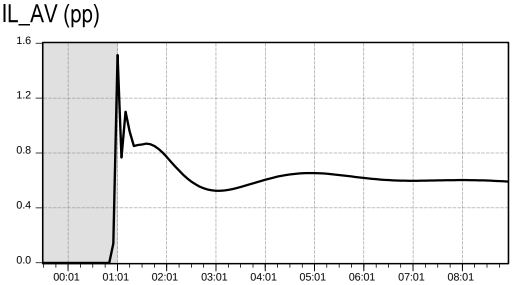
ECB_REF (pp)



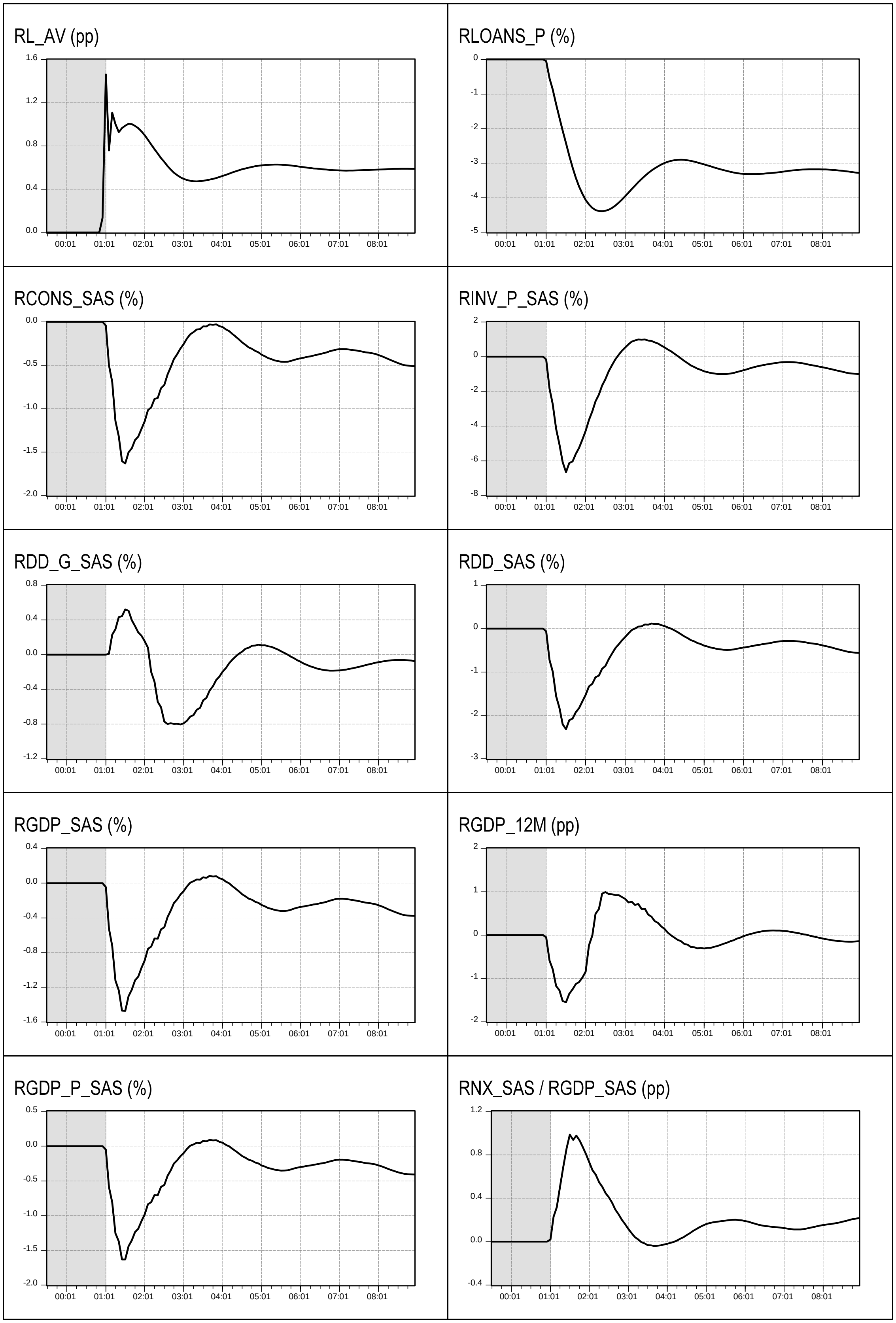
EURIBOR_3M (pp)

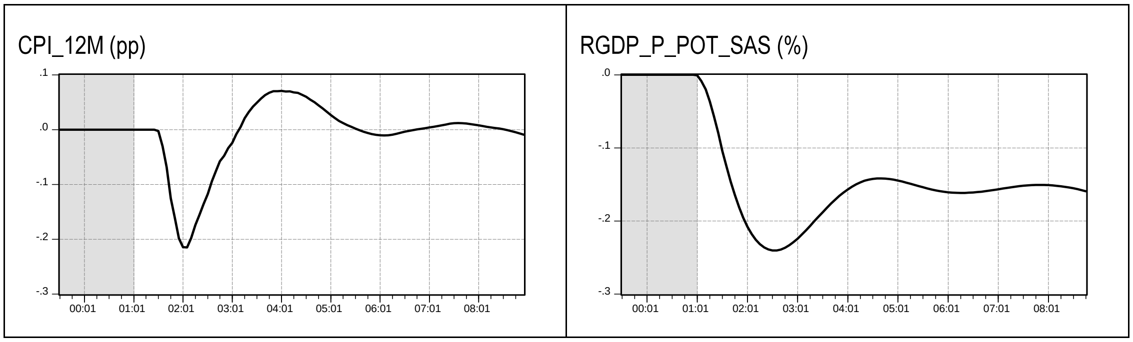


IL_AV (pp)

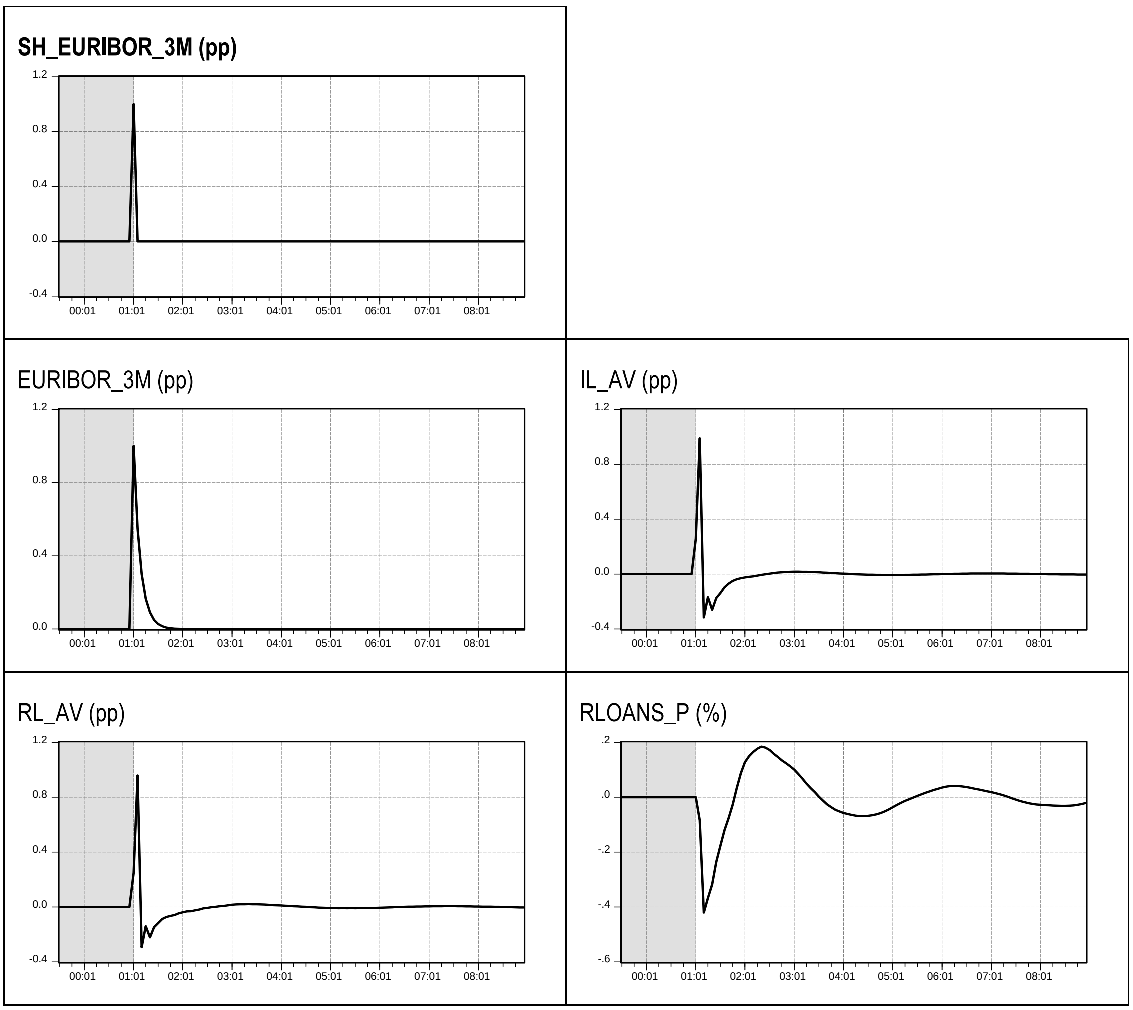


[21] Quantitative measure of the deviation is given in the brackets (percental difference from base simulation - % or percentage point difference from base simulation - pp).

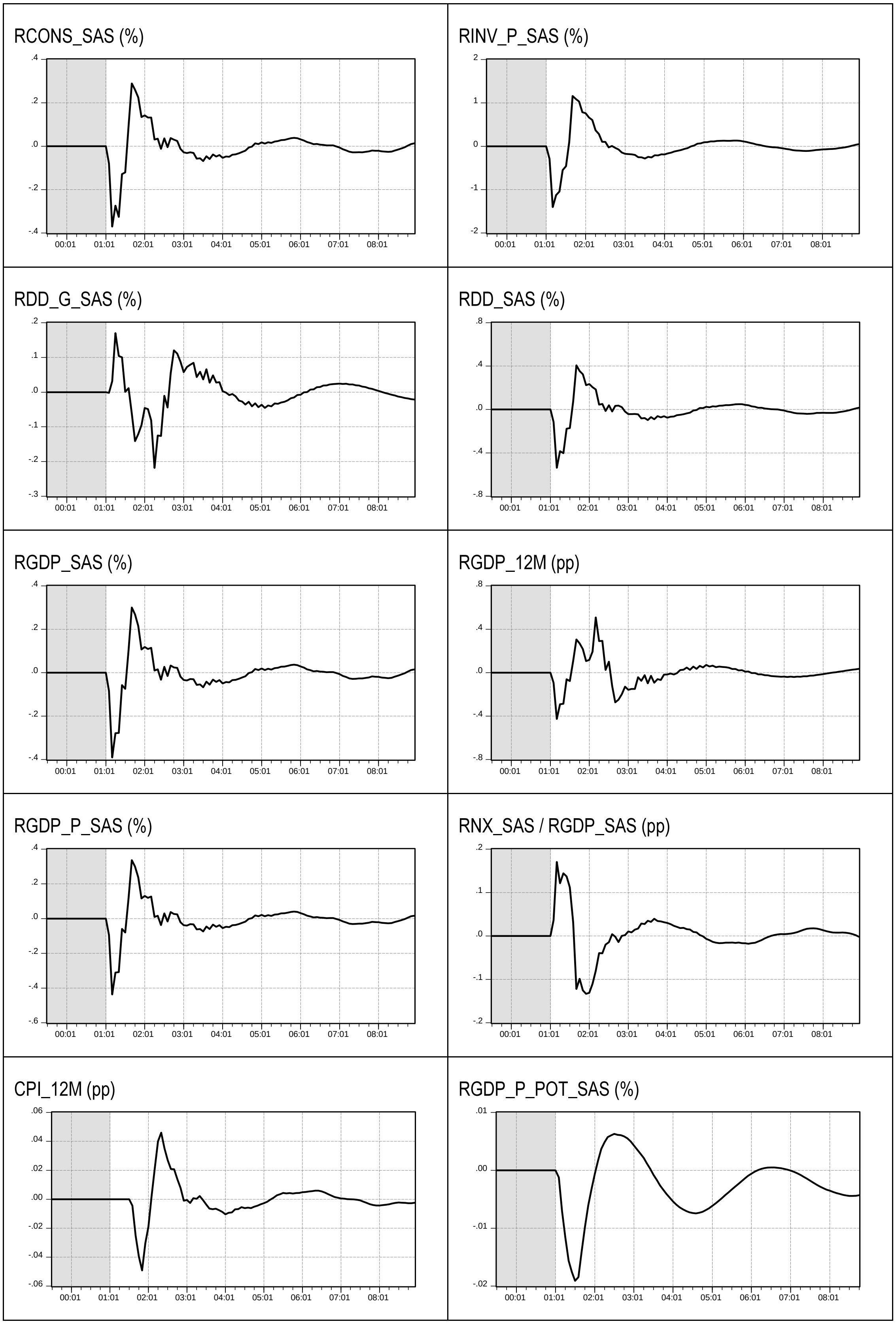

RL_AV (pp)
1.6
1.2
0.8
0.4
0.0
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RLOANS_P (%)
0
-1
-2
-3
-4
-5
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RCONS_SAS (%)
0.0
-0.5
-1.0
-1.5
-2.0
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RINV_P_SAS (%)
2
0
-2
-4
-6
-8
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RDD_G_SAS (%)
0.8
0.4
0.0
-0.4
-0.8
-1.2
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RDD_SAS (%)
1
0
-1
-2
-3
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RGDP_SAS (%)
0.4
0.0
-0.4
-0.8
-1.2
-1.6
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RGDP_12M (pp)
2
1
0
-1
-2
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RGDP_P_SAS (%)
0.5
0.0
-0.5
-1.0
-1.5
-2.0
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RNX_SAS / RGDP_SAS (pp)
1.2
0.8
0.4
0.0
-0.4
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01



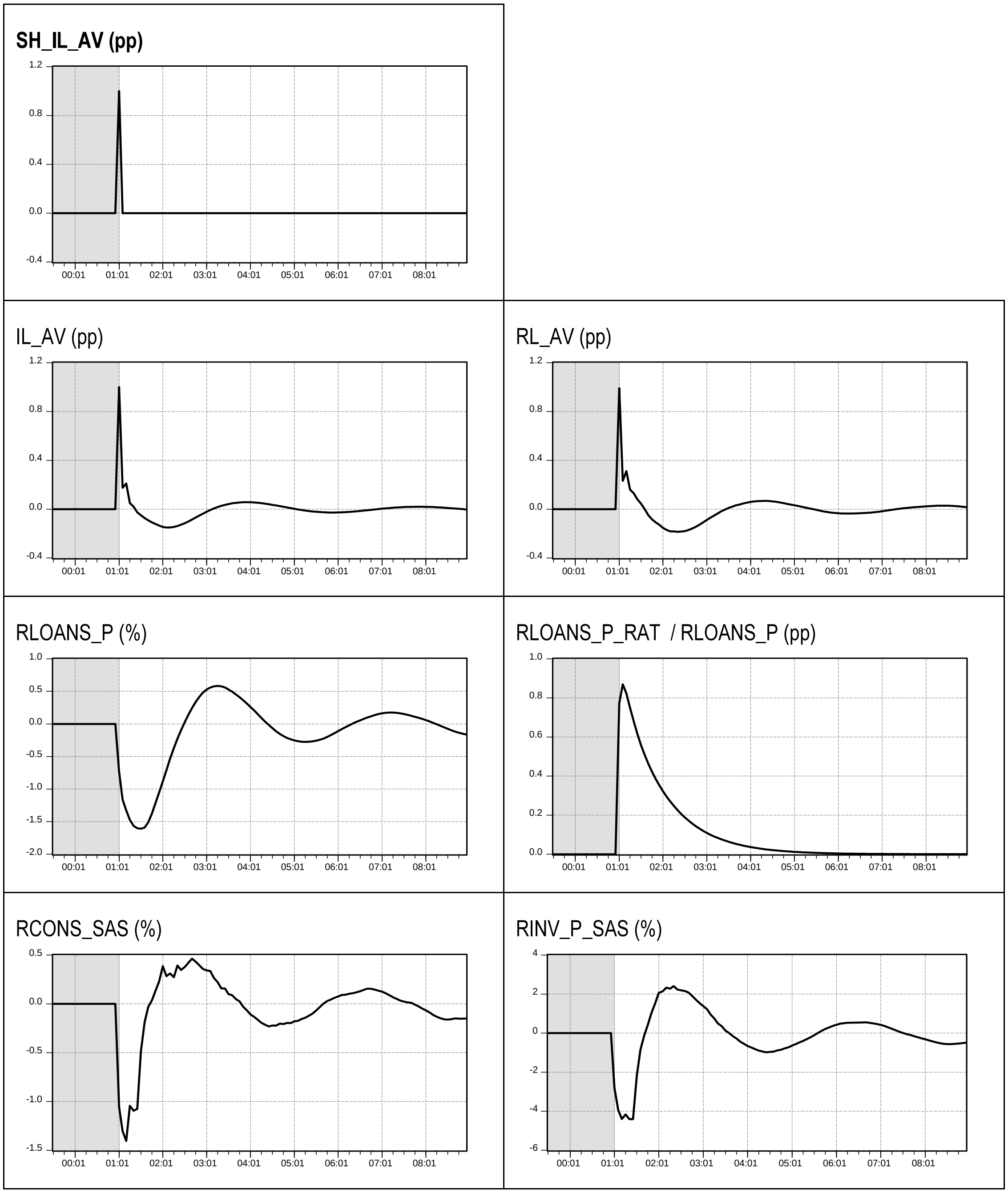
Appendix 5.2. Deviations from base-simulation (after 1 pp temporary increase in SH_EURIBOR_3M on 01:01)[22].



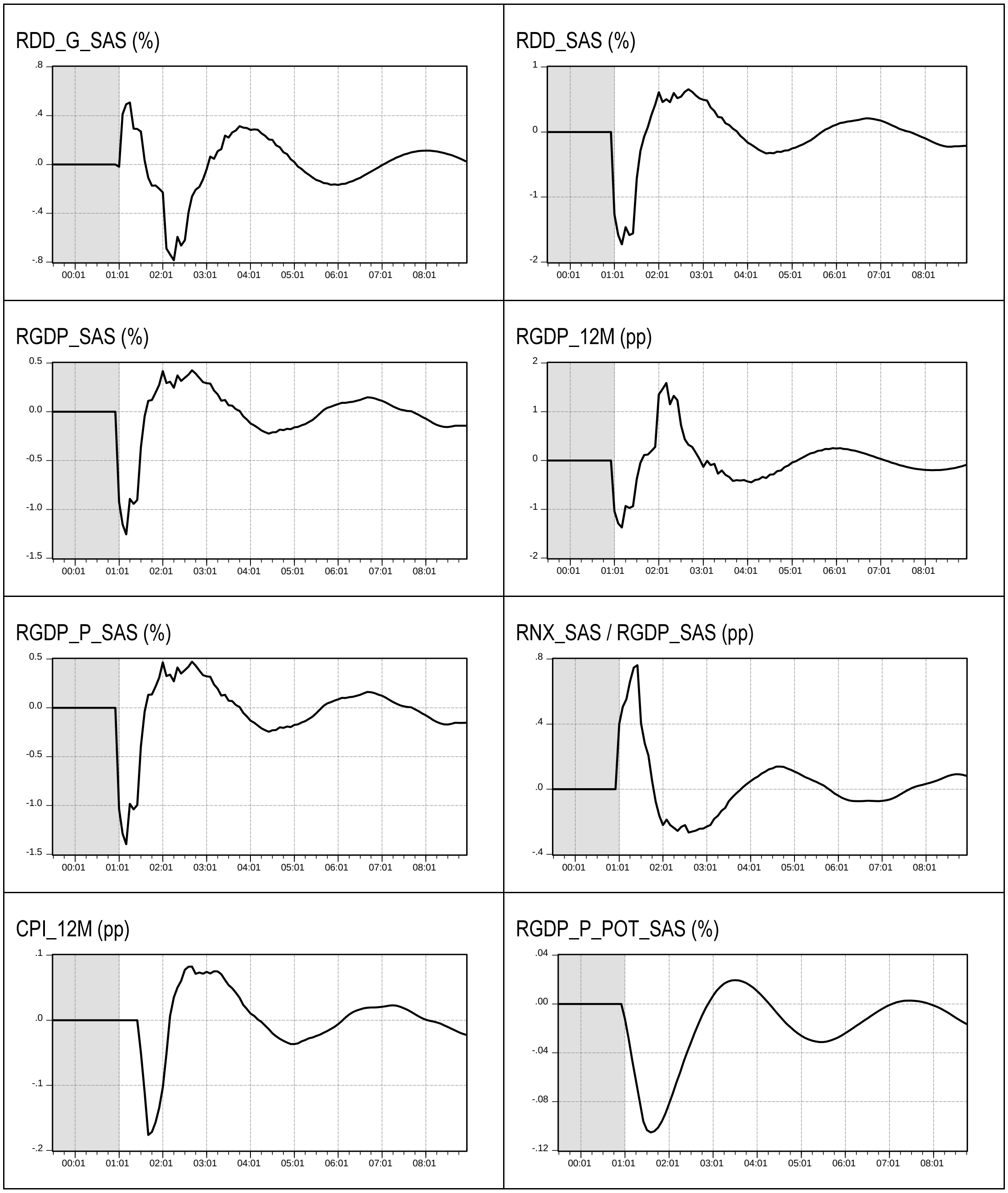
[22] Quantitative measure of the deviation is given in the brackets (percental difference from base simulation - % or percentage point difference from base simulation - pp).


RCONS_SAS (%)
.4
.2
.0
-.2
-.4
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RINV_P_SAS (%)
2
1
0
-1
-2
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RDD_G_SAS (%)
.2
.1
.0
-.1
-.2
-.3
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RDD_SAS (%)
.8
.4
.0
-.4
-.8
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RGDP_SAS (%)
.4
.2
.0
-.2
-.4
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RGDP_12M (pp)
.8
.4
.0
-.4
-.8
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RGDP_P_SAS (%)
.4
.2
.0
-.2
-.4
-.6
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RNX_SAS / RGDP_SAS (pp)
.2
.1
.0
-.1
-.2
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
CPI_12M (pp)
.06
.04
.02
.00
-.02
-.04
-.06
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RGDP_P_POT_SAS (%)
.01
.00
-.01
-.02
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01

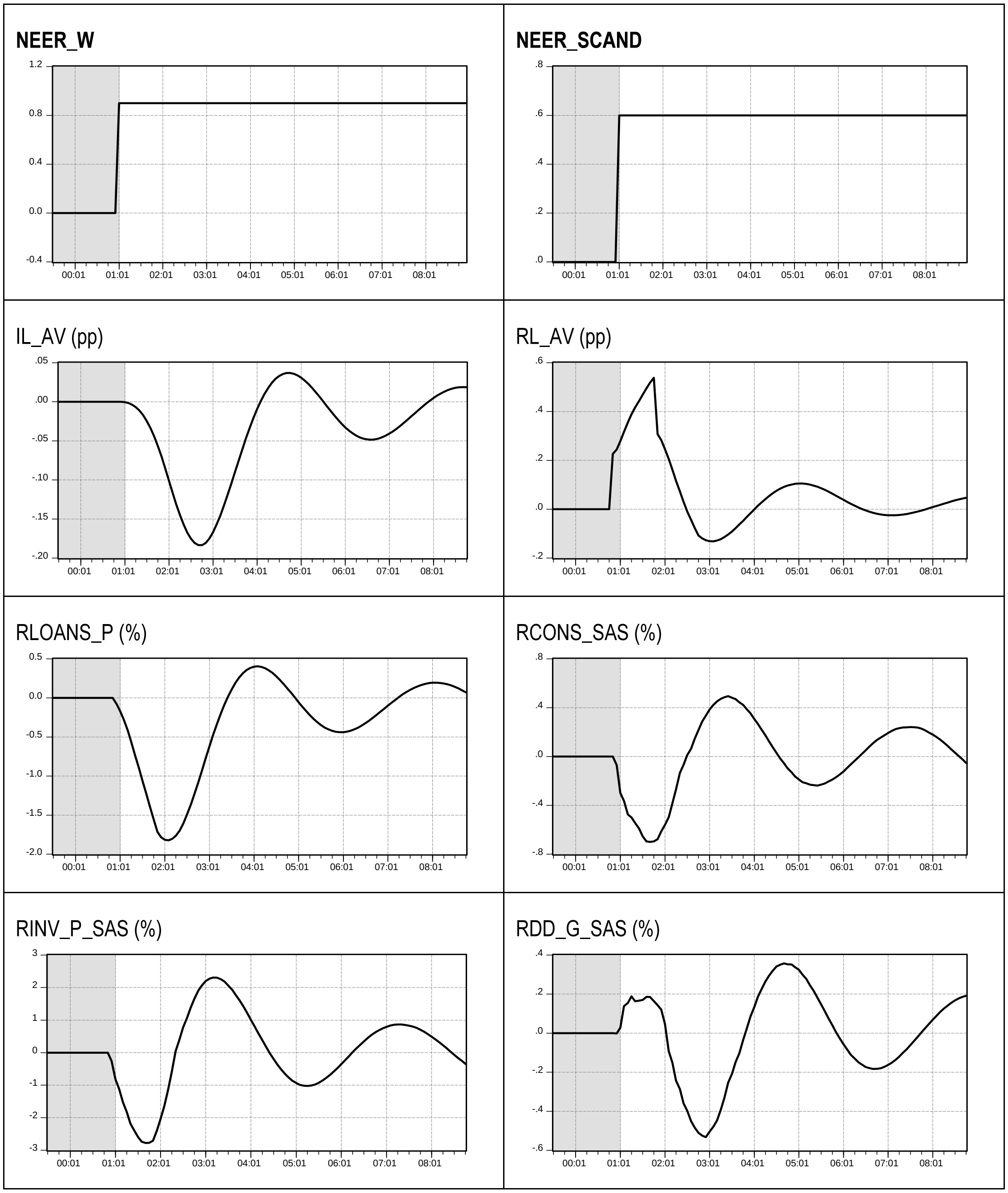
Appendix 5.3. Deviations from base-simulation (after 1 pp temporary increase in SH_IL_AV on 01:01)[23].



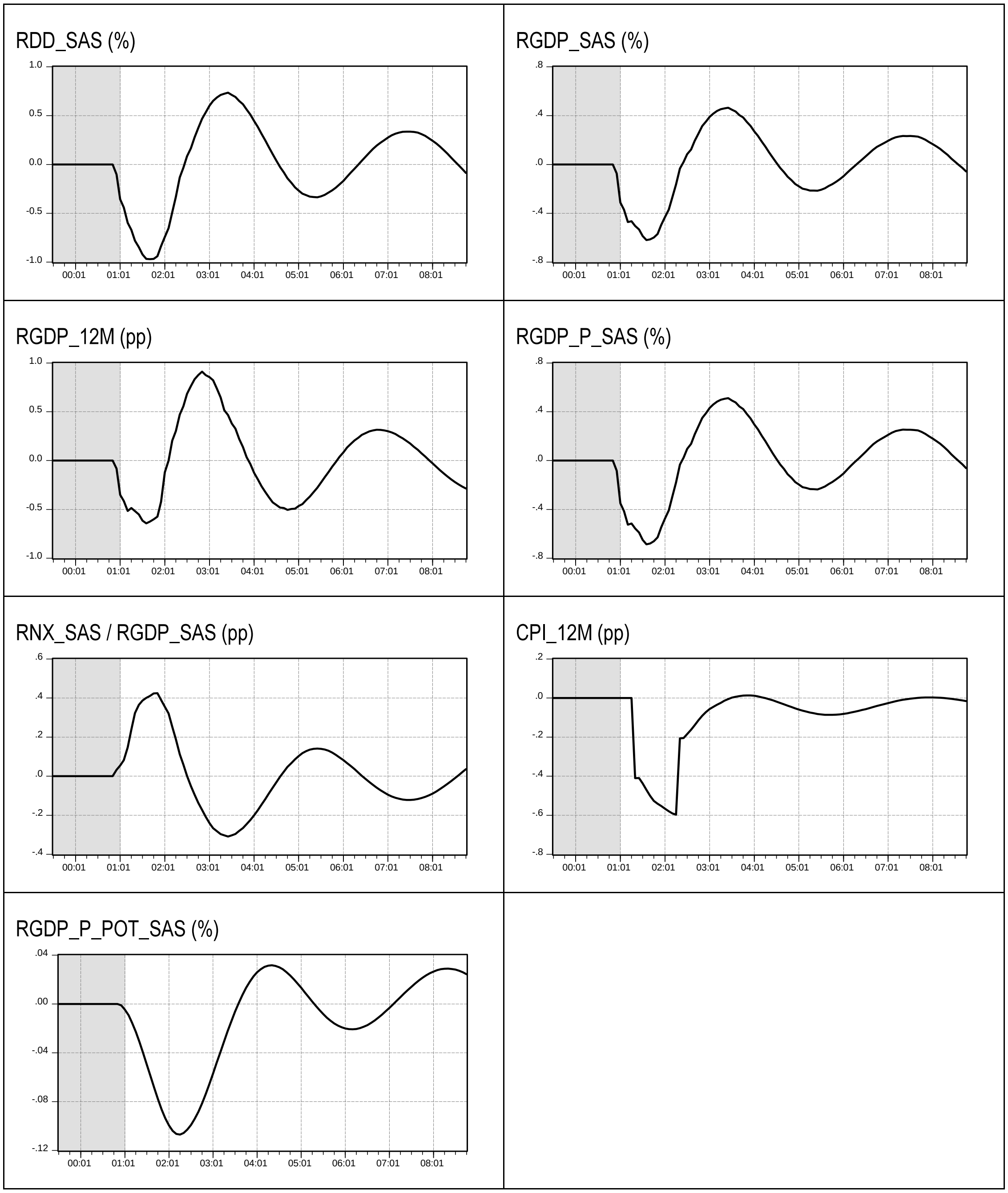
[23] Quantitative measure of the deviation is given in the brackets (percental difference from base simulation - % or percentage point difference from base simulation - pp).


RDD_G_SAS (%)
.8
.4
.0
-.4
-.8
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RDD_SAS (%)
1
0
-1
-2
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RGDP_SAS (%)
0.5
0.0
-0.5
-1.0
-1.5
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RGDP_12M (pp)
2
1
0
-1
-2
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RGDP_P_SAS (%)
0.5
0.0
-0.5
-1.0
-1.5
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RNX_SAS / RGDP_SAS (pp)
.8
.4
.0
-.4
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
CPI_12M (pp)
.1
.0
-.1
-.2
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RGDP_P_POT_SAS (%)
.04
.00
-.04
-.08
-.12
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01

Appendix 5.4. Deviations from base-simulation (after 1 % permanent increase in average NEER (equal to 0.6% increase in NEER_SCAND and 0.9% increase in NEER_W) on 01:01)[24].



[24] Quantitative measure of the deviation is given in the brackets (percental difference from base simulation - % or percentage point difference from base simulation - pp).


RDD_SAS (%)
1.0
0.5
0.0
-0.5
-1.0
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RGDP_SAS (%)
.8
.4
.0
-.4
-.8
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RGDP_12M (pp)
1.0
0.5
0.0
-0.5
-1.0
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RGDP_P_SAS (%)
.8
.4
.0
-.4
-.8
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RNX_SAS / RGDP_SAS (pp)
.6
.4
.2
.0
-.2
-.4
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
CPI_12M (pp)
.2
.0
-.2
-.4
-.6
-.8
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01
RGDP_P_POT_SAS (%)
.04
.00
-.04
-.08
-.12
00:01 01:01 02:01 03:01 04:01 05:01 06:01 07:01 08:01

Glossary

EMPIRICAL ESTIMATION

CPI_12M	12 month inflation (= CPI_BM/CPI_BM(-12)-1)
CPI_BM	domestic price level (base index)
CPI_BM_SCAND	Scandinavian price level (base index, weights from trade volumes)
CPI_BM_W	world price level (base index, using import weights)
ECB_REF	ECB rate on main refinancing operations (before January 1999 Deutsche Bundesbank's main refinancing operations rate was employed), also referred to as ECB official rate, as ECB policy rate of just as ECB rate.
EXP_INFL_AD6	adaptive inflation expectations for the period of 6 months from current observation
EXP_INFL_AVG6	average inflation expectations for the period of 6 months from current observation
EXP_INFL_FL6	forward looking inflation expectations for the period of 6 months from current observation
IL_AV	average domestic lending rate for loans provided to households and firms
LP	number of employed in the private sector
EURIBOR_3M	3months European inter bank money market offer rate (before January 1999, 3 months London inter bank money market DEM offer rate)
NEER_SCAND	nominal effective exchange rate against Scandinavian currencies (weights from trade volumes)
NEER_W	nominal effective exchange rate against world trade partners (on import weights)
RCONS	real private consumption expenditure
RDD	real domestic demand
RDD_G	real domestic government expenditure
REER_SCAND	real effective exchange rate against Scandinavian currencies (weights from trade volumes)
REER_W	real effective exchange rate against world trade partners (on import weights)
REGPI_BM	level of domestic administratively regulated prices
RGDP_G	real value added in public sector
RGDP_P	real value added in private sector
RGDP_P_GAP	output gap
RGDP_P_POT	real potential output
RGDP_SCAND	Scandinavian real GDP
RINV_P	real private fixed capital formation (including changes in inventories)
RK_P	derived stock of real fixed capital in private sector using quarterly amortization rate equal to 2% and initial fixed capital of 42bln EEK in 1995
RL_AV6	real *ex ante* average lending rate
RLOANS_P	real level of loans outstanding (provided to households and firms, excluding single-purpose loans, deflated with CPI_BM)
RLOANS_P_NR	real level of demanded credit without credit rationing effect
RLOANS_P_RAT	amount of rationed credit (deflated with CPI)
RNX	real net export of goods and services
TALSE	Stock index of Tallinn Stock Exchange

Self-generated time series

DMS_*nnxx*	fictive variable taking value 1 on year's *nn* month *xx*, otherwise equals to 0.
F_INDEBTEDNESS	fictive value reflecting average indebtedness of private sector = @MOVAV(RLAEN_J_ERA,12)/@MOVSUM(RSKP_P_SAS(-1),12)
F_OWNERSHIP	estimated trend in the share of banks' foreign ownership
F_SH_ASSETSP	domestic shock in form of fall in domestic equity prices = -(ABS(@PCH(TALSE(-1)))-@PCH(TALSE(-1)))/2
F_SH_IL_AV	unanticipated increases in domestic lending rate {negative side of residual from

	domestic interest rate equation, = (D(SH_IL_AV)+ABS(D(SH_IL_AV))/2)^(1/4)}

Used extensions

*x*_SA	seasonally adjusted series *x*
*x*_SAS	seasonally adjusted quarterly time series *x* that is interpolated to a monthly series and smoothed with three period (current, leading and lagging observation) moving average.
SH_*x*	residuals from estimated equations (*ex post*) or self-generated shocks (*ex ante*) for variable *x*.

Mathematical functions

ABS(*x*)	absolute value of *x*
@PCH(*x*,*n*)	Per cent change in *x* over *n* periods (in base points)
@MOVAV(*x*,*n*)	Moving average of *x* over last *n* observations
@MOSUM(*x*,*n*)	Moving sum of *x* over last *n* observations
@TREND	Simple time trend
x^*n*	*X* on power *n*
D(*x*,*n*)	n^{th} difference from time series *x* (if *n*=1, *n* does not have to be written down)
D3(*x*,*2*)	n^{th} difference over 3 period (if *n*=1, *n* does not have to be written down) for example, D3(x) = *x* – *x*(-3) and D3(*x*,*2*) = D3(*x*,*1*)- D3(*x*(-3),*1*)