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Abstract

Modeling work on Estonian data indicates that external financing of the private sector has strong impact on domestic demand, which implies that valuable insights may be gained in this case from understanding the behavioral relationships in the monetary sector. The current paper provides a theoretical analysis of the monetary sector under a currency board regime and applies specification tests to Estonian data. As a final product, empirical equations for average lending rate, loans provided to the private sector and money demand are estimated. While estimations herein use monthly data, quarterly modifications of the model will be inserted into Eesti Pank's quarterly macromodel in the future.

Keywords: currency board, economic modelling, bank lending, capital flows, Estonia

* All comments are welcome.

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1 Introduction

Over eight years ago, Estonia introduced its own currency, the kroon. It has conducted independent monetary policy ever since. At the time of the currency reform in 1992, Estonia had 42 commercial banks.[1] Today, bankruptcies and intense consolidation have winnowed the field to six banks and a branch office of a foreign bank. The two largest banks control over 80% of the market. This consolidation occurred in anticipation of major market expansion, and indeed, between 1993 and 1999, total deposits rose from EEK 2.5 billion to EEK 28 billion, while loans provided to the private sector rose from EEK 1.3 billion to EEK 27 billion. Nominal GDP, meanwhile, increased only 2.5 times, which reflects high growth rates in monetization of the economy and relaxation of liquidity constraints in the real sector of the economy.

The banking sector has likely played an important role in generating domestic demand by relaxing liquidity constraints faced by the private sector. This assumption finds support in demand-side models of the Estonian data. These models often reveal that the amount of loans provided to the private sector or domestic lending rates have a significant impact on variables reflecting domestic demand and propensities to import.[2]

The objective of the current paper, therefore, is to develop an econometric model of the Estonian monetary sector. In the future, the estimated model will be modified to be used in the aggregated quarterly macroeconometric model currently under construction by economists at Eesti Pank, Estonia’s central bank. Nevertheless, the objective of the current work is not merely to generate empirical estimates, but also to analyze developments in the monetary sector to get a reliable specification of the model. Thus, monthly data are used in the current analysis. Moreover, the current quarterly time series (23 observations from the beginning of 1994 until Q3 1999) is too short to provide meaningful empirical estimates. The samples from 1994 and early 1995 also fall into an unstable period when annual inflation exceeded 30% and output contracted.

Because Estonia uses a currency board arrangement (CBA) and therefore lacks independence in determining its monetary policy, foreign impacts deserve special discussion. Herein, two alternative specifications for foreign capital supply regimes will be tested.

Macroeconomists earlier found little reason to analyze factors determining bank credit demand (Fase 1995, Rother 1999), since they are mainly interested in overall economic activity. They devote effort to discerning how financial intermediation promotes growth, rather than how economic activity (or expectations) affect demand for external financing. Thus, it is difficult to find a widely accepted economic theory on which to base the current modeling exercise.

Fortunately, there are several *ad hoc* works analyzing the monetary sector and these provide great help in specifying equations for domestic loans market.

Olexa (1998) has estimated a monetary sub-model for the Slovak Republic using a structure of dependent variables quite similar to the one used in the current paper. Although he gives no theoretical foundation for his reasoning, he does estimate the nominal amount of bank credit provided to the private sector as a function of nominal GDP, the real interest rate on credit (deflated with current investment price deflator) and credit provided to government. The credit function is estimated as a function separate from interest rates and the money stock and assumes no simultaneity.

Catao (1997) specifies supply and demand equations for bank credit using Argentine data to determine whether demand or supply-side factors caused a contraction in domestic bank lending. His work is particularly relevant as it concerns the monetary sector under a currency board arrangement. He specifies the long-run supply equation as a function of lending capacity (defined as deposits – liquidity requirements – cash in vault + own capital + net foreign liabilities) and the average lending rate. In dynamic equations, supply is defined as a function of change in lending capacity, change in interest rate and change in the share of problematic loans in bank portfolios. The long-run demand of bank credit is estimated as a function of nominal GDP and the average lending rate. The change in demand is specified as a function of the expected change in nominal GDP, change in lending rate, and the level of structural unemployment. Both dynamic supply and demand equations were accompanied with error-correction terms derived from the long-run equations. The estimated functions reveal that the slow recovery in banking credit in Argentina was caused mainly by the behavior of the domestic non-banking sector, not supply-side restrictions.

The paper is structured as follows: First, we briefly discuss an orthodox currency board arrangement and contrast it with the system used in Estonia. The third section gives possible specifications of the monetary sector model's structure with speculation on possible changes in foreign debt capital supply regimes. Section 4 presents tests for accuracy of various specifications and an empirical estimation of the model. Section 5 concludes and offers some future perspectives.

2 Overview of an orthodox currency board arrangement and Estonia's monetary system

Before attempting an analysis of Estonia's monetary sector, we require a brief comparison of the differences between orthodox currency board systems and the Estonian system. An orthodox currency board arrangement (CBA) is an exchange rate arrangement whereby the monetary authority stands ready to exchange local currency for another (anchor) currency at a fixed exchange rate without quantitative limits. (Korhonen 1999). To be reliably ready to supply any amount of foreign currency on demand, orthodox currency boards call for a 100% backing of emitted domestic currency (or the total domestic liabilities of the domestic monetary authority) with foreign exchange reserves. 100% backing implies 100% technical or non-political credibility of the stated peg, since there is no possibility that the monetary authority will run out of reserves. Of course, if the monetary authority is not 100% politically independent or is concerned with issues other than foreign exchange operations at a stated exchange rate, the possibility that the peg will not hold arises[3] To avoid this risk, a politically independent monetary authority runs the CBA and is invested with the sole responsibility of carrying out demanded foreign exchange operations. Full backing of the domestic base money and full convertibility at a fixed exchange rate assures a totally endogenous base money supply. This basic specification of the monetary system under orthodox a CBA assures automatic sterilization of excess liquidity. Assuming a credible exchange rate peg, any changes in money demand (other things being equal) will be accompanied by changes in base money and by corresponding changes in foreign exchange reserves.

With the CBA and 100% backing, use of one of the most common monetary policy instruments is restricted to excess reserves, i.e. the amount of reserves exceeding the monetary base at the disposal of the monetary authority. Typically, this means the automatic lender-of-last-resort facility or discount window.

The currency board system in 1992 was introduced in conjunction with a new currency. The Estonian kroon (EEK) was pegged to the Deutsche Mark (DEM) at a rate of one mark to eight kroons. As a result, Eesti Pank's main monetary policy instrument is continuous and immediate participation in the spot foreign exchange market at the fixed exchange rate (Lättemäe and Randveer, forthcoming). To support smooth operation of the foreign exchange market, there are no restrictions on capital account transactions. This can be interpreted as an unlimited foreign exchange window where transactions of buying and selling foreign currencies against reserve currencies are initiated by commercial banks (Lepik 1999).[4]

Eesti Pank also uses several other monetary policy instruments, which is why its CBA is sometimes referred to as a "currency board-like" system. The most important monetary policy instrument here is the required reserves ratio.[5] A fixed exchange rate and reserve requirement impact the monetary sector indirectly through increased costs of financial intermediation.[6] Eesti Pank's other instruments include remunerated deposit facilities for commercial banks and auctions of certificates of deposits.[7] Eesti Pank also conducts banking supervision, bank licensing, acts as an interbank clearing and settlement center, and provides the organizational and legal framework for the interbank money market.

The CBA framework bars Eesti Pank from effective conduct of monetary policy to smooth shocks in the monetary sector. The central bank can help the Estonian banking sector by improving the legal framework and market mechanisms to better enable the banking sector to cope with large external and internal shocks.

3 Specification of the Estonian model's structure

In recent decades, economists have engaged in an active debate on the endogeneity of the money stock. Endogenous money theories vary widely with respect to the period of analysis, as well as with respect to factors determining the endogeneity of money, the degree of endogeneity, and the nature of direction of causality between economic activity, bank lending, price levels, and the money stock (Niggle 1991).

In Estonia's case, the fundamental cause of endogeneity in monetary sector aggregates is the currency board arrangement and its consequent lack of control over foreign capital flows. If we assume perfect information, then domestic interest rates under a credibly pegged exchange rate should converge with anchor currency rates. Interest rate convergence reflects higher integration of international financial markets where different financial assets become better substitutes and capital tends to seek out the highest possible risk-adjusted returns (Fase 1999, pp. 83-95).

Under a currency board arrangement, domestic interest rates should theoretically equal foreign interest rates plus domestic economy risk premium. If the domestic economy is small in relation to overseas economies and has low accumulated (foreign) debt, we can assume that the long-run risk premium for foreign credit will not depend on amounts lent and all reasonable amounts demanded will be offered at a rate equal to foreign interest rates plus a risk premium. That risk premium, in turn, is a function of domestic fundamental variables that reflect the risk of the domestic economy. Intuitively, this premium is likely to be fairly stable over the short run.

An alternative, and perhaps more elegant, way to explain formation of domestic interest rates applies the concept of uncovered interest rate parity, equalizing risk-adjusted expected returns across countries. Here the difference between domestic and international nominal interest rates equals foreign interest rates plus expected devaluation plus risk premium. This risk premium, in turn, can be divided into two parts: (1) the premium covering exchange rate risks, and (2) the country-specific risk premium covering risks from possible lack of liquidity in the system, term structure and default risk (Fase 1999, pp. 83-95).

It is reasonable to assume that over the long run the above descriptions hold and that foreign capital is elastic. However, historical data are also likely to show that the above descriptions do not hold over a shorter period of time and that in the short run the foreign capital supply can sometimes be non-elastic. Now consider the Estonian case. Estonia is tiny country and any amounts borrowed from international financial institutions most likely constitute a tiny share of a large lender's total loan portfolio. In the event of financial turmoil in emerging markets, international institutions may find it more expedient and cheaper to simply freeze lending to small countries, rather than bother to analyze possible linkages between turmoil elsewhere in the world and the local economy. This effect may be amplified by the fact regions are often grouped together rather that consider by individual states. Moreover, some foreign institutions may forego analysis altogether and simply copy the actions of others with good records.

Figure 1 indicates periods of non-elastic foreign capital supply. It should be mentioned here, however, that after the banking sector consolidation and the radical change in ownership of domestic banks during summer 1998, credible interbank money market rates were scarce.[8] After consolidation, the country's two largest banks controlled around 80% of the domestic banking sector and the new owner structure assured credible credit channels outside the domestic interbank money market. This is easily notable in the decline in overnight interbank lending amounts to nearly zero after summer 1998. An obvious indicator of the interbank money market is the Tallinn Interbank Offer Rate (TALIBOR), but it has problems similar to overnight money market and the time series are limited.[9] Moreover, TALIBOR rates are not the average price of money actually lent, but the market average of quotations on what banks on the market are obliged to supply to others on the market. From Figure 1 it can be seen that the sharp increase in overnight money market rates in 1997 coincided with a rise in the TALIBOR. This gives us some confidence to assume that movements in overnight interest rates over the period with low turnover may be accurate, as these movements are consistent with TALIBOR movements.

Nevertheless, it remains tricky to specify from that figure exactly when the supply of foreign capital was restricted. Some additional figures may help this decision. Figure 2 presents a plot of the difference between the average domestic lending rate (IL_AV) and the 3-month London Interbank Deutsche Mark Offer Rate (LIBOR_DEM_3M). The trend should present a possible proxy for developments in total domestic risk premia (including country risk, banking sector risk and entrepreneur's risk). There is an observable clear decline in the long run as compared to the temporary upward pressures between the end of 1997 and beginning of 1999. As the overall long-run decline becomes more pronounced, the exact period of temporary upward pressure is harder to detect.

Figure 1. Key market rates and turnover on overnight interbank money market.

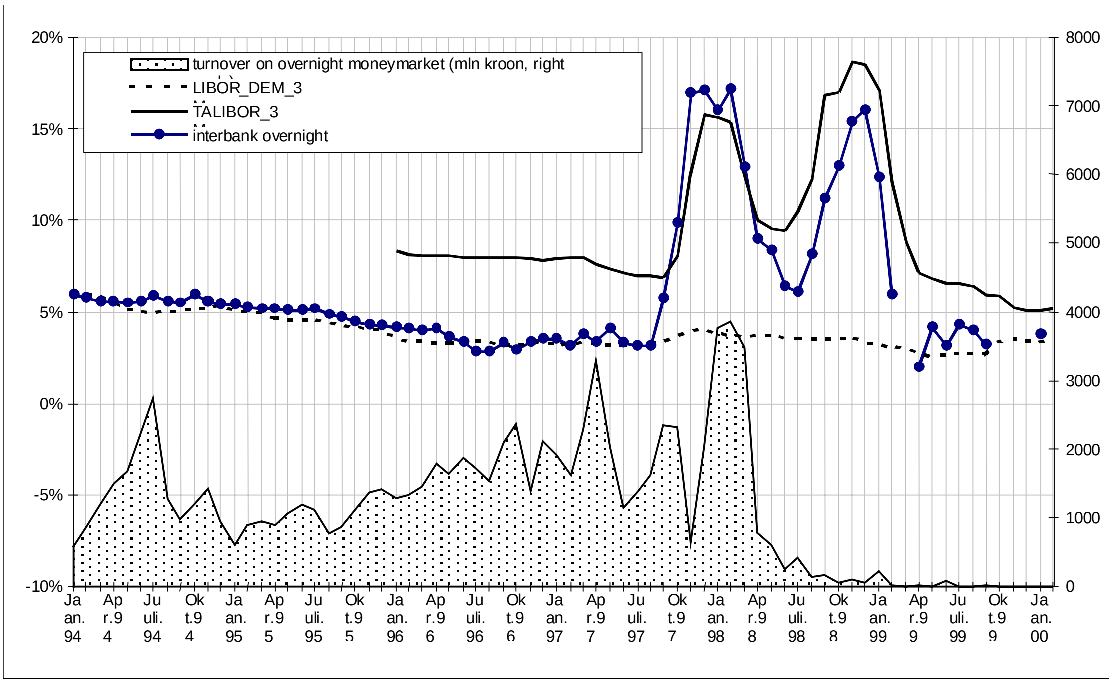


Figure 3 presents the difference between average domestic deposit rate (ID_AV) and LIBOR_DEM_3M. This difference should reflect the additional price commercial banks are ready to pay to attract domestic deposits. A sharp increase in this difference, therefore, should reflect higher competition for domestic deposits, which in turn should indicate restrictions on foreign capital supply. Competition for domestic deposits can increase deposit rates to abnormally high levels only in situations involving problems with external financing (otherwise, banks will resort to cheaper sources abroad).[10] The long-run decline is easily notable here, but the increase in domestic interest rates at the end of 1997 is even more distinct. Figure 2 broadly supports Figure 1 findings using overnight and interbank 3-month offer rates.

These figures present the period between September 1997 and April 1999 when domestic financial institutions found it hard to attract foreign capital in the amounts demanded. During this period, domestic interest rates were driven not only by foreign interest rates and reasonable risk premium, but also by adjustments in the supply and demand of domestic bank credit. Precise determination here is problematic. For example, a broad determination may include periods when constrained foreign capital supply had upward pressure while low bank credit demand placed a downward pressure on interest rates. The sum effect would then be close to zero.

Figure 2. Difference between lending rate and 3-month DEM LIBOR.

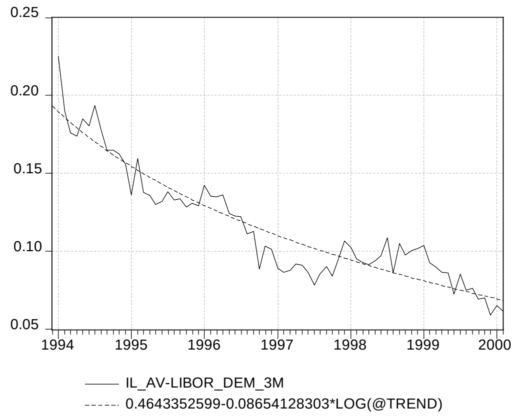
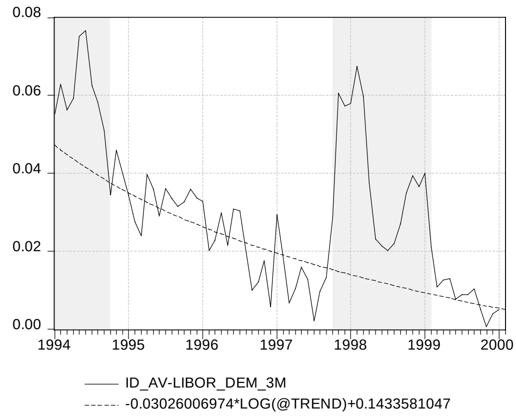
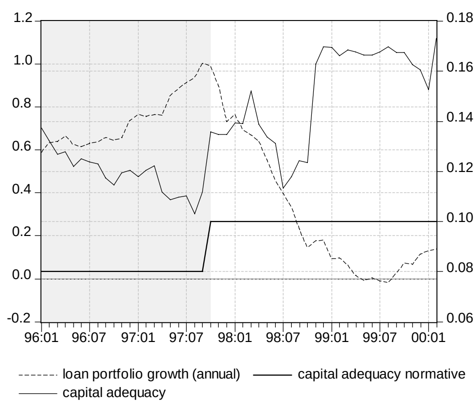


Figure 3. Difference between deposit rate and 3-month DEM LIBOR



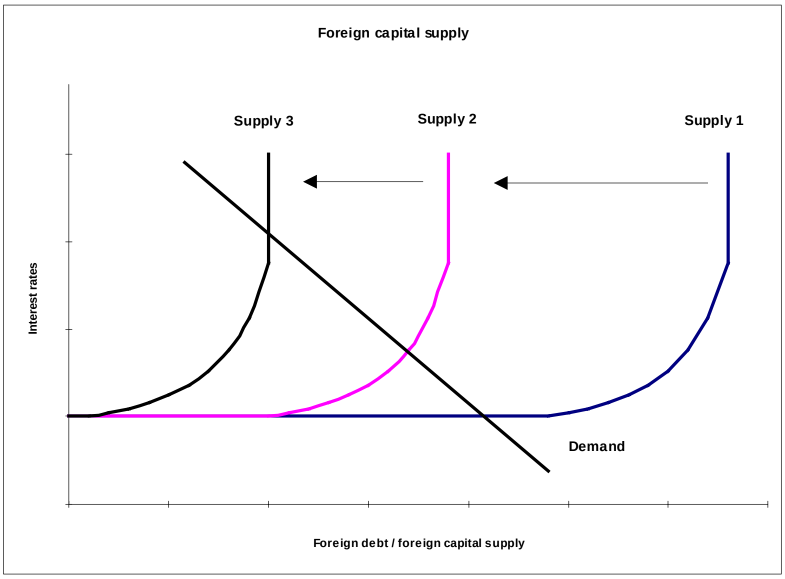
The figures may also reflect domestic constraints on foreign capital flows. For example, it is reasonable that commercial banks might find it relatively more time-consuming and costly to expand equity than to attract (foreign) debt flows. If this assumption holds, then banks may find it hard to expand foreign liabilities in line with increase in credit demand because of the required capital adequacy ratio. Figure 4, however, shows that even during the period of fastest loan portfolio growth (growth rates reaching 100% per year!) commercial banks found ways to expand equity almost in the line with the loans outstanding. The banking sector's average capital adequacy consistently stood more than 2 percentage points above the required level.

Figure 4. Capital adequacy and loan portfolio growth rates.



According to analysis of changes in the nature of foreign capital supply, the model must be specified for two periods, the first covering the theoretically more convenient long-run condition with perfectly elastic foreign capital supply and the second for periods with restrictions on foreign debt capital supply. There may also exist a third, intermediate period, where foreign debt capital supply is not zero and when the price asked depends positively on the amounts lent. It seems more likely, however, that entrance to the environment with a constrained foreign capital supply is faster and sharper than movement back to elastic supply. These possible movements of curves of foreign debt capital supply related to entrance or exit from crisis situations are presented in Figure 5.

Figure 5. Supply of foreign debt capital during normal and restricted periods.



Before further specification, it is important to point out that, if, in the long run, there is no intuitive difference between the supply of foreign debt capital and loan supply from the domestic banking sector, then a difference arises with constrained foreign capital supply. Let's consider a "normal" situation, wherein all amounts of credit demanded by the non-banking sector will be supplied by commercial banks or directly from abroad at interest rates determined by anchor currency interest rates and risk premia. In this situation, the banking sector will have no problem financing lending by foreign debt flows. Competition, moreover, will assure proper domestic interest rates for private sector.

In the case of shocks, the supply of foreign debt capital can be seriously constrained so the supply of new foreign loans to domestic financial intermediaries can get close to zero. In these situations, the supply of foreign debt capital (essentially zero) and bank credit supply are two clearly distinguishable functions. Here, the traditional model of a small open economy is inappropriate. An information problem may violate the assumption of free and effective capital movements.

In the event of shocks (assuming no changes in bank credit demand), banks will find themselves in a situation where they are involved in intermediation of a good that is under-represented in the economy. Here the usual market forces kick into action so the amount of loans with corresponding interest rates will be derived by the supply and demand function. The supply of bank credit will not be necessarily freeze, however, as banks can optimize their asset structures to earn extra profit. Here, different monetary transmission channels will be more pronounced (especially "credit channels")[11] as most are related to problems with information. Indeed, the information problem becomes more critical as interest rates increase.

Without specifying the exact form and content of supply and demand equations, long-run (or normal situation) relationships may be specified as follows:[12]

(1.1) $i = i(\ldots, i^*, r, i^r, \underline{F}, \ldots)$

(1.2) $L^S = L^D = L^D(\ldots, i, \ldots, Y, \ldots)$

(1.3) $M^D = M^D(\ldots, i, \pi, \ldots, Y, \ldots)$

Under this specification domestic interest rates do not depend on demand variables and bank credit demand interest rates are given exogenously.

For the periods with restricted supply of foreign capital, interest rates belong to the same system with supply and demand equations as the adoption variable. The system can be specified as follows:

(2.1) $L^S = L^S(\ldots, i, \ldots)$

(2.2) $L^D = L^D(\ldots, i, \ldots, Y, \ldots)$

(2.3) $L^S = L^D$

(2.4) $M^D = M^D(\ldots, i, \pi, \ldots, Y, \ldots)$

For explicit specification of the system, the motivation underlying supply and demand of different monetary aggregates needs explaining.

Demand for bank credit

Demand for bank credit is the outcome of several economic indicators and estimated future developments. Most are related to expected future developments in profits and cash flows. For example, if an increased demand for a firm's production is expected, additional investments will be needed. One way to finance investment, obviously, is bank credit. Also, according to simple life cycle models for households, if estimates about future incomes change, the optimal consumption path will change and the need to consume during the current period will change as well. To increase consumption today in correspondence to expected future incomes, external financing is needed.

It is generally difficult to find good time series about expected developments in incomes or turnovers, so the current economic situation must be used as possible indicator of attitudes on future developments. Available indicators that reflect the current economic situation, macroeconomic stability and certainty are GDP, inflation, unemployment, and the proportion of troubled loans (a higher proportion reflects current problems in the economy or an overestimation of growth prospects in the past).[13]

Long-run demand for real bank credit will be specified as a function of real GDP (scale variable), real lending rate (*ir*) (or separately nominal lending rate (*i*) and inflation (π) or inflation expectation (π^e))[14] and the open vector of variables reflecting confidence and certainty $\underline{\sigma}$.

$$L^D = L^D(i, \pi, RGDP, \underline{\sigma})$$

In the short run, the demand for bank credit should depend broadly on the same variables. Additionally, a certain amount of asymmetry of processes may also be introduced. The appropriate way to introduce short-run asymmetry is through economic activity when we wish to estimate stock of loans outstanding (as opposed to new loans provided), because loans are usually non-recallable in the short run. During a period of rapid economic growth, demand for stock of loans outstanding will increase faster than it is possible to reduce the stock of loans outstanding during an economic recession.

There are also additional restrictions on borrowing by households. As we live in a world with asymmetric information, private agents are likely to have better information about their future prospects than commercial banks. To cope with this problem, clients must provide additional information. If the client is a private person, the information used to determine creditworthiness is typically current wage income. This does not mean that wage income is the sole supply-side factor (actually, it is also a demand-side factor, because repayment of a loan starts usually shortly after borrowing and needs extra funds from personal budget).

Supply of bank lending

In "normal" cases, bank credit supply is assumed to be totally elastic meaning that all amounts demanded by non-banking sector at a given price will be supplied. This relationship relies on assumption of totally passive banking sector what can attract foreign debt capital in all reasonable amounts at given interest rates and risk premia.

During the periods of constrained foreign capital supply, however, banks cannot afford to be totally passive, because they must supply a good that is in high demand. In these cases, the limited amount of available credit (or purchasing power) in the economy allows banks to raise their lending rates and earn extra profit. Another motivation for banking sector activity during these periods is the fact that during financial distress other problems with the economy are likely to emerge. For example, asset prices may collapse over uncertainty about the future or clients may have problems with loan repayment. To avoid or minimize losses from loans related to projects with increased uncertainty, banks must temporarily alter their normal lending behavior.

Under situations of restricted supply of foreign debt capital, the supply of bank credit can be specified as function of interest rates (i) and (constrained or fixed) resources for lending activity (LR). Additional information about the quality loan portfolios $\underline{\phi}$ can be used as well.

$$L^S = L^S\left(i, LR, \underline{\phi}\right)$$

Specification of the variable reflecting resources for lending activity during a foreign debt capital supply shock is quite crucial. If we assume that money demand depends positively on deposit rates, then money supply (which is fully determined by demand for money under a CBA) should be included into the simultaneous system of equations. It will have a role in determining the equilibrium interest rate during shock periods as it is a component of lending resources (LR). There are several arguments against this in the Estonian case and they will be introduced in the next section.

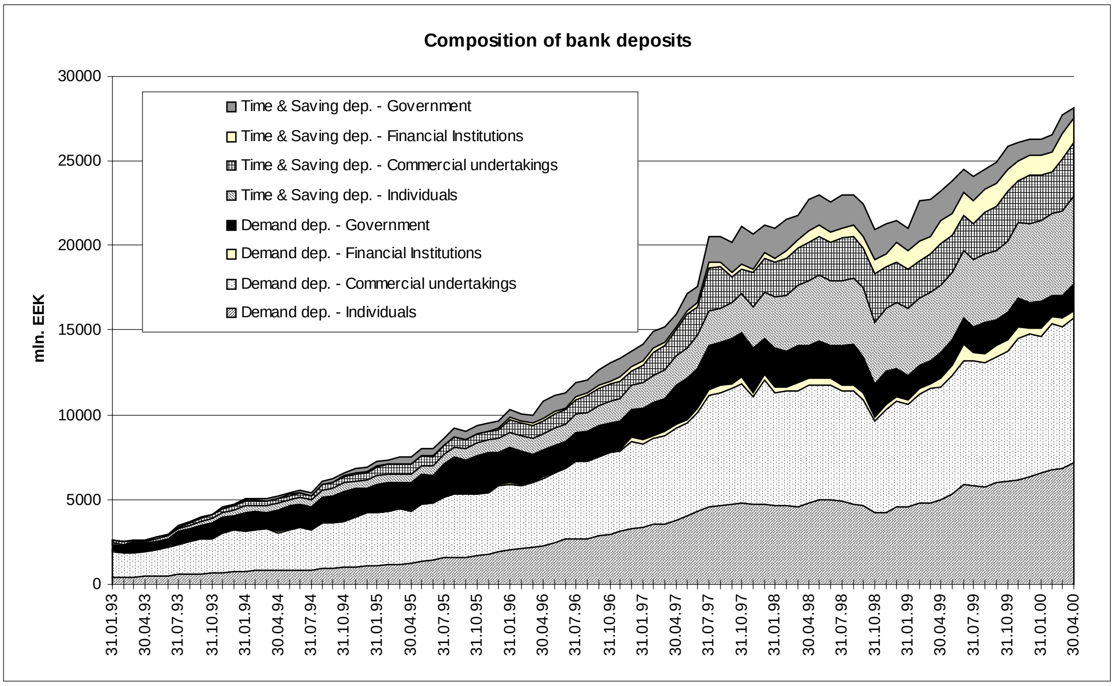
In any case, if we assume that money has to be included into this system, then the only dynamics in LR during shock periods will come from money supply. In the meantime, however, this dynamic will depend on interest rates, which, in turn, depend on the bank credit supply function. Here, changes in the money supply during a shock period can originate from the current account (as we still have free trade) or from investments from capital account (as we assume constraints on the supply of foreign debt capital only).

Money demand

As mentioned, the functional form of money demand is crucial in specification of the full system. Works dealing with money demand usually assume that economic agents can choose between at least two types of liquid assets.[15] One, of course, is money and the second is usually securities. The underlying idea is that if the return from money gets too low (or holding of money gets too costly), it may be profitable to change money savings to securities or just decrease average money holdings to buy securities. This specification needs to fulfill two conditions. First, there must exist alternative assets that are highly liquid, but carry low risk, e.g. government bonds. Second, the transaction cost of switching assets must be low. In the Estonian case, there are no close substitutes for money. The closest asset alternative to money is perhaps equity,[16] but even so, equity carries higher risk in exchange for a potentially higher average expected return. In this sense, equity is not a very close substitute for money.

A lack of close substitutes for money may cause a situation where aggregate money demand ceases to depend on interest rates, because there are no alternative ways to accumulate wealth other than time or savings deposits. A change in interest rates may result shifts between money aggregates (demand, time and savings deposits) or micro-level changes between banks as a result of competition, but not necessarily shifts between money and other assets. The composition of domestic bank deposits is presented in Figure 6. Note that the importance of time deposits grows constantly. In the beginning of 1993 M1[17] made up close to 90% of M2.[18] At end-1999, M1 was less than 60% of M2 (see also Appendix III).

Figure 6. Composition of bank deposits by client groups and type of deposit.



According to the above, there are many different processes going on simultaneously behind formation of aggregate money demand. It follows that demand for money can be divided roughly into two (quantitatively undistinguishable) parts. The first is the standard demand for money as demand for means of exchange and carrier of purchasing power. The second motivation is demand for money as an asset allowing accumulation of wealth.[19] If processes from the first motivation are theoretically easy to model, modeling the second motivation is far harder, since the quantities of money demanded by different motivations are inseparable and there is no accurate data on the total wealth of Estonian households.

Using the most popular approach to estimation of money demand, demand for real money balance is specified as a function of income variable RGDP (as scale variable) and the vector of variables $\underline{\gamma}$, which reflect the opportunity cost of holding money rather than other assets. The interest rate *i* or real rate of interest *ir* can be included if money demand M1 and demand for broader aggregates are modeled separately.

$$M^D = M^D\left(RGDP, i, \underline{\gamma}\right)$$

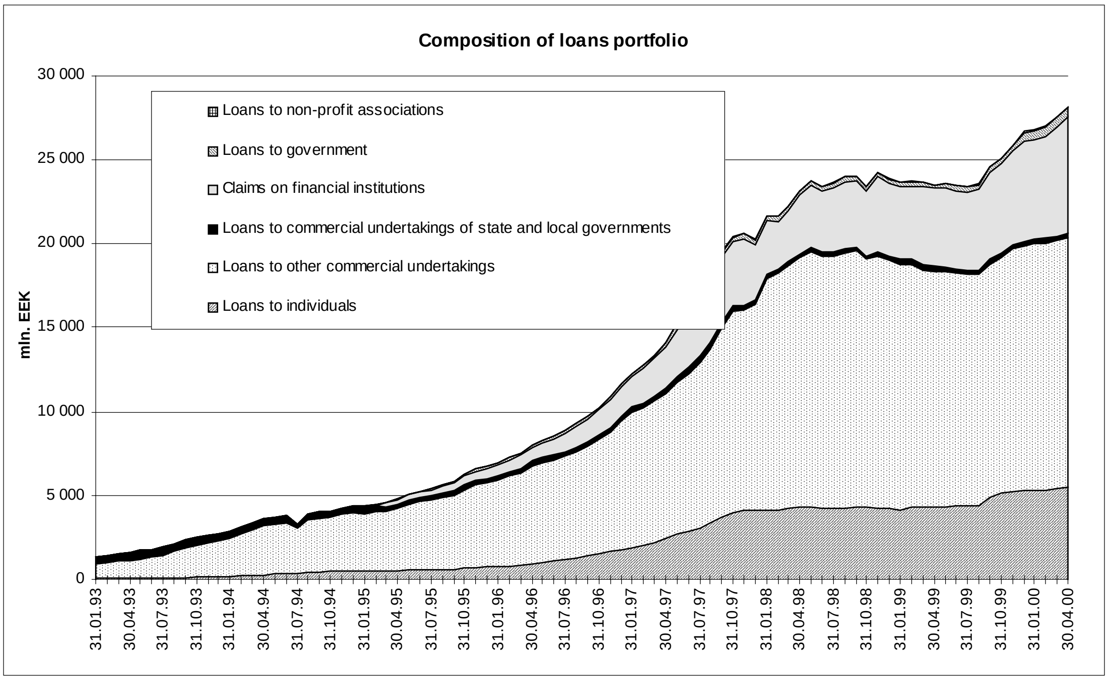
Similarly to bank lending, in short run some asymmetry or non-linearity can be tested.

4 Empirical estimation

Background

Selection or more precise specification of dependent variables is straightforward. First, there are only three main groups of lenders: (1) commercial undertakings, (2) individuals and (3) financial institutions (Figure 7). Financial institutions include most loans provided to leasing companies, because such companies are often owned by commercial banks. Here, such loans are excluded from the empirical analysis. While one may well argue that financial institutions should be included because this money will ultimately be lent to the real economy, the legal forms of leasing companies change. Moreover, the balance sheet data of these companies do not explain their financing, so the use of amounts lent to financial institutions in estimations can easily lead to inconsistency in data over time. Changes in financing, for example, might include replacement of direct borrowing from commercial banks with guarantees provided by the same banks. A second serious question has to do with commercial undertakings owned by the local or central government. It is reasonable to believe that many of these loans are backed by state guarantees, so again they may bias our estimation. At the same time, most of these enterprises have now been privatized and changes on commercial banks' balance sheets can occur without any real changes in lending activity. Thus, these loans should be added to the analysis.

Figure 7. Composition of commercial bank's loan portfolio by client groups.



The next decision involves whether to use the amount of new loans provided or the stock of loans outstanding. The first may cause problems due to possible refinancing of old loans with new loans with better conditions. Rolling over old loans without corresponding cash flows can easily occur on the account of new loans. Further, the report form for commercial banks concerning new loans has changed. Prior to 1997, the forms failed to distinguish among commercial undertakings, financial institutions and the government. Balance sheet reports are available without serious modifications from the beginning of 1993, but here the problem is that loan provisions are subtracted from the stock of loans outstanding. This balance sheet area is notorious for "creative accounting." Our decision to use stock of loans outstanding rather than new loans provided stems from our goal of estimating long-term relationships. It is reasonable to believe that there exists some kind of long-term relationship between stock of loans outstanding and economic activity rather than between much more volatile amounts of new loans and economic activity. The last reason for using stock of loans outstanding is the pragmatic fact that the macroeconometric model covering the real sector of Estonian economy uses input stock of loans outstanding. Thus, estimation of new loans provided calls for some additional equations connecting the model of monetary sector with the real economy.

For interest rates, the average lending rate reflecting same client group as defined above is used. Money demand is calculated as the sum of cash circulating in the economy plus all deposits in commercial banks (with no restrictions on residency of the holder or denomination of a currency deposit). Only amounts deposited by other commercial banks are excluded from the empirical estimations.

Before proceeding with the empirical estimation, a few questions are appropriate. First, are the two regimes/periods proposed in the last section merely a convenient fiction? It may be, after all, that an observed increase in interest rates arises because of corresponding changes in fundamental variables and not restrictions on foreign debt capital supply.

To test which model specification holds on empirical data, first causality between credit provided to private sector and resources of commercial banks[20] was tested using the Granger causality test.[21] As commercial banks can most likely adjust their assets and liabilities rapidly, tests were performed on data with monthly and 10-day frequencies.[22] The test results were similar regardless of frequency, rejecting the zero hypothesis of growth in commercial bank resources being not caused by changes in bank lending (test with residuals from corresponding VARs are reported in Appendix I). A stability test of estimated VAR parameters was also performed. The results showed that parameters of the function with bank resources on the left side were far more stable over time than the parameters of the function with loans on the left side (at both monthly and 10-day frequencies). In the estimated function explaining changes in lending resources, there was a temporary shock to the parameters at the end of 1997. Eventually, the parameters return to their original path. Both of these analyses reject the hypothesis that there have been long-lasting (over two months) restrictions on the supply of foreign debt capital and show that causality has consistently run from loans to bank resources. The assumption of possible long-lasting (over a year) restrictions on the supply foreign debt capital was brought up by analysis of domestic interest rates in section dealing with monetary sector under a CBA. We have already noted that shocks are clearly reflected in domestic money market rates, but changes and possible causes of changes in lending rates are not so clear.

The next test determines error correction from equations for lending rate using two time samples. The first (regression *a*) was estimated for the period from 1995m3 to 1999m8. The second (regression *b*) excludes all observations between 1997m9 to 1999m3 (suspect for shock). The interest rate equation was specified as function of base interest rate (London Interbank 3-month Deutsche Mark Offer Rate), inflation, and real economic growth[23] (actually a proxy estimated from real export) as fundamental variables.[24] Residuals from these two regressions are plotted in Figure 8 with correlograms in Figures 9 and 10. One can see that the regression excluding possible shock period underestimates interest rates during the period excluded from the estimates. Nevertheless, this difference is relatively small, so one might argue that time period left out from regression *b* is the only period of serious economic recession during the sample and estimations excluding period of recession will not average asymmetry effect over movements to the both sides. This argument is supported by the beautifully distributed residual from regression *a*, which shows no signs of shocks lasting longer than the shaded time period. Also there are no signs of positive autocorrelation that might indicate a systematic error in the *ex post* simulations.

Figure 8. Ex-post simulation errors from lending rate equation.

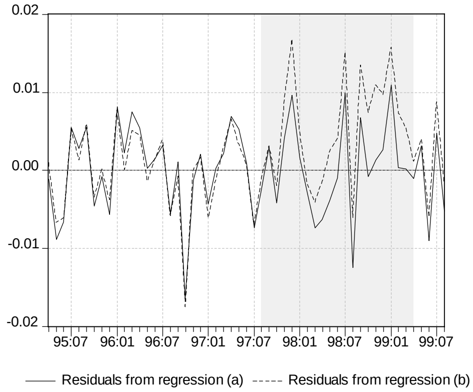


Figure 9. Correlogram of residual from regression (a).

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. | .	. | .	1	-0.025	-0.025	0.0369	0.848
. |*.	. |*.	2	0.151	0.151	1.3705	0.504
.*| .	.*| .	3	-0.187	-0.184	3.4346	0.329
.*| .	.*| .	4	-0.131	-0.166	4.4755	0.345
**| .	.*| .	5	-0.225	-0.188	7.5943	0.180
. | .	. | .	6	0.019	0.020	7.6178	0.267
.*| .	.*| .	7	-0.106	-0.108	8.3348	0.304
. | .	.*| .	8	0.039	-0.078	8.4339	0.392
.*| .	.*| .	9	-0.103	-0.156	9.1478	0.424
. |*.	. | .	10	0.109	0.031	9.9601	0.444

Figure 10. Correlogram of residual from regression (b).

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
. |*.	. |*.	1	0.104	0.104	0.6203	0.431
. |**	. |**	2	0.232	0.224	3.7536	0.153
.*| .	.*| .	3	-0.077	-0.127	4.1092	0.250
. | .	. | .	4	-0.012	-0.048	4.1174	0.390
.*| .	. | .	5	-0.083	-0.032	4.5442	0.474
. |*.	. |*.	6	0.118	0.145	5.4182	0.491
. | .	. | .	7	0.010	0.008	5.4251	0.608
. |*.	. | .	8	0.105	0.030	6.1436	0.631
. | .	. | .	9	-0.003	-0.006	6.1440	0.725
. |*.	. |*.	10	0.148	0.138	7.6428	0.664

Estimation results

In the current empirical estimations, the assumption of no long-lasting shock periods is employed (and specification of the system of simultaneous equations abandoned). This decision is supported by the tests mentioned above and a concession to the lack of good data on country-risk premia. Estonia had no low-risk assets on the market and statistics about price paid for foreign debt capital by commercial banks offers little insight as the banking sector has been in constant upheaval. There was also no data to specify the foreign debt capital supply function. Finally, the two regime/period model requires enormous amounts of empirical work to specify functions and proper time periods for shock periods.

It is also unclear whether the mistake of using an assumption of two sharply changing absolutely different regimes (one with horizontal and other with vertical foreign debt capital supply curve) is smaller than from an assumption of only one regime with horizontal supply curve.[25]

For all empirical estimates, error correction specification is used and estimations are carried out using Engle-Granger two-stage procedure as suggested by Enders (1995 pp. 373-384). Tests for unit roots were carried out on all data. In most cases, time series were found to be I(1). Indeed, the only problematic series was the consumer price index CPI_BM, which was found to be I(2). Unit root test may arguably suffer from low reliability, so the results of unit root tests are not presented. The relevant time series are plotted in Appendix II along with other time series giving background information about developments in Estonia.

To avoid possible problems with simultaneity between monetary sector variables and GDP, a two-stage least squares (TSLS) procedure is used (again, export is used as the instrumental variable). In some reported estimates, GDP is explicitly replaced with GDP estimates (in reports with suffix P_TSLS). In some simple equations, the TSLS report generated by Eviews software is directly presented.

For lending rate, two equations are estimated. The first ignores changes in costs faced by commercial banks coming from Eesti Pank monetary policy exercises with reserve requirement and remuneration rate (specification 1). The second estimates directly the total risk premium (including country risk, banking sector risk and lender risk) against the average lending rate and London Interbank Offer Rate (specification 2). From that difference, the directly derived cost coming from reserve requirement is subtracted.[26] There is the slightly problematic assumption that costs faced from reserve requirements equal to London Interbank Offer Rate. Here it seems reasonable that such money is probably lent at slightly higher rates. Also there are few dynamics from monetary policy exercises as there are only two changes in variable $i^r r$ as reserve requirement and remuneration rates both changed only once (see Appendix II. *Evolution of Eesti Pank monetary policy operational framework*), which makes the outcomes from both estimation approaches quite similar.

In both cases, the lending rate is specified as a function of the 3-month London Interbank Deutsche Mark Offer Rate (LIBOR_DEM_3M), inflation (CPI_12M), and real economic growth (RGDP_12M). LIBOR_DEM_3M presents international (base) interest rate and inflation with economic growth represents fundamental variables affecting risk premia asked. Problems with simultaneity also led to exclusion of the current account balance (TSB/GDP). The current account balance may have an impact on risk premia asked by foreign debt capital suppliers, but lower interest rates will have a direct negative impact on the current account balance. Preliminary tests indicated no clear relationship between domestic interest rates and the current account balance.

Estimation results with most primary statistics are presented in the Appendix IV, parts 1 and 2. Also included are plotted residuals from dynamic regression, ex-post simulation and responses to changes in explanatory variables.[27] As indicated by high values in the error-correction term in dynamic equations, the long-run levels after exogenous shocks are attained within a few periods. The long-run influences (depending on equation specification) are as follows:

	LIBOR_DEM_3M	CPI_12M	RGDP_12M	R	IR_REM
specification 1	1.951	0.152	-0.122	0.000	0.000
specification 2	1.932	0.157	-0.130	0.050	-0.149

Foreign interest rates exert a surprisingly powerful influence. There is a huge amplification of foreign shock transmission to the domestic monetary sector. As various risk premia (country-risk, banking sector risk and entrepreneur risk) are estimated here together, the amplification seems to be supported by certain monetary transmission channels (e.g. credit channel).

The high foreign interest rate parameter may be caused by misspecification of the model. This misspecification is likely the result of missing explanatory variables. The regression between IL_AV and LIBOR_DEM_3M may also be spurious. On the other hand, the LIBOR_DEM_3M parameter is significant both in static and dynamic equations with very similar parameters (1.95 and 2.13 respectively). Moreover, the classic indicator of missing explanatory variables, positive autocorrelation, is not present in the equations.

For estimation of bank credit, the long-run relationship between the stock of loans outstanding and GDP is estimated using TSLS. In the dynamic part, the change in stock of loans outstanding is estimated as a function of the real interest rate (nominal rate deflated by expected inflation in six months,[28] the share of loans overdue in the economy (as a share of GDP), fictive variable covering January 1998, and an error correction term derived from the long-run relationship (see Appendix III part 3).

Some explanatory variables in the equation are given as levels (GDP) and some as percentages (IL_AV), so responses to shocks in explanatory variables are derived in two parts. First, changes in explanatory/exogenous variables are measured in percentage points, and second, exogenous shocks are measured in percentage differences from base values. The outcome from this shock analysis appears in Appendix 3.5.

The estimated equations and shock analysis show that that a 1% increase in nominal GDP causes a 2.4% increase in credit demand. This is higher than one might expect. Very probably a number of other processes besides income and turnover effect are a work behind that high elasticity. For example, higher GDP may mean a more stable environment, higher confidence and more optimistic expectations about the future. Financial deepening and initial conditions of low bank credit and low monetization may also explain the high elasticity.

If all the adjustments took place rapidly in the interest rate equations, then adjustments in bank lending are quite slow. The equilibrium values took more than a year-and-a-half to reach after the shock.

For real money balance, the long-run relationship with real GDP and a three-period moving average (current, leading and lagging) inflation was estimated (see Appendix III, part 4). Income elasticity was also higher than expected (2.02). The reasons for high elasticity may be similar those given with regards to bank credit, but one additional reason should be added. In Estonia, substitutes for money are hard to find. Thus, money itself is used as an accumulator of wealth and this raises the income elasticity of money demand.

Asymmetry is also introduced in the dynamic equation. As money seems to be relatively inflexible, different reactions to increases and to decreases in income can be expected. To test short-run asymmetry in money, demand coming from income, changes in GDP were divided between two time series. The first covers increases in logs of GDP and is labeled as LRGDP_UP. The second reflects decreases and is labeled as LRGDP_DOWN. According to reported results, the increase in real GDP is followed with 1.96% increase in money demand immediately. Decrease in real GDP will be reflected in demand for real money balance only through a long-run relationship with slow adjustment (error correction term's parameter -0.2). The same is seen in simulated responses to shocks. The figures in the appendix show that a 1% increase in real GDP is followed almost immediately by a 2% increase in money. Adjustments to a decrease in real GDP, on the other hand, take over a year.

Some non-homogeneity coming from prices is also introduced. According to the estimated empirical model, rapid changes in prices will not be realized at once and adjustments will be carried out slower than price changes through an error correction mechanism balancing real money demand. This is presented as price level difference on the right hand side of the dynamic equation.

Prices enter the money demand equation in three ways: through deflator of nominal money, through opportunity cost in the form of inflation, and through variable adjustments in real money demand in terms of non-homogeneity. Thus, the adjustment process of nominal money demand to changes in prices is quite complicated. According to simulated responses, a 1% increase in prices will be followed by 0.6% increased in money during the same time period. As a result of increased inflation (opportunity cost), money demand decreases slightly during the following year. The nominal money demand slowly regains equilibrium after two years.

5 Concluding remarks

Two alternative hypotheses about relationships in the monetary sector can be proposed. First, we can assume a close-to-perfect world and a currency board arrangement with reliable peg. Prices in the monetary sector are set according to production costs and amounts by demand at given prices. The alternative hypothesis is that close-to-perfect conditions apply most of time, but there are also periods of serious disturbances in the supply of foreign capital. As we are unable to distinguish the extent to which changes in commercial banks liabilities are restricted by the supply of foreign capital and by changes in demand, these alternative hypotheses are difficult to test. Thus, a visual inspection of domestic interest rates was made and two tests were performed. Figures showed that at the end of 1997, following the crisis on the Tallinn stock exchange, some domestic interest rates increased sharply (overnight and deposit rates) while for some rates shocks were less pronounced (e.g. lending rates). As a more quantitative test, the causality between bank credit to private sector and resources of commercial banks was also tested. Tests were carried out on data with one-month and 10-day frequencies. Both test results suggested that it is more likely that causality runs from bank credit to bank resources rather than the reverse. For the second test, an equation for lending rate was estimated and behavior of residuals was inspected over the possible shock period and tested for signs of positive autocorrelation. Positive autocorrelation would indicate that during shock periods certain important explanatory variables are missing. Moreover, the missing part is very likely related to constraints on supply. It turned out that residuals behaved over the suspected shock period rather well and all changes in lending rate could be explained with base rate and fundamentals (reflecting part of risk premia).

According to the test results, a model for the Estonian monetary sector was developed and estimated from the demand side only. Behavioral equations were estimated for domestic lending rates, loans provided to private sector and money demand. The lending rate was estimated dependent on the foreign base rate and fundamentals reflecting domestic risk premium with no impact from demand variables making specification consistent with assumed infinite foreign capital supply function. For empirical estimations, specification of error correction model was employed. Estimation results were complemented with *ex post* forecasts and figures presenting responses from changes in explanatory variables over time.

The current monthly model found surprisingly high income (GDP used here as proxy for income) elasticities of money demand and bank credit. Also impacts coming from international interest rates were larger than expected. The high income elasticity may be explained by other processes that accompany the increase in GDP. These hidden processes can be increased confidence, optimistic expectations about the future, higher accumulated wealth, quite possibly financial deepening etc. At the same time, model users must beware of the possibility that these elasticities may decline in the future.

Looking ahead, we plan to modify this model of the monetary sector to fit quarterly data. It will be inserted into Eesti Pank's quarterly aggregated macromodel of the Estonian economy. This macromodel is used for forecast exercises (currently bank credit is determined as exogenous variable) and hopefully will be modified soon to suit simulation exercises as well. Additionally, equations for money multiplier will be used in estimating changes in reserves.

Glossary

Theoretical model specifications

δ	cost margin related to lending activity
π	opportunity cost
f	banking sector's cash (liquidity) preference ratio
$\underline{F}$	vector of fundamental variables
i	domestic interest rate
i^*	foreign interest rate
i^r	required reserve's remunerator
ir	real interest rate
L	lending
LR	commercial banks resources
M	money stock
P	price level
r	required reserve requirement ratio
Y	output, GDP
$\underline{\phi}$	vector of variables reflecting information about loan portfolio quality
$\underline{\gamma}$	vector of variables reflecting opportunity cost from holding money
$\underline{\sigma}$	vector of variables reflecting confidence and certainty

Empirical estimations

CPI_12M	12-month inflation [*CPI_12M = CPI_BM/CPI_BM(-12)*-1]
CPI_12MF(6)	12-month inflation expectations for 6 month
CPI_BM	price level, base index
GDP	gross domestic product
GDPP_TSLS	estimated proxy for GDP using export
ID_AV	average deposit rate
IL_AV	average lending rate
IR_REM	required reserve's remunerator
LIBOR_DEM_3M	from 3-month London Interbank Deutsche Mark Offer Rate
LOANS_PR	amount of banking loans provided to private sector
M2	money stock M2
OVERDUE	amount of loans with repayment arrears
R	reserve requirement ratio
REG_U	registered unemployment
RGDP	gross domestic product on real values
RGDP_12M	12-month growth rate for real GDP [*RGDP_12M = RGDP_BM/RGDP_BM(-12)*-1]
RGDP_12MP_TSLS	estimated proxy for RGDP 12 month growth rates using real exports
RGDPP_TSLS	estimated proxy for RGDP using real exports
RM2	real money stock M2 (*RM2 = M2/CPI_BM*)
U	unemployment (according to ILO standards)

Mathematical functions

LOG(x)	natural logarithm of variable *x*
D(x)	first difference of variable *x*
DLOG(x)	first difference from natural logarithm of variable *x*
@MOVAV(x,n)	*n* period moving average of variable *x*

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Appendix I. Evolution of Eesti Pank monetary policy operational framework [1]

Table 45 Evolution of Eesti Pank monetary policy operational framework

	1995	**1996**	**1997**	**1998**
1. "Forex window"	Exchange rate spread of DEM-EEK (purchase and sale) transactions between credit institutions and Eesti Pank (1 DEM = 7,999 / 8,001 EEK). *Since 23 May 1994.*	No exchange rate spread of DEM-EEK (purchase and sale) transactions between credit institutions and Eesti Pank (1 DEM = 8 EEK). *Since 1 July 1996.*	No exchange rate spread of DEM-EEK (purchase and sale) transactions between credit institutions and Eesti Pank (1 DEM = 8 EEK).	No exchange rate spread of DEM-EEK (purchase and sale) transactions between credit institutions and Eesti Pank (1 DEM = 8 EEK). *Since 1999 no exchange rate spread of EEK and euro as well as EEK and national currencies of common currency countries purchase and sale transaction.*
2. Reserve requirement				
1) reserve requirement base	a) Liabilities to customers *Since monetary reform.*	a) Liabilities to customersa; b) debt securities issued by banks. *Since 1 July 1996.*	a) Liabilities to customers; b) debt securities issued by banks; c) net liabilities to foreign credit institutions. Since 1 July 1997.	a) Liabilities to customers; b) debt securities issued by banks; c) net liabilities to foreign credit institutions; d) financial quarantees to financial institutions and non-resident credit institutions. *Since 1 September 1998*(3).
2) monthly minimum reserve requirement	10% of the reserve requirement base. *Since 1 January 1993.*	10% of the reserve requirement base.	10% of the reserve requirement base.	10% of the reserve requirement base.
3) cash component in monthly minimum reserve requirement	50% *Since 7 July 1994.*	40% *Since 1 July 1996.*	30% *Since 1 July 1997.*	20% *Since 19 June 1998.*
4) averaging	Non-averaged *Since monetary reform.*	Averaged on monthly basis. *Since 1 July 1996.*	Averaged on monthly basis.	Averaged on monthly basis.
5) daily minimum reserve requirement	Same as monthly minimum reserve requirement (see 2.2) *Since 1 January 1993.*	2% of the reserve requirement base. *Since 1 July 1996*	4% of the reserve requirement base. *Since 1 November 1997*	4% of the reserve requirement base.

1 Eesti Pank 1999b, p. 50

Table 45 (continued)

6) penalty interest rate for non-compliance with the reserve requirement (annual interest rate)	15% / 25%[1] *Since 30 December 1993.*	15% *Since 1 July 1996.*	20% *Since 1 November 1997.*	20%
3. Additional liquidity requirement *Since 1 November 1997.*				
1) additional liquidity requirement	–	–	3% of the reserve requirement base[2].	3% of the reserve requirement base.
2) penalty for non-compliance with additional liquidity requirement	–	–	Higher reserve requirement or other sanctions.	Higher reserve requirement or other sanctions.
3) remuneration for compliance with additional liquidity requirement	–	–	Deutsche Bundesbank's discount rate. *Since 1 November 1997.*	Deutsche Bundesbank's discount rate. *Since 1 November 1997.* European Central Bank's deposit interest rate. *Since 1 January 1999.*
4. Interest paid on excess reserves[4] [5] *Since 1 July 1996.*	0% *Since monetary reform.*	Deutsche Bundesbank's discount rate minus 1%. *Since 1 July 1996.*	Deutsche Bundesbank's discount rate. *Since 1 November 1997.*	Deutsche Bundesbank's discount rate. *Since 1 November 1997.* European Central Bank's deposit interest rate. *Since 1 January 1999.*

[1] *Penalty rate is 15% (0,042% daily) if the use of bank's balances with Eesti Pank does not exceed 15% of the required level; and 25% (0,069% daily) if the use of bank's balances with Eesti Pank reaches 15-30% of the required level. The use of bank's balances with Eesti Pank more than 30% of the required level is not allowed.*
[2] *Since 1 November 1997 – 2%, from 1 December 1997 – 3% of reserve requirement base.*
[3] *Since 1 August 1998 the reserve requirement base was calculated by 50%, since 1 September by 100%.*
[4] *Standing deposit facility allows banks to deposit funds with EP and by this earn interest on the free balance of the settlement account. This free balance is the monthly average of the settlement account with EP which exceeds monthly minimum and additional liquidity requirement level.*
[5] *As of 1 July 1999 Eesti Pank pays interest (equal to Deutsche Bundesbank's discount rate) on all credit institutions deposits held with the central bank* (Eesti Pank 1999c pg. 40)

Appendix II. Results from Granger Causality Test and VAR regressions

Causality test using monthly data

Pairwise Granger Causality Tests

Sample: Jan. 1995 to Apr. 2000

Lags: 3

Null Hypothesis:	Obs	F-Statistic	Probability
DLOG(RESOURCES) does not Granger Cause DLOG(LOANS_PR+ASSETS_01_RES)	62	0.87679	0.45881
DLOG(LOANS_PR+ASSETS_01_RES) does not Granger Cause DLOG(RESOURCES)		5.65263	0.00189

Causality test Using 10 day data

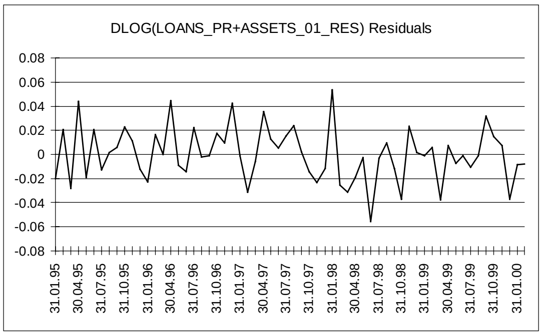
Pairwise Granger Causality Tests

Sample: 10 Jan. 1995 to 30 Apr. 2000

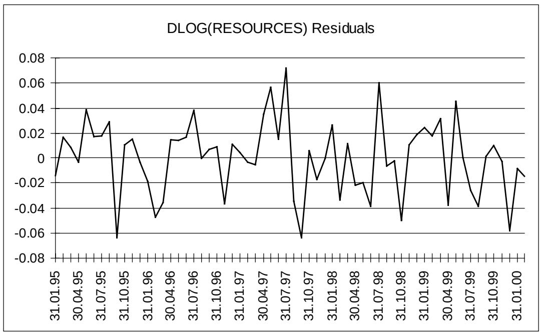
Lags: 9

Null Hypothesis:	Obs	F-Statistic	Probability
DLOG(RESOURCES) does not Granger Cause DLOG(LOANS_PR+ASSETS_01_RES)	192	1.65831	0.10247
DLOG(LOANS_PR+ASSETS_01_RES) does not Granger Cause DLOG(RESOURCES)		2.22086	0.02282

Residuals from corresponding VAR(3)

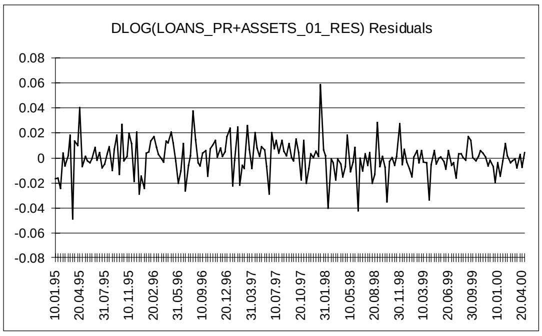


Auto-correlation	Partial Correlation		AC	PAC	Q-Stat	Prob
.*| .	.*| .	1	-0.092	-0.092	0.5511	0.458
. | .	. | .	2	-0.044	-0.053	0.6772	0.713
.*| .	.*| .	3	-0.111	-0.121	1.5000	0.682
. |*.	. |*.	4	0.166	0.145	3.3913	0.495
. | .	. | .	5	0.031	0.050	3.4583	0.630
. | .	. |*.	6	0.056	0.070	3.6768	0.720
. | .	. | .	7	0.010	0.062	3.6837	0.815
. |*.	. |*.	8	0.112	0.116	4.6077	0.799
. |*.	. |*.	9	0.101	0.136	5.3735	0.801
. | .	. | .	10	0.007	0.035	5.3770	0.865

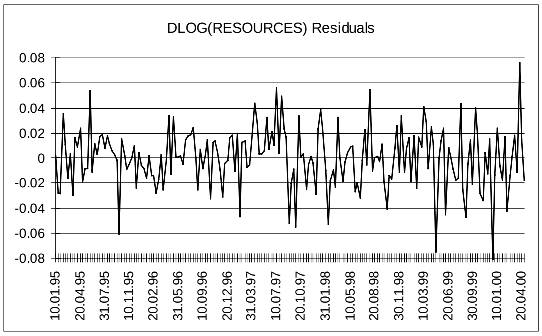


Auto-correlation	Partial Correlation		AC	PAC	Q-Stat	Prob
. | .	. | .	1	0.024	0.024	0.0360	0.850
. | .	. | .	2	-0.006	-0.006	0.0380	0.981
.*| .	.*| .	3	-0.083	-0.083	0.5050	0.918
.*| .	.*| .	4	-0.126	-0.123	1.5956	0.810
. | .	. | .	5	-0.038	-0.035	1.6940	0.890
. |*.	. |*.	6	0.107	0.102	2.4995	0.869
**| .	**| .	7	-0.232	-0.264	6.3803	0.496
. | .	. | .	8	0.057	0.054	6.6195	0.578
.*| .	.*| .	9	-0.086	-0.093	7.1737	0.619
. | .	. | .	10	0.031	0.025	7.2478	0.702

Residuals from corresponding VAR(9)

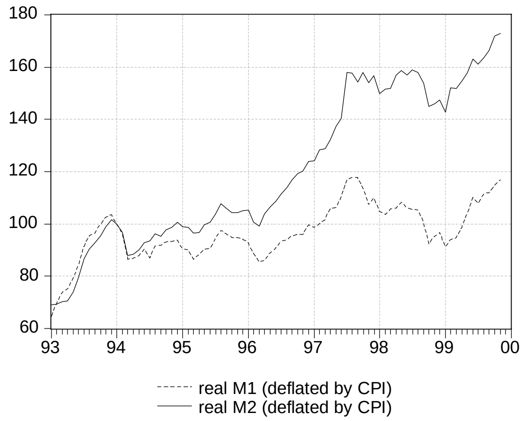


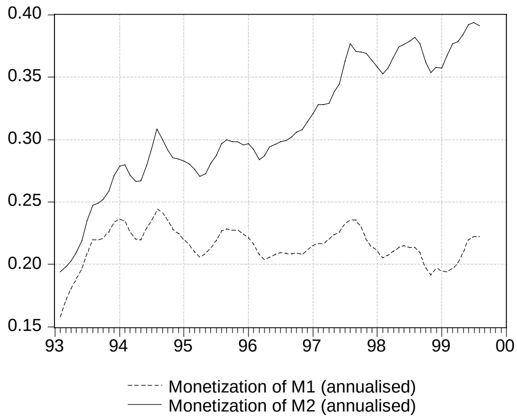
Auto-correlation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|.	.|.	1	-0.006	-0.006	0.0075	0.931
.|.	.|.	2	0.025	0.025	0.1309	0.937
.|.	.|.	3	-0.034	-0.033	0.3547	0.949
.|.	.|.	4	-0.024	-0.025	0.4669	0.977
*|.	*|.	5	-0.103	-0.101	2.5623	0.767
.|.	.|.	6	-0.039	-0.041	2.8625	0.826
.|*	.|*	7	0.079	0.083	4.1210	0.766
*|.	*|.	8	-0.071	-0.077	5.1538	0.741
.|*	.|*	9	0.092	0.082	6.8717	0.650
.|.	.|.	10	0.000	-0.003	6.8717	0.738

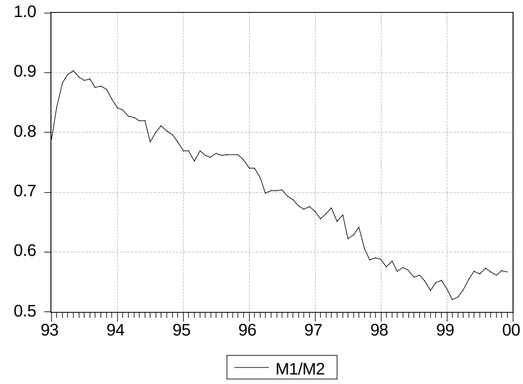


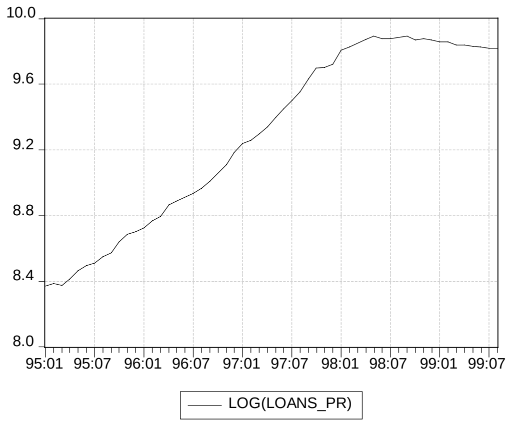
Auto-correlation	Partial Correlation		AC	PAC	Q-Stat	Prob
.|.	.|.	1	0.005	0.005	0.0056	0.941
.|.	.|.	2	-0.006	-0.006	0.0116	0.994
.|.	.|.	3	-0.008	-0.008	0.0234	0.999
.|.	.|.	4	-0.008	-0.008	0.0375	1.000
.|.	.|.	5	-0.022	-0.022	0.1330	1.000
.|.	.|.	6	-0.009	-0.009	0.1477	1.000
.|.	.|.	7	0.040	0.040	0.4665	1.000
.|.	.|.	8	0.061	0.060	1.2085	0.997
*|.	*|.	9	-0.060	-0.061	1.9405	0.992
.|.	.|.	10	0.017	0.018	1.9969	0.996

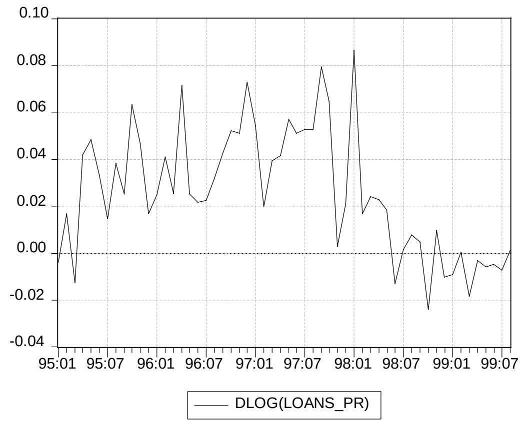
Appendix III. Figures

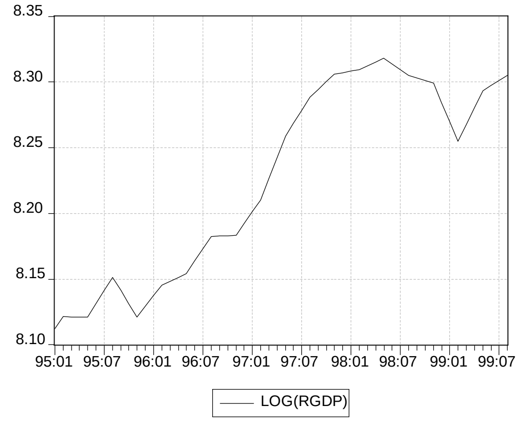








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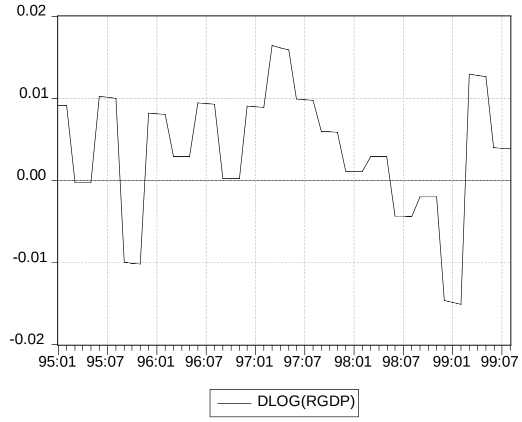
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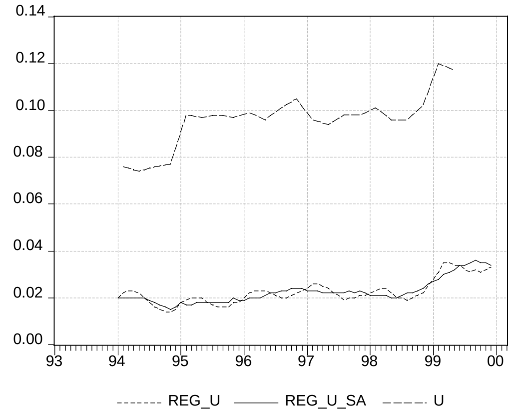
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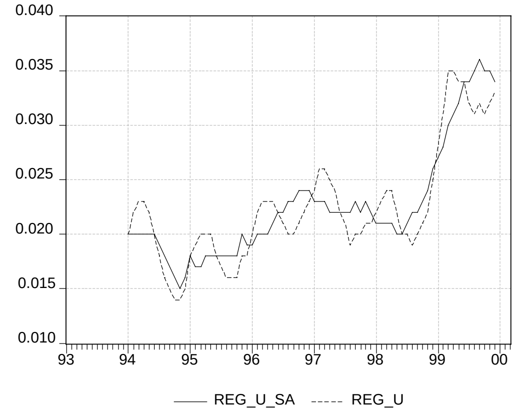
REG_U_SA
U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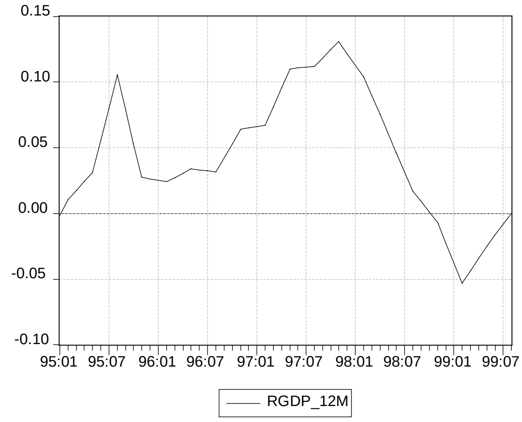
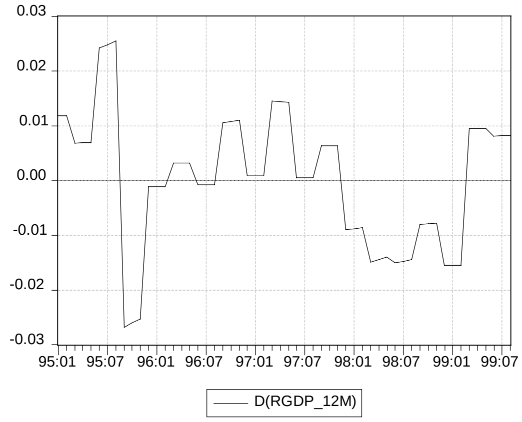

RGDP_12M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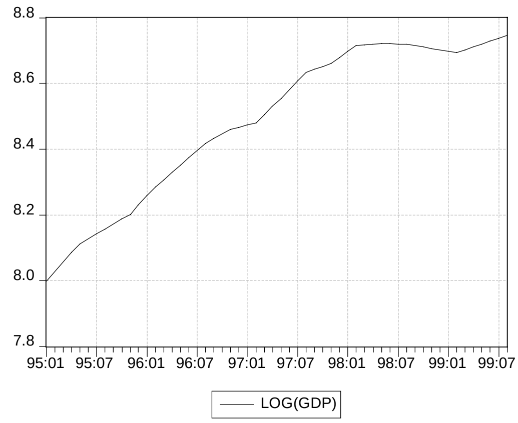
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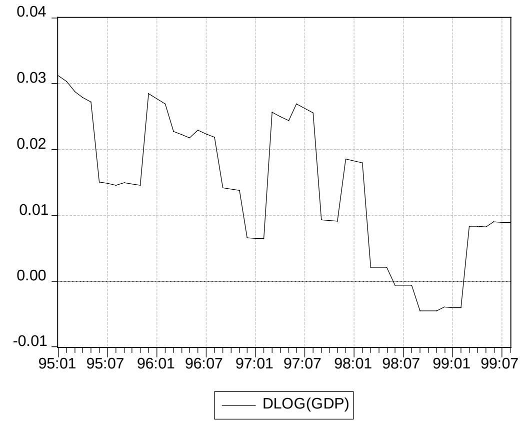
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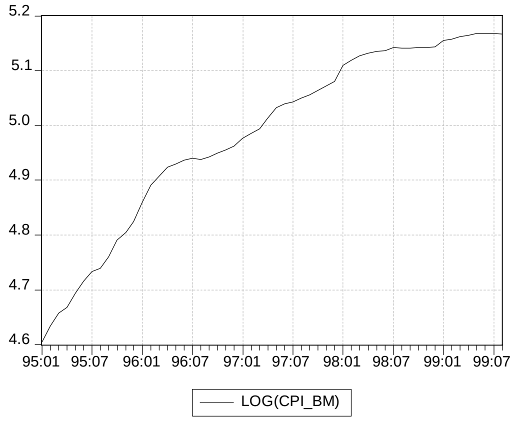
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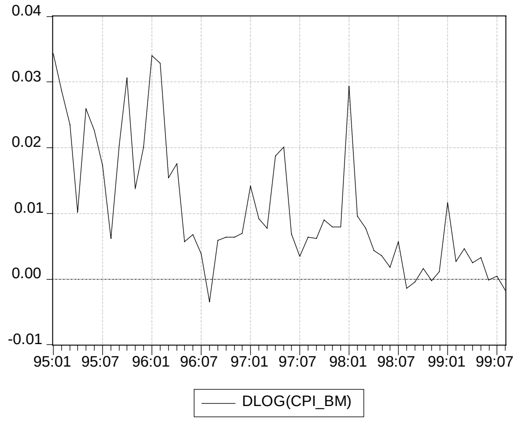
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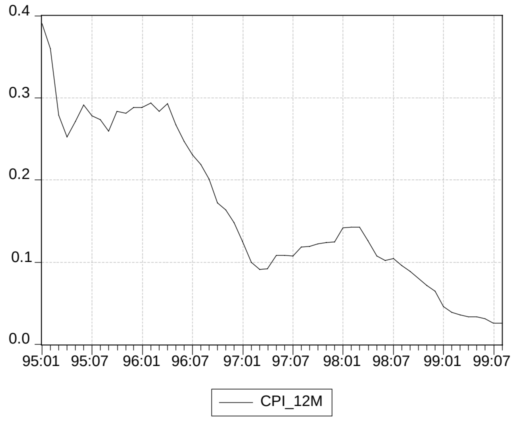
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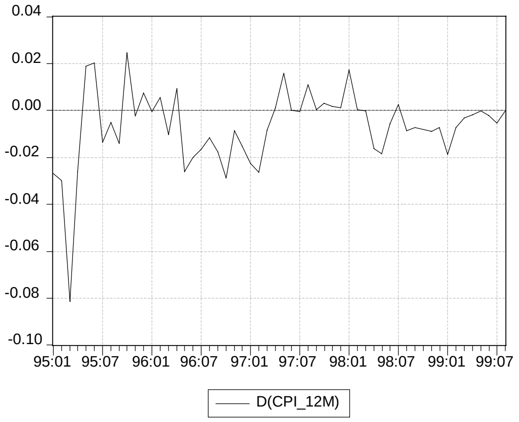
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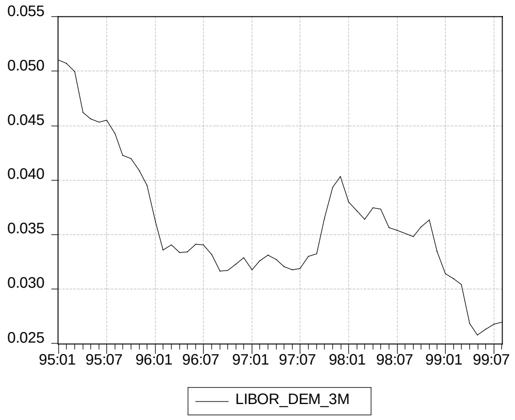
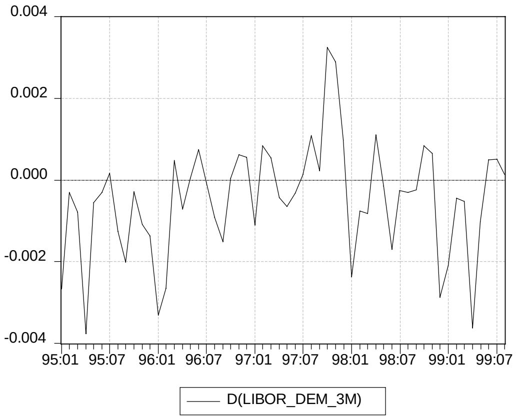
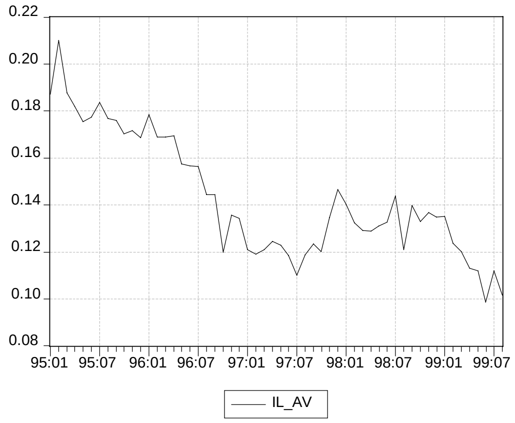
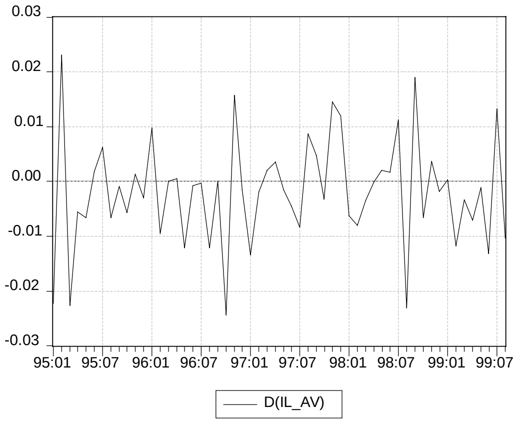
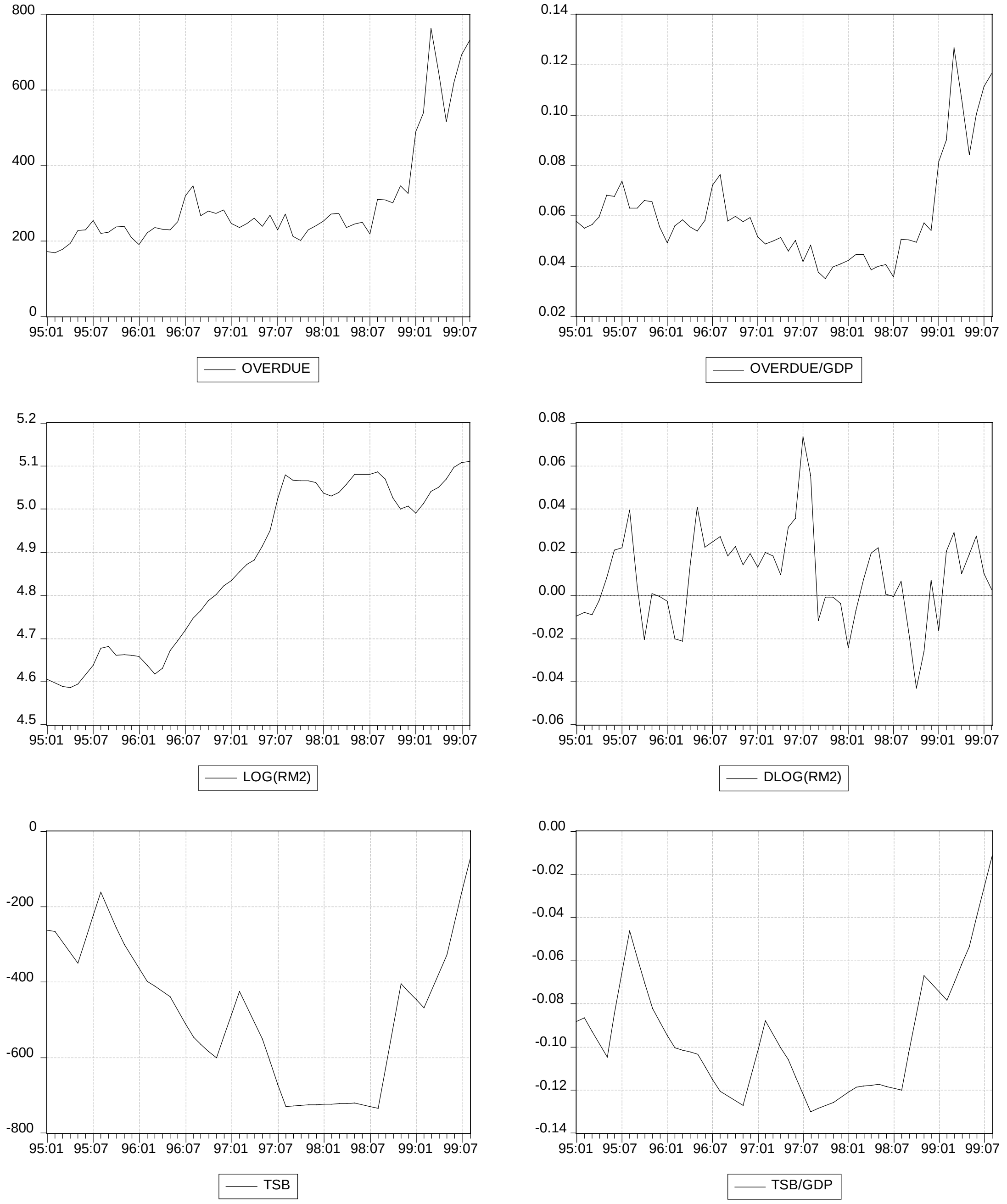

LIBOR_DEM_3M


D(LIBOR_DEM_3M)


IL_AV


D(IL_AV)


OVERDUE
OVERDUE/GDP
LOG(RM2)
DLOG(RM2)
TSB
TSB/GDP
95:01 95:07 96:01 96:07 97:01 97:07 98:01 98:07 99:01 99:07

Appendix IV. Statistical protocols

1. Statistical protocols for lending rate equation (without costs from reserves)

1.1. Johansen test for cointegration

Sample: Mar. 1995 to Aug. 1999
Included observations: 54
Test assumption: No deterministic trend in the data
Series: IL_AV LIBOR_DEM_3M CPI_12M RGDP_12MP_TSLS
Lags interval: 1 to 1

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.478724	59.32361	53.12	60.16	None *
0.223497	24.14393	34.91	41.07	At most 1
0.142235	10.48438	19.96	24.60	At most 2
0.039911	2.199403	9.24	12.97	At most 3

*(**) denotes rejection of the hypothesis at 5%(1%) significance level
L.R. test indicates 1 cointegrating equation(s) at 5% significance level

Normalized Cointegrating Coefficients: 1 Cointegrating Equation(s)

IL_AV	LIBOR_DEM_3M	CPI_12M	RGDP_12MP_TSLS	C
1.000000	-1.704298	-0.166623	0.178427	-0.064704
	(0.17647)	(0.01090)	(0.02137)	(0.00517)

1.2. Long-run relationship

Dependent Variable: IL_AV
Method: Least Squares
Sample: 1995:03 1999:08
Included observations: 54

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LIBOR_DEM_3M	1.951061	0.212686	9.173417	0.0000
CPI_12M	0.151774	0.012952	11.71867	0.0000
RGDP_12MP_TSLS	-0.122031	0.019556	-6.240224	0.0000
C	0.053387	0.006285	8.494333	0.0000

R-squared	0.940015	Mean dependent var	0.140827
Adjusted R-squared	0.936416	S.D. dependent var	0.024035
S.E. of regression	0.006061	Akaike info criterion	-7.302783
Sum squared resid	0.001837	Schwarz criterion	-7.155451
Log likelihood	201.1751	F-statistic	261.1800
Durbin-Watson stat	1.876715	Prob(F-statistic)	0.000000

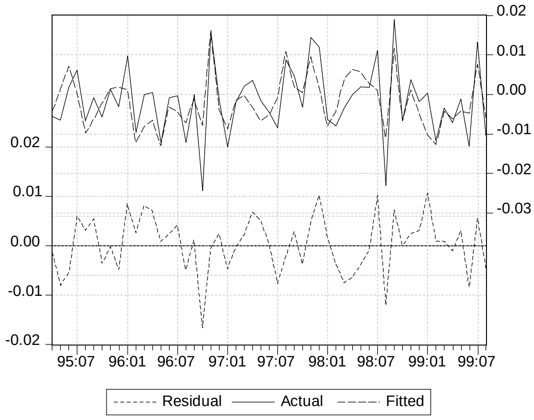
1.3. Error-correction model

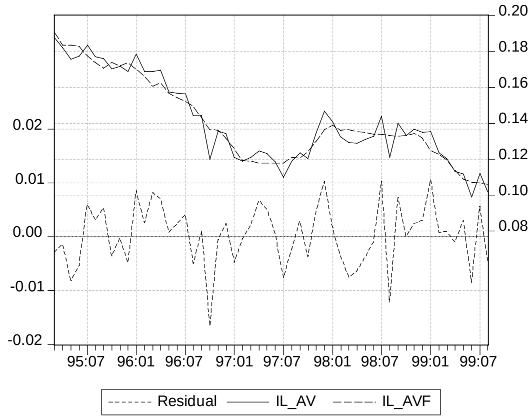
Dependent Variable: D(IL_AV)
Method: Least Squares
Sample: 1995:04 1999:08
Included observations: 53

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ECT_il_av(-1)	-0.999581	0.146810	-6.808663	0.0000
D(CPI_12M)	0.182934	0.064261	2.846746	0.0064
D(RGDP_12MP_TSLS)	-0.237346	0.095719	-2.479614	0.0166
D(LIBOR_DEM_3M)	2.129417	0.706248	3.015112	0.0041

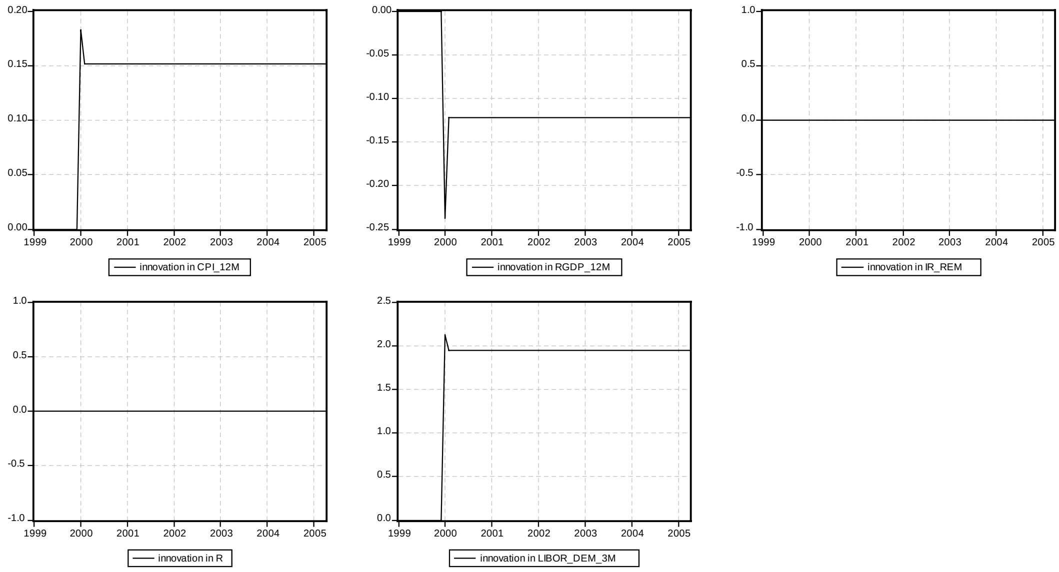
R-squared	0.564550	Mean dependent var	-0.001622
Adjusted R-squared	0.537890	S.D. dependent var	0.008767
S.E. of regression	0.005959	Akaike info criterion	-7.335238
Sum squared resid	0.001740	Schwarz criterion	-7.186536
Log likelihood	198.3838	Durbin-Watson stat	2.003029

1.4. Residuals from error-correction model and simulation results





1.5. Simulated responses in pp. to 1 pp. permanent innovation in independent variables (shock moment 01:2000)



2. Statistical protocols for lending rate equation (using costs from reserves)

2.1. Johansen test for cointegration

Sample: Mar. 1995 to Aug. 1999
Included observations: 54
Test assumption: No deterministic trend in the data
Series: IL_AV-(LIBOR_DEM_3M-IR_REM*R)/(1-R) CPI_12M RGDP_12MP_TSLS LIBOR_DEM_3M
Lags interval: 1 to 1

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.516856	62.46058	53.12	60.16	None **
0.218081	23.17880	34.91	41.07	At most 1
0.131309	9.894613	19.96	24.60	At most 2
0.041576	2.293124	9.24	12.97	At most 3

*(**) denotes rejection of the hypothesis at 5%(1%) significance level
L.R. test indicates 1 cointegrating equation(s) at 5% significance level

Normalized Cointegrating Coefficients: 1 Cointegrating Equation(s)

IL_AV-(LIBOR_DEM_3M-IR_REM*R)/(1-R)	CPI_12M	RGDP_12MP_TSLS	LIBOR_DEM_3M	C
1.000000	-0.170710	0.180881	-0.550725	-0.065338
	(0.01020)	(0.02034)	(0.16557)	(0.00485)

2.2. Long-run relationship

Dependent Variable: IL_AV-(LIBOR_DEM_3M-IR_REM*R)/(1-R)
Method: Least Squares
Sample: 1995:03 1999:08
Included observations: 54

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CPI_12M	0.156919	0.013170	11.91525	0.0000
RGDP_12MP_TSLS	-0.130328	0.019885	-6.554156	0.0000
C	0.054917	0.006391	8.593089	0.0000
LIBOR_DEM_3M	0.782160	0.216268	3.616623	0.0007

R-squared	0.908439	Mean dependent var	0.101212
Adjusted R-squared	0.902945	S.D. dependent var	0.019782
S.E. of regression	0.006163	Akaike info criterion	-7.269384
Sum squared resid	0.001899	Schwarz criterion	-7.122052
Log likelihood	200.2734	F-statistic	165.3607
Durbin-Watson stat	1.974650	Prob(F-statistic)	0.000000

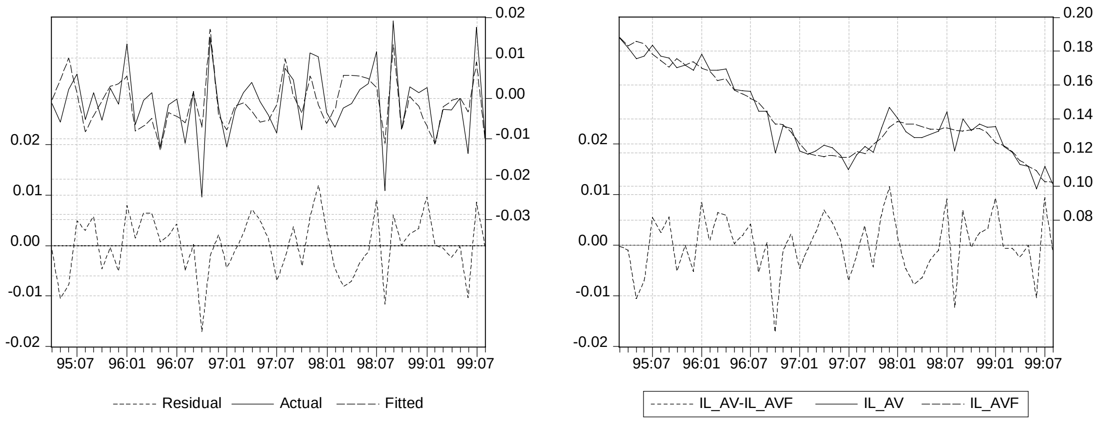
2.3. Error-correction model

Dependent Variable: D(IL_AV-(LIBOR_DEM_3M-IR_REM*R)/(1-R))
Method: Least Squares
Sample: Apr. 1995 to Aug. 1999
Included observations: 53

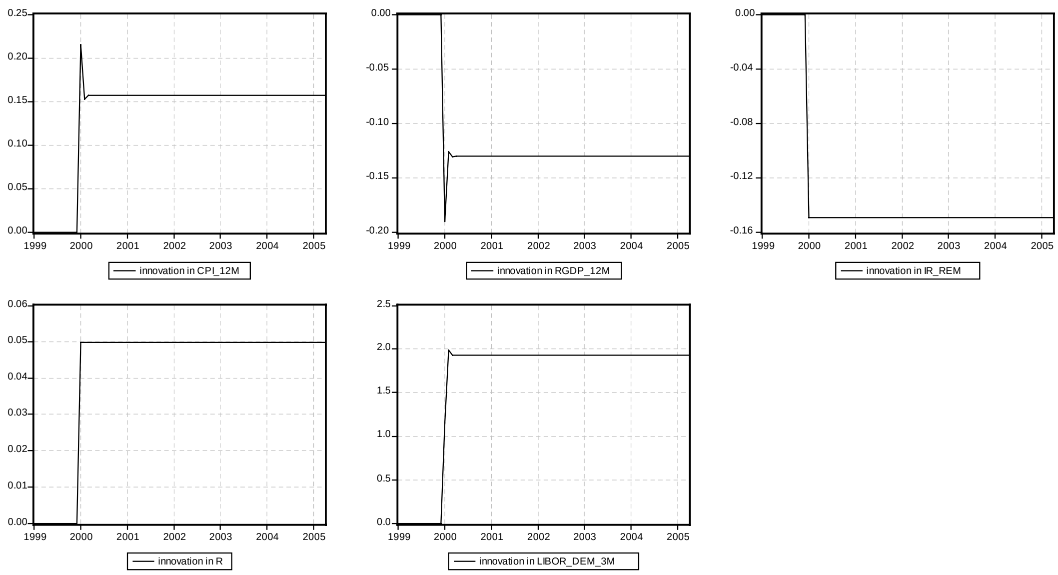
Variable	Coefficient	Std. Error	t-Statistic	Prob.
ECT_il_av(-1)	-1.072484	0.144932	-7.399934	0.0000
D(CPI_12M)	0.215619	0.065268	3.303619	0.0018
D(RGDP_12MP_TSLS)	-0.190008	0.094196	-2.017147	0.0491

R-squared	0.535785	Mean dependent var	-0.001067
Adjusted R-squared	0.517216	S.D. dependent var	0.008744
S.E. of regression	0.006075	Akaike info criterion	-7.314212
Sum squared resid	0.001845	Schwarz criterion	-7.202687
Log likelihood	196.8266	Durbin-Watson stat	1.897910

2.4. Residuals from error-correction model and simulation results



2.5. Simulated responses in pp. to 1 pp. permanent innovation in independent variables (shock moment 01:2000)



3. Statistical protocols for bank credit equation

3.1. Johansen test for co-integration

Sample: Apr. 1995 to Aug. 1999
Included observations: 53
Test assumption: No deterministic trend in the data
Series: LOG(LOANS_PR) LOG(GDPP_TSLS)
Lags interval: No lags

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.733486	75.78670	19.96	24.60	None **
0.102022	5.703324	9.24	12.97	At most 1

*(**) denotes rejection of the hypothesis at 5%(1%) significance level
L.R. test indicates 1 cointegrating equation(s) at 5% significance level

Normalized Cointegrating Coefficients: 1 Cointegrating Equation(s)

LOG(LOANS_PR)	LOG(GDPP_TSLS)	C
1.000000	-2.053101	7.965108
	(0.11625)	(1.02090)

3.2. Long-run relationship

Dependent Variable: LOG(LOANS_PR)
Method: Two-Stage Least Squares
Sample: Mar. 1995 to Aug. 1999
Included observations: 54
Instrument list: LOG(X) C

Variable	Coeffi-cient	Std. Error	t-Statistic	Prob.
LOG(GDP)	2.394420	0.042852	55.87675	0.0000
C	-11.04192	0.364604	-30.28467	0.0000

R-squared	0.983616	Mean dependent var	9.324471
Adjusted R-squared	0.983301	S.D. dependent var	0.524189
S.E. of regression	0.067738	Sum squared resid	0.238600
F-statistic	3122.211	Durbin-Watson stat	0.140621
Prob(F-statistic)	0.000000		

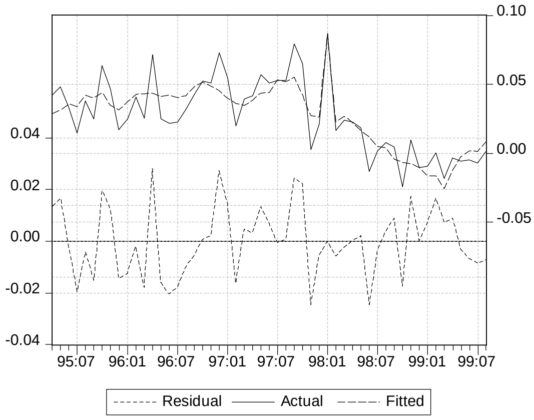
3.3. Error-correction model

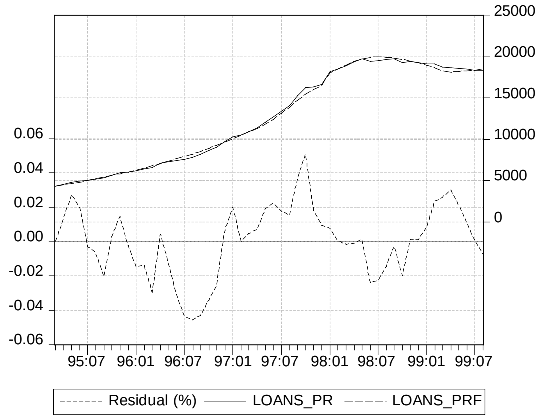
Dependent Variable: DLOG(LOANS_PR)
Method: Least Squares
Sample: Apr. 1995 to Aug. 1999
Included observations: 53

Variable	Coeffi-cient	Std. Error	t-Statistic	Prob.
ECT_loans_pr(-1)	-0.184417	0.029084	-6.340923	0.0000
(IL_AV+1)/(CPI_12MF(6)+1)	-0.224623	0.029094	-7.720646	0.0000
OVERDUE/GDPP_TSLS	-0.222112	0.094977	-2.338580	0.0236
DMS_9801	0.055846	0.014281	3.910348	0.0003
C	0.270251	0.028482	9.488439	0.0000

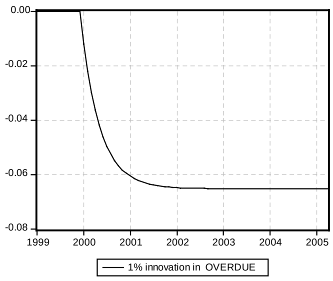
R-squared	0.749718	Mean dependent var	0.027303
Adjusted R-squared	0.728861	S.D. dependent var	0.026861
S.E. of regression	0.013987	Akaike info crite-rion	-5.611836
Sum squared resid	0.009390	Schwarz criterion	-5.425959
Log likelihood	153.7136	F-statistic	35.94590
Durbin-Watson stat	1.801896	Prob(F-statistic)	0.000000

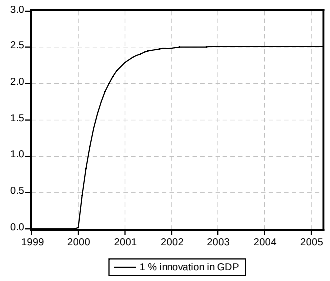
3.4. Residuals from error-correction model and simulation results

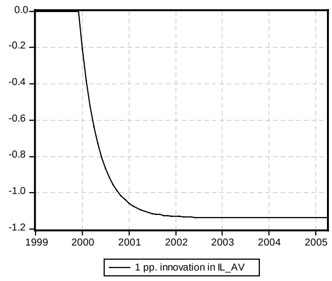


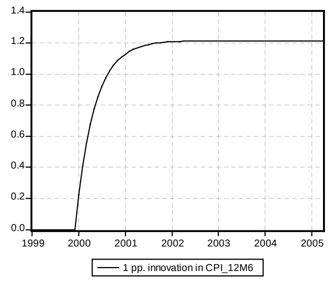


3.5. Simulated responses in (%) to 1 % / 1 pp. permanent innovation in independent variables (shock moment 01:2000)









4. Statistical protocols for real money demand equation

4.1. Johansen test for cointegration

Sample: Mar. 1995 to Aug. 1999
Included observations: 54
Test assumption: No deterministic trend in the data
Series: LOG(RM2) LOG(RGDP) @MOVAV(CPI_12M(1),3)
Lags interval: No lags

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.486283	47.81774	34.91	41.07	None **
0.141412	11.84928	19.96	24.60	At most 1
0.064773	3.616137	9.24	12.97	At most 2

*(**) denotes rejection of the hypothesis at 5%(1%) significance level
L.R. test indicates 1 cointegrating equation(s) at 5% significance level

Normalized Cointegrating Coefficients: 1 Cointegrating Equation(s)

LOG(RM2)	LOG(RGDP)	@MOVAV(CPI_12M(1),3)	C
1.000000	-1.008819	1.033102	3.177488
	(0.62820)	(0.41797)	(5.26369)

4.2. Long-run relationship

Dependent Variable: LOG(RM2)
Method: Least Squares
Sample(adjusted): Apr. 1995 to Nov. 1999
Included observations: 56 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(RGDP)	2.022336	0.110420	18.31494	0.0000
@MOVAV(CPI_12M(1),3)	-0.483480	0.087057	-5.553629	0.0000
C	-11.68384	0.920825	-12.68844	0.0000

R-squared	0.978355	Mean dependent var	4.902263
Adjusted R-squared	0.977538	S.D. dependent var	0.187617
S.E. of regression	0.028119	Akaike info criterion	-4.252686
Sum squared resid	0.041905	Schwarz criterion	-4.144185
Log likelihood	122.0752	F-statistic	1197.806
Durbin-Watson stat	0.486382	Prob(F-statistic)	0.000000

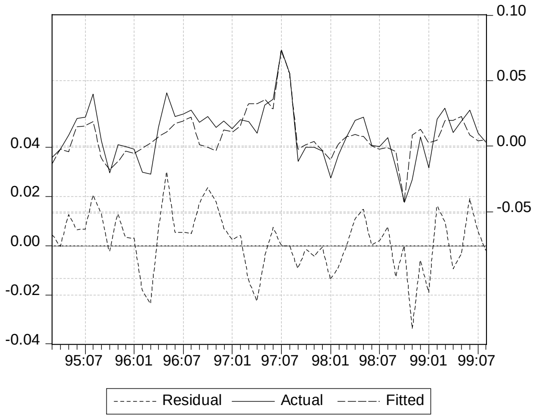
4.3. Error-correction model

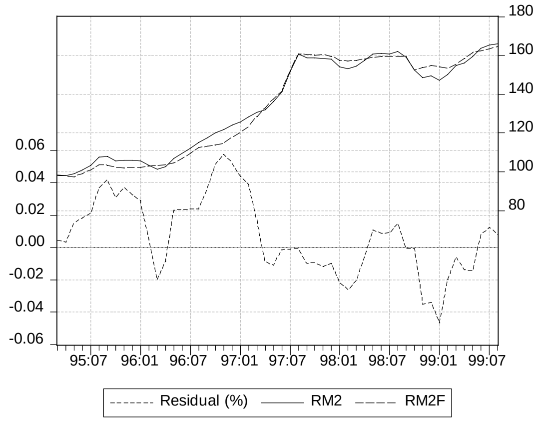
Dependent Variable: DLOG(RM2)
Method: Least Squares
Sample: Mar. 1995 to Aug. 1999
Included observations: 54

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ECT_m2(-1)	-0.209706	0.069634	-3.011558	0.0041
DLOG(CPI_BM)	-0.366105	0.162252	-2.256405	0.0286
LRGDP_UP	1.963785	0.315525	6.223864	0.0000
DMS_9707	0.047940	0.013702	3.498732	0.0010
DMS_9708	0.042820	0.013582	3.152699	0.0028
DMS_9810	-0.041540	0.013237	-3.138241	0.0029

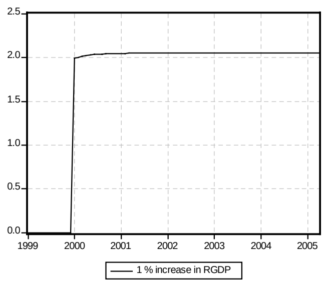
R-squared	0.642317	Mean dependent var	0.009509
Adjusted R-squared	0.605058	S.D. dependent var	0.021054
S.E. of regression	0.013231	Akaike info criterion	-5.708043
Sum squared resid	0.008403	Schwarz criterion	-5.487045
Log likelihood	160.1172	Durbin-Watson stat	1.298895

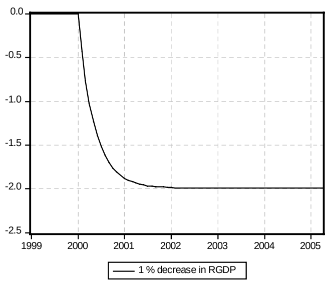
4.4. Residuals from error-correction model and simulation results

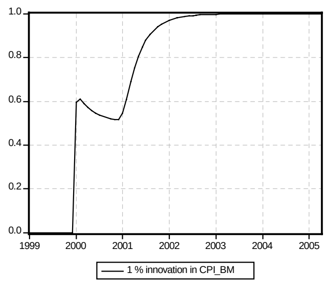




4.5. **Simulated responses in % to 1 % permanent innovation in independent variables (shock moment 01:2000)**







Notes

[1] Eesti Pank (1999a, p. 44)

[2] Sepp, Pikkani and Rell (1999); Sepp (1999)

[3] This includes concern over the real sectors' ability to cope with external shocks. In the event of a sharp decline in international competitiveness caused by irresponsible fiscal policy or a foreign productivity shock, adjustments through prices can take a long time and carry great costs. A politically dependent monetary authority may find devaluation an expedient means to speed up recovery from such a shock.

[4] There are no spreads between buying and selling rates of euro or other EMU currencies.

[5] Also composition of liabilities facing reserve requirements, composition of reserves assets and remuneration.

[6] And not directly through reduction of banking sector lending resources as is commonly claimed in standard textbook discussions on closed economies.

[7] A table describing the evolution of Eesti Pank monetary policy is presented in Appendix I.

[8] For detailed information about banking sector consolidation see Eesti Pank (1999b, p. 40-41).

[9] Eesti Pank started fixing TALIBOR and TALIBID quotations after January 9, 1996. The five largest banks on the market were listed and periods quoted were 1 week, 1 month and 3 months (Eesti Pank 1996 p. 7-8). After September 1998, because banking sector consolidation had reduced the number of banks to three and maximum sum banks had to deliver on quoted rates had increased from EEK 1 million to EEK 10 million (Eesti Pank 1998 p. 5). In February 1999, Svenska Handelsbanken and Merita Bank Plc. Tallinn filial were added to the list and a new time-structure of quotation was introduced. New periods quoted are 1 month, 2 months, 3 months, 6 months, 9 months and 12 months (Eesti Pank 1999c p. 6)

[10] Another possibility is heavy competition between Hansapank and Ühispank for the title of largest commercial bank in Estonia.

[11] For a closer description of monetary transmission channels, see Mishkin (1996) or Bernanke and Gertler (1995).

[12] See Glossary.

[13] Figures with developments in most important variables are presented in Appendix V.

[14] During rapidly falling inflation, accurate estimates of real interest rates are hard to derive. Real interest rates are determined by deflating nominal rates according to inflation expectations.

[15] Laidler 1993 and Sriram 1999 provide excellent coverage of developments in money theory.

[16] This holds for an average economic agent. Several money mutual funds exist, but entry barriers are quite high and earnings do not differ significantly from time deposit rates. Once Estonia had numerous open investment funds, but most cancelled operations after the near-collapse of the Tallinn stock exchange at the end of 1997. A third alternative is to deposit money abroad, but this is out of the scope of an average domestic economic agent (i.e. individuals and small business are put off by the high transaction costs, but larger companies routinely use foreign deposit accounts for liquidity management and similar purposes).

[17] Defined as sum of cash in economy and demand deposits in commercial banks.

[18] Defined as M1 + time and saving deposits.

[19] According to the Statistical Office of Estonia, the average total income per member of household in 1999 was 2,000 kroons. At the same time, the average amount of demand deposits per resident averaged around 3,700 kroons. The amount of time and saving deposits averaged around 2,700 kroons, or 3.2 times the monthly average income (in 1998, respectively, 1,900 kroons, 3,100 kroons, 2,500 kroons and 2.9 times)

[20] Credit provided to the private sector is defined as the sum of loans outstanding and the amount of bought domestic debt securities. Commercial banks' resources are defined as the sum of amounts owed to customers; amounts owed to foreign credit institutions; issued debt securities and share capital minus the sum of claims on the central bank, foreign debt securities held by foreign residents and other assets.

[21] Appropriate lag length was derived by estimating VAR between same variables and minimizing Akaike info criterion. As there is no proper test to decide whether one VAR is significantly better than other one with slightly different lag length, causality tests were also carried out with lag lengths close to one with minimal Akaike info criterion and test results were very similar to the ones reported.

[22] Commercial banks balance sheets are reported approximately every 10 days.

[23] There are no official data about monthly GDP, so a simple interpolation was carried out (both for real and nominal GDP). Quarterly GDP was first divided equally among corresponding months, then these series were smoothed with a three-period moving average (current, leading and lagging).

[24] The reasoning behind the equation is provided with empirical estimates of interest rate equation.

[25] Due to a lack of data, it is impossible to specify supply curves for intermediate periods. Only two regimes, therefore, can be specified: one with an infinite supply of foreign debt capital and one with no supply.

[26] If we assume that the banking sector is competitive, we also must assume that the price of bank credit equals the price of foreign liabilities plus costs related to lending business. As amounts held on required reserve accounts do not bear interest (or the rate is well above the market average), additional reserve requirements are also additional costs for commercial banks. Under assumed conditions, we can derive an equation for the price of bank credit:

$$i = \frac{i^* - i^r \cdot r}{(1\text{-}r)} + \delta$$

where i is price of credit form costs side, i^* price of money commercial banks have to pay to foreign financial institutions (includes country and domestic banking sector risk premium), δ is cost related to lending activity, i^r is interest paid by central bank from reserves (remunerator) and r is legal reserve requirement. If we assume that demand for bank loans is a negative function of the lending rate and that the supply of foreign capital is elastic, then increased reserve require-ments (r) will reduce bank loans outstanding and an increased remunerator (i^r) will have a positive impact on lending activity.

[27] It is important to note that as model tested here is partial and covers only the monetary sector. The response tests only describe properties of estimated equations, not absorption of shocks by the aggregate economy.

[28] Inflation expectations were estimated here with a simple 12-lag time series equation.

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