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Abstract

The paper tests the presence of cointegration by estimating the impact of monetary policy on household and corporate loans, while taking account of developments in the macroeconomic environment. The testing is applied using the Johansen procedure based on a factor-augmented vector error correction model (FAVEC model), which is augmented by the factor of the macroeconomic environment, for the period from January 2003 to December 2010. Factor analysis is used to estimate the macroeconomic environment factor, which reflects developments in domestic economic activity based on a large number of time series. The monetary policy indicator, which adequately represents the complexity of the CNB measures, is also defined. The paper confirms the existence of a long-run relation between household loans, the macroeconomic environment factor and the monetary policy indicator. At the same time, no such a relation was confirmed for corporate loans. This is probably due to the fact that, in contrast to households, enterprises raised substantial funds from other financing sources (particularly abroad) in preceding years, and not only from commercial banks. This has limited the impact of monetary policy on corporate loans. Impulse response functions estimated on the basis of the FAVEC model showed that a restrictive monetary policy shock leads to a decrease in household loans, while a positive shock in the macroeconomic environment factor, which generally represents an increase in overall economic activity, has a favourable impact on bank loans to households. The identification of the long-run relation yields the conclusion that CNB measures were justified; without them credit growth would certainly have been larger, which means that external imbalances in the Croatian economy would have been worse. On the other hand, the recent crisis and the halt in bank lending coupled with the weak credit channel of monetary policy in Croatia limited the impact of incentives for credit growth. This could in future undermine the long-run relation estimated in this paper.

Keywords:

monetary policy, loans, cointegration, factor analysis

JEL:

E51, E52

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Contents

1 Introduction

In addition to the achievement of its primary objective – low inflation based on the stability of the domestic currency – the main goal of Croatian National Bank (CNB) activities in the past ten years has been to limit bank credit growth. Credit expansion, largely financed from foreign sources, fuelled excessive private and public consumption, which ultimately increased the country's external imbalances – the current account deficit and external debt. In view of the weak credit channel of monetary policy and the lack of any market influence on bank loans via interest rates, the CNB implemented a number of unconventional measures to keep credit growth within limits sustainable in the long run. However, the spillover effect of the global financial and economic crisis on domestic developments in late 2008 and 2009 generated a domestic economic contraction, which brought the several-year long credit growth to an end. The central bank found itself in a situation in which it wanted to encourage credit activity, particularly towards the corporate sector, so as to spur economic recovery. In this context, it is useful to explore whether and to what extent central bank actions affect bank lending and whether monetary policy in Croatia, together with overall macroeconomic developments, determines bank lending to households and/or enterprises in the long-run.

The main objective of this paper, then, is to estimate the cointegration by estimating the impact of monetary policy on household and corporate loans, while taking account of developments in the overall macroeconomic environment. For estimation purposes, the paper defines a monetary policy indicator that adequately represents central bank actions. In addition, factor analysis is used to calculate the macroeconomic environment factor, which takes into account developments in about a hundred time series that describe developments in the Croatian economy. By including the factor in the model, also defined and analysed is a factor-augmented vector error correction model (FAVEC) model. Based on the FAVEC model, estimated impulse response functions show how and to what extent a monetary policy shock (e.g. monetary policy tightening) or a macroeconomic environment shock (e.g. increase in overall economic activity) affects developments in loans.

Cointegration tests significantly confirmed the existence of a long-run relation between household loans, the macroeconomic environment factor and the monetary policy indicator, while such a relation was not confirmed for corporate loans. Impulse response functions estimated on the basis of the FAVEC model showed that a restrictive monetary policy shock leads to a decrease in household loans, while a positive shock in the macroeconomic environment factor, which generally implies an increase in economic activity, has a favourable impact on bank loans to households.

The paper is structured as follows: following the introduction, the second section describes developments in bank loans in Croatia with particular emphasis on CNB measures to influence bank lending. The third section defines the econometric basis for model estimation, including a review of the most relevant papers that used similar methods and motivated this paper. The fourth section provides empirical analysis, which includes the calculation of the macroeconomic environment factor and the definition of the monetary policy indicator, followed by the FAVEC model estimation and results. Concluding observations are given in the final section.

2 Monetary policy and bank loans in Croatia

Bank lending in Croatia grew steadily in the years up to 2009, when it came to a halt. This ended the credit cycle that had started in the early 2000s, after the end of the previous banking crisis in the late 1990s.[1] Credit growth was based on a number of factors, such as: the privatisation and rehabilitation of banks with the entry of foreign banks, liberalisation of capital flows, enhanced competition in the banking market (which was also due to financial liberalisation – Kraft and Jankov, 2005), increased domestic demand (in particular, personal consumption), a gradual decrease in interest rates and macroeconomic stability (low inflation and stable exchange rate), etc.

Table 1 Bank loans in Croatia

	2003	2004	2005	2006	2007	2008	2009	2010
Household loans								
Stock (billion HRK)	55.0	65.3	78.6	95.7	112.9	126.6	122.9	127.5
Absolute change (billion HRK)	11.9	10.3	13.3	17.1	17.2	13.6	–3.7	4.6
Annual rate of change (%)	27.7	18.7	20.3	21.8	18.0	12.1	–2.9	3.8
Corporate loans								
Stock (billion HRK)	49.4	53.4	62.1	78.3	86.3	96.8	98.7	108.2
Absolute change (billion HRK)	2.4	3.9	8.7	16.2	8.0	10.6	1.9	9.5
Annual rate of change (%)	5.1	8.0	16.3	26.1	10.2	12.3	2.0	9.6
Loans to the private sector								
Stock (billion HRK)	105.2	119.7	141.8	175.5	201.1	224.3	222.9	238.5
Annual rate of change (%)	16.0	13.8	18.5	23.8	14.6	11.6	–0.7	7.0
as % of GDP	45.9	48.4	53.2	60.3	63.2	65.0	66.5	71.3

Note: The private sector includes households, enterprises and other banking and financial institutions.
Sources: CNB and CBS.

From 2003 to 2010, the average annual growth in loans to the private sector reached 13%.[2] The share of private sector loans in GDP steadily increased in the analysed period, from 46.3% in 2003 to 71.3% in 2010. This was due to the fact that credit growth outpaced the increase in overall economic activity, with the exception of 2009, when the fall in GDP was larger than the fall in loans (–5.8% vs –0.7%). Total loans to the private sector more than doubled in the eight years observed.

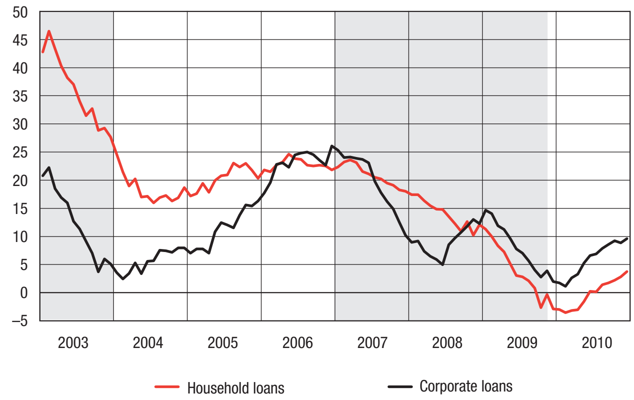
The household sector contributed more to credit growth than the corporate sector. Among other things, this lending structure was a reflection of the banks' lending policies. Gattin Turkalj et al. (2007) state that commercial banks, which encouraged clients to borrow from their subsidiary leasing companies or directly from foreign creditors (most often, their parent banks abroad), circumvented CNB measures as they directed the bulk of the permissible credit growth to households, which have no other financing sources available.

Typically, household loans grew faster than corporate loans, particularly in the period from 2003 to 2006 (Figure 1). The same trends were recorded from mid-2007 up to the onset of the crisis in late 2008. Only towards the end of the analysed period were annual growth rates of household lower than those of corporate loans. Figure 1 shows that in periods of direct limits on credit growth (shaded areas), the annual growth rate of household and corporate loans declined, while opposite trends were observed in periods when limits were not imposed.

1 Developments in the Croatian banking sector in the 1990s and early 2000s and banking crises and credit booms are discussed in detail in Kraft and Jankov (2005).

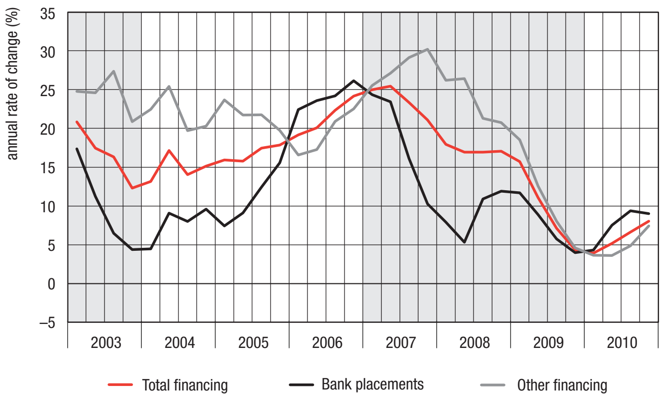
2 The description of loan developments and the later presentation of CNB measures cover only the period from 2003 to 2010 since this period is used in the econometric analysis given in this paper. Therefore, it was unnecessary to describe in detail developments prior to 2003.

Figure 1 Developments in household and corporate loans of banks in Croatia
annual growth rates



Note: The shaded areas denote the period when administrative limits on bank credit growth were in force.
Source: CNB.

Figure 2 Total corporate financing



Note: Other corporate financing includes external borrowing and financing from non-banking financial institutions (leasing companies). The shaded areas denote the period when administrative limits on bank credit growth were in force.
Source: CNB.

Enterprises obtained substantial funds from other sources, apart from banks: on average, other financing grew faster than bank loans, particularly during periods when limits on credit growth were imposed (Figure 2). Therefore, CNB measures did not much affect the possible unavailability of funding for enterprises, which met some of their domestic financing needs through foreign sources.

In view of the weak development of the traditional credit channel in Croatia, as stated in Lang and Krznar (2004),[3] and the absence of any transmission of the CNB interest rate to other interest rates (Kraft and Jankov, 2005),[4] the central bank resorted to controlling credit expansion by a series of unconventional measures. The text below provides a brief overview of instruments and measures the CNB used to influence bank lending.[5] It is relevant for the later definition of the monetary policy indicator (section 4.1.2) and its use in the econometric estimation.

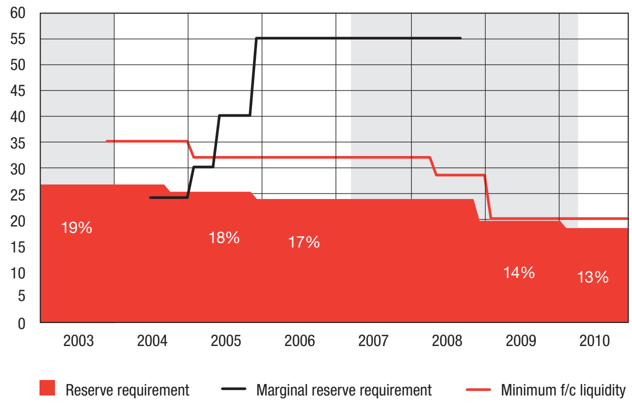
3 Further discussion of the (non-) functioning of the credit channel in Croatia and all its aspects may be found in CBA Analyses No. 17 (2009).

4 Talking about the CNB interest rate, Kraft and Jankov (2005) considered the interest rate on CNB bills, which could be considered relevant at the time. Later on, the CNB stopped issuing CNB bills. Under the new framework for monetary policy implementation, open market operations were introduced in 2005. Reverse repo auctions were then introduced, but the reverse repo rate has never become a benchmark interest rate.

5 Although this goes beyond the presentation of measures in this paper, one should note that in the preceding years bank loans were also strongly affected by prudential regulation measures of the CNB. They reinforced the impact of monetary instruments and led to the strong growth in bank capital.

Within CNB monetary policy, reserve requirements are the most important instrument of sterilisation. In the period from 2003 to 2010, the reserve requirement rate was reduced from 19% to 13%. The rate was first cut from 19% to 18% in October 2004 to prompt the substitution of external government debt by domestic debt. It was reduced further to 17% in January 2006 to release the liquidity as at that time the CNB began increasingly to penalise foreign sources (marginal reserve requirement). A reduction to 14% was implemented in the midst of the spillover of the global crisis to domestic developments in December 2008. In the context of interruptions of foreign capital inflows, it was crucial to secure liquidity in the domestic market.[6] The most recent cut in the reserve requirement rate, to 13%, was made in February 2010, when the CNB supported the government's programme to stimulate corporate lending through the CBRD (the so-called "Model A").

Figure 3 Reserve requirement rates and the minimum required foreign currency liquidity



Note: The shaded areas denote the period when administrative limits on bank credit growth were in force. The reserve requirement rates are written within the red-shaded area.
Source: CNB.

The relatively high reserve requirement rate was largely the outcome of the nature of monetary policy and the environment in which it operated. The CNB converted the bulk of foreign capital inflows through foreign exchange interventions. At the same time, it was necessary to put some of these large inflows outside the system because of potential inflationary pressures capable of threatening the main central bank objective. Although the CNB has never relied on the reserve requirement as the primary instrument to control credit growth, as was the case with the marginal reserve requirement and compulsory CNB bills, this instrument certainly affected bank lending.

From 2004 through to nearly the end of 2008, the CNB also applied the marginal reserve requirement. This type of reserve *penalised* foreign borrowing by the banks and controlled the abundant inflows of cheap foreign capital. As it was calculated together with the general reserve requirement, it was an additional cost for banks. The rationale behind this measure was to limit credit growth, since the credit expansion was largely financed from foreign sources. The marginal reserve requirement was modified several times[7] and was steadily tightened. It was repealed in October 2008, when the crisis began to spread to the domestic financial system. In general, one may say that the marginal reserve requirement substantially helped in slowing down the increase in debt and debt-funded loans as well as in sterilising foreign currency inflows.

In February 2006, the CNB introduced special reserve requirements on bank liabilities arising from bonds

6 In the period from October 2008 to February 2009, through a number of changes in monetary policy instruments and foreign exchange market interventions, the CNB released almost EUR 4.0bn. It thereby improved substantially the foreign currency liquidity of the banking system and preserved exchange rate and financial system stability.

7 The rate was initially set at 24% of the increase in external borrowing relative to the initial balance (June 2004). The rate was raised to 30% and further to 40% in February and May 2005 respectively. In November 2005, it was decided that from the beginning of 2006 banks would have to set aside another 15% of the debt increase relative to the debt balance in November 2005. Also, the calculation base was expanded to include guarantees of foreign entities at the calculation rate of 55%. The base was further expanded in June 2006 to include the increase in external borrowing of non-residents and persons connected with banks, also at the rate of 55%.

issued in the domestic market. This was to prevent banks from avoiding the marginal reserve requirement by issuing bonds that would be purchased by foreign parent banks on the secondary market (as one bank did prior to the introduction of this measure). After the introduction of special reserve requirements no bank attempted to circumvent the marginal reserve requirement in this way. The special reserve requirement was abolished in February 2009.

The administrative limit on bank credit growth was in force in 2003 and from January 2007 to December 2009. It was based on the subscription of compulsory CNB bills and was applied to banks whose credit growth was in excess of the permissible limit. Compulsory subscription to CNB bills entailed additional costs for banks as the interest rate on these bills was much lower than the market interest rate. The subscription also involved the immobilisation of bank assets, which could not be offered to the market.

In 2003, compulsory CNB bills had to be purchased by banks whose credit growth exceeded 4% per quarter, i.e. whose annual credit growth exceeded 16%. Banks had to subscribe to CNB bills in an amount equal to 200% of their excessive credit growth. Although credit growth of some banks exceeded the permitted limit, the measure successfully slowed down credit growth; it was exactly 16% in 2003 (in contrast with 2002 when it was twice as large).[8]

As credit growth picked up again after 2003 and external imbalances continued to build up, the CNB reacted again in 2007. Subscription of compulsory CNB bills was introduced for banks whose annual placement growth exceeded 12%. This measure was later modified on several occasions to increase its efficiency. The largest change was made in August 2007 (until then credit growth was much faster than anticipated): the permissible rate of growth was set at 0.5% a month, so that placement growth decelerated strongly. The CNB retained this measure in 2008, but the monthly cumulative limit was set at 1%. Placement growth was kept within targeted limits. However, slower credit growth was also associated with the fall in demand due to higher interest rates. In 2009, faced with the economic crisis and the turmoil in the financial market, banks became reluctant to finance risky clients. Increased government financing also squeezed the private sector out of the credit market. As lending stopped, in December 2009 the CNB decided to abolish the Decision on the purchase of compulsory CNB bills. At the same time, the CNB began to conduct a policy to increase liquidity in the domestic market so as to stimulate a recovery in lending. Such a policy was also implemented in 2010.

In addition to the described measures of reserve requirements and compulsory CNB bills, the CNB influenced the overall supply of bank loans by imposing requirements related to the maintenance of banking system liquidity. The strongest impact was made by the Decision on the minimum required amount of foreign currency claims (“the 35% Decision”). The decision was adopted in 2003 to increase the system’s foreign currency liquidity. It replaced the former “53% decision” under which banks had to cover 53% of their short-term foreign currency liabilities. Under the new decision, the coverage ratio between total foreign currency liabilities of banks and their liquid foreign currency claims was 35% and it had to be maintained on a daily basis. This actually implied an increase in bank foreign assets and a decrease in domestic credit potential. Therefore, in addition to improving the system’s foreign currency liquidity, the “35% decision” slowed down the increase in domestic assets of banks. The decision on the minimum foreign currency liquidity ratio was amended several times from 2003 to 2010, in line with the banks’ needs for foreign currency and the market situation. To stimulate government financing from domestic sources, the ratio was cut to 32% in February 2005 and further to 28.5% in May 2008. In response to the crisis and sluggish capital inflows, this measure was relaxed twice in February 2009, first to 25% and then to 20%.

Apart from foreign currency liquidity, the central bank managed kuna liquidity by means of open market operations and foreign exchange interventions. In this way the CNB implemented the policy of stable exchange rate, i.e. price stability. In the context of their impact on loans, it is not necessary to describe in more detail the measures related to kuna liquidity management.

8 The rate of placement growth as defined under the Decision was even lower, as the CNB *Annual Report* for 2003 states: “As suggested by unaudited data as at 31 December 2003, the CNB measures were successful in accomplishing their immediate goals. The annual growth rate of targeted domestic banks’ placements to the private non-financial sector declined considerably, from 33.6% at end-2002 to 11.3% at the end of 2003.”

3 Econometric basis for FAVEC model estimation

Factor analysis in this paper is used to estimate the variable (macroeconomic environment factor) that summarises much information and enables an estimate of the cointegration model with a small number of variables. The motivation for applying factor analysis is based on Dave et al. (2009), where a FAVAR model (*Factor Augmented Vector Autoregression*) is used to examine the bank lending channel in the U.S. Dave et al. (2009) use a large number of macroeconomic indicators to estimate the impact of monetary policy shocks. Their implementation of the FAVAR model follows the paper by Bernanke, Boivin and Eliasz (2005), which measured the effects of monetary policy in the U.S.

Bernanke et al. (2005) define a theoretical framework for a FAVAR analysis, which is exploited in most other papers mentioned. They emphasize that the scarce information sets typically used in VAR estimates of monetary policy effects lead to potential problems with the results. First, to the extent that central banks have information not reflected in the VAR, the measurement of monetary shocks is likely to be "contaminated". A second problem is that impulse responses can be estimated only for the included variables. They generally constitute only a small subset of the variables since any additional variable in the VAR model significantly reduces degrees of freedom. In fact, central banks follow a large number of variables, sometimes hundreds of data series. Therefore, the information that the FAVAR approach exploits on the basis of a large number of variables is indeed important properly to identify the monetary transmission mechanism.

Generally speaking, the FAVAR approach used by Bernanke et al. (2005) could be illustrated as follows. Let us assume that an economy is affected by the vector C_t, which includes common components affecting all analysed variables. For example, a common component could consist of a monetary policy measure or the central bank's benchmark rate, R_t. The remaining movement (dynamics) of all series in the data set is captured by $K \times 1$ vector of unobserved factors F_t, where K is relatively small. These unobserved factors represent fluctuations in general economic phenomena such as economic activity, aggregate prices, etc. These phenomena or economic processes cannot be represented simply and easily by movements in several variables. For example, economic activity cannot be represented exclusively by industrial production.

It is assumed that the joint dynamics of factor F_t and the central bank's interest rate R_t are given by:

$$C_t = \Phi(L)C_{t-1} + v_t, \tag{1}$$

where $C_t' = [F_t' R_t]$, v_t are uncorrelated and equally distributed errors, while $\Phi(L)$ stands for a polynomial lag operator of infinite order:

$$\Phi(L) = \Phi_0 + \Phi_1 L + \Phi_2 L^2 + \ldots \tag{2}$$

As equation (1) gives a VAR model with variable C_t, it cannot be directly estimated because the factors F_t are unobservable. However, as the factors affect many economic variables, one may use the set of "observed" information, i.e. changes in many variables that would enable an insight into factor developments. Let X_t denote $N \times 1$ vector of variables that provide an insight into developments of a factor, i.e. a general economic process or phenomenon. The number of N is very large. It is assumed that X_t is related with all common components under equation:

$$X_t = \Lambda C_t + e_t, \tag{3}$$

where Λ is a $N \times 1$ matrix of factor loadings, while the $N \times 1$ vector of relation errors e_t comprises a specific part that is uncorrelated with C_t, but may be serially and weakly correlated with other variables. Equation (3) represents "pervasive" forces of C_t that drive the dynamics of X_t. Conditional on the R_t, the variables in X_t are thus noisy measures of the underlying unobserved factors F_t.

The two-step procedure is used in the estimation of the defined model. In the first step, the principal components, which are consistent estimates of the common factors, are selected from X_t. In the second step, the interest rate R_t is added to the estimated common factors. This serves as a basis to estimate equation (1), i.e. the initial VAR model. Finally, Bernanke et al. (2005) emphasize that if a small number of estimated factors effectively summarize large amounts of information about the economy, then a natural solution to the degrees-of-freedom problem in VAR analysis is to augment standard VARS with estimated factors (2005).[9]

The given methodological framework is the basic econometric framework used in many other papers. In addition to Dave et al. (2009), Boivin et al. (2009) use FAVARs to analyse sticky prices and the effects of monetary policy. The authors reiterate that the risk of a poor model specification is considerably reduced in the context of FAVAR analysis as all available information is used in estimations. Blaes (2009) investigates the transmission of monetary policy in the euro area based on the FAVAR methodology and compares it with the results of a standard VAR model.[10] A similar application may also be found in Morgese Borys and Horvath (2008), who examined monetary policy effects in the Czech Republic by combining VAR, structural VAR (SVAR) and FAVAR models.

Apart from analyses of monetary policy, Mumtaz and Surico (2009) use a FAVAR approach to investigate international structural shocks (such as a fall in short-term world interest rates). On a panel of data for 17 industrialised countries, the authors investigate the impact of these shocks on the UK economy by using a panel FAVAR model. Smith and Zoega (2005) also use a panel FAVAR model to explore the link between changes in unemployment and investment in 21 OECD countries over the period 1960-2002.

Among papers by Croatian authors, one may single out the useful application of factor analysis in forecasting inflation given in Kunovac (2007), though he applies a FAVAR model differently than the previously mentioned papers. Kunovac (2007) tests whether information derived from 144 economic variables (represented by only a few constructed factors) can be used for the forecasting of consumer prices in Croatia and confirms that the use of one factor enhances the precision of the model's ability to forecast inflation.

With regard to the use of factor analysis in error correction models in this paper, one should mention the paper by Banerjee and Marcellino (2008). In that paper, the authors bring together several important strands of the econometrics literature: error correction, cointegration and dynamic factor models. The authors define the Factor-augmented Error Correction Model (FECM), where the factors estimated from a large set of variables in levels are jointly modelled with a few key economic variables of interest. Banerjee and Marcellino (2008) stress that, in contrast with the standard Error Correction Model, the FECM protects, at least in part, against omitted variable bias and the dependence of cointegration analysis on the specific limited set of variables under analysis.

In addition, the FECM is a natural generalization of FAVAR models defined by Bernanke et al. (2005). FAVAR models are specified in first differences and are therefore misspecified in the presence of cointegration. Also, Banerjee and Marcellino (2008) use simulations and empirical applications to show that the FECM is systematically better than the FAVAR and the ECM in terms of the explanatory power of the model. The analysis and conclusions of that paper are further explained by Banerjee, Marcellino and Masten (2009), who point out advantages of the forecasting based on the FECM.

Factor analysis will be used in this paper to calculate the macroeconomic environment factor based on about a hundred time series that describe overall developments in the Croatian economy. Together with household/corporate loans and the monetary policy indicator, the estimated factor will eventually augment the vector error correction (VEC) model, and thus become the FAVEC model (Factor Augmented Vector Error Correction Model).

9 A large number of parameters that would have to be estimated by a large number of variables in a VAR may reduce the robustness of results due to many degrees of freedom.

10 Papers relying on the FAVAR methodology often compare their results with those of VAR models.

4 Empirical estimation of the FAVEC model

4.1 Data description

The data set used in the econometric analysis in this paper covers the period from January 2003 to December 2010. The year 2003 was chosen as the beginning of the sample period as at that time the CNB first began to impose direct limits on bank credit growth (as explained in the second section). The data frequency is monthly so that time series contain 96 data each. The sections below describe in detail the calculation of the macroeconomic environment factor and the definition of the monetary policy indicator. The third variable included in the model is loans, with household and corporate loans being considered separately. They need no further explanation as loan values are neither derived nor estimated.

4.1.1 Calculation of the macroeconomic environment factor

The factor of the macroeconomic environment in Croatia is calculated on the basis of 108 time series. This large set of data covers developments in nearly all relevant fields that describe the Croatian economy. Finally, the estimated value of the factor describes well the overall economic activity in the country. The method of principal components was used in the calculation. It was determined in advance that one factor would be extracted from the data set and later used in the model. The macroeconomic environment factor was calculated for a period that is a bit longer than the one to be used in the econometric estimation of the FAVEC model, i.e. from January 2000 to December 2010.

The advantage of the estimated factor is that it is calculated according to high-frequency data, i.e. on a monthly basis. As data on loans and the monetary policy indicator are also available on a monthly basis, it will be possible to estimate the cointegration model on a larger sample. This protects against the loss of information on developments within a quarter, which would be the case if GDP data were used instead of the factor.

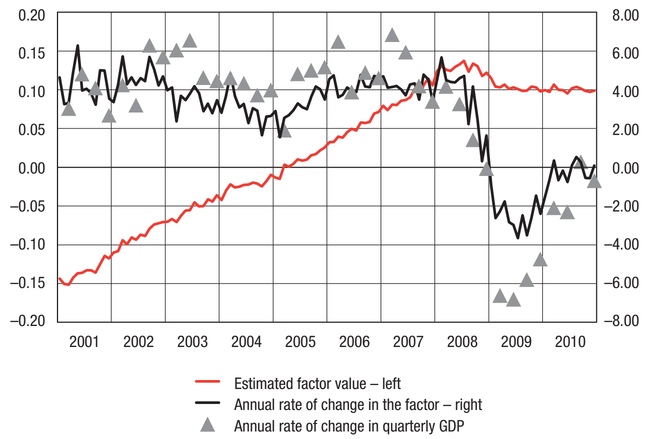
The series used to calculate the factor may be grouped in the following sets: price and exchange rate series, real sector series, wages and employment series, tourism sector series, external sector series, monetary and financial series, interest rate series and fiscal sector series.[11] Used are original data in levels without transformations in the form of logarithms, differentiating or growth rates. The X-12 ARIMA method is used to eliminate the seasonal component from all time series with the exception of interest rates, which do not exhibit significant seasonal dynamics. For some series with pronounced seasonal patterns, such as the number of arrivals and nights stayed by tourists, it was important to eliminate seasonal fluctuations to justify their use in factor estimation. Although the seasonal adjustment process was not so important for some other series it still reduced the range of fluctuations.

Figure 4 shows developments in the estimated value of the macroeconomic environment factor in Croatia from 2001 to 2010. One may note that the estimated value of the factor captures overall developments in the economy very well. The Croatian economy was on an upward trend throughout most of the period, until the crisis emerged in 2008, when it fell into recession. The economy took a dive in 2009 and held steady in 2010. This is confirmed by the annual growth rates calculated on the basis of estimated factor values, which are similar to movements in annual growth rates of change in quarterly GDP. The factor thus approximates overall domestic demand in terms of the impact of domestic sector demand for loans on a monthly basis. The good representative quality of the factor confirms the usefulness of factor analysis and gives a reason to include the factor in the cointegration estimation.

The correlation between the variables used in factor estimation and the factor itself may be analysed through factor loadings. As stated by Hair et al. (2006), factor loadings are crucial to understand the nature of the estimated factor. The factor loadings indicate the degree of correlation between a certain variable and the

11 A detailed description of all time series used in the factor calculation is given in Appendix I at the end of the paper.

Figure 4 Estimated macroeconomic environment factor in Croatia, 2001–2010



Sources: CBS, CNB and author's calculations.

factor. The bigger the factor loadings, the bigger the variable importance in the factor definition (Hair et al., 2006).

The analysis of the factor loadings showed that the estimated factor has the strongest positive correlation mostly with monetary series (in particular, monetary aggregates), international reserves, wage indicators, individual price indices, construction, external debt (total and separate for commercial banks), and central government debt. Industrial production and exports may also be added to this.[12] These variables characterise different sectors of the Croatian economy and their increase may be economically correlated (interpreted) with the increase in the factor and overall economic activity.

The same may be confirmed for the largest negative factor loadings. This primarily relates to exchange rate variables, both the real effective and nominal exchange rate (against the US dollar), followed by the administrative unemployment rate and the number of the unemployed, money multipliers and individual series of banks' interest rates. These series are expected to have negative factor loadings. In particular, their increase (exchange rate depreciation, an increase in interest rates and unemployment) may, as a rule, be correlated with the fall in overall economic activity (decrease in the value of the macroeconomic environment factor).

Series whose factor loading values are close to zero (e.g. free reserves, EMBI spread on Croatian government debt, excises on refined petroleum products, etc.) are weakly significant for the definition of the macroeconomic environment factor. However, as Hair et al. (2006) point out, even these variables are needed for factor significance as they also provide information that is built in developments of the estimated factor. This is particularly true in analyses of either a very large sample or a large number of variables, both of which are the case in this paper.

One of the main disadvantages of the estimated factor is its value, which ranges from –0.15 to 0.14 and does not have any economic meaning. This will hamper the subsequent interpretation of the results as the cointegration model uses series in levels. However, an analysis of FAVEC model results will be based on estimations of impulse response functions, i.e. the extent to which a shock on the demand (factor) side affects developments in loans. An interpretation of the value of the parameters estimated in equations will be less important.

4.1.2 Calculation of the monetary policy indicator

When estimating the effects of monetary policy on bank lending, what is usually considered is the central bank's benchmark rate, which is used to analyse the lending channel. This channel is one of the

12 The values of the factor loadings for individual variables are available on request (to the author).

segments of the monetary policy transmission mechanism. Due to the weak transmission mechanism the CNB has never used interest rate policy to achieve its primary objective. Therefore, in the absence of an interest rate variable needed for an econometric analysis, it is necessary to construct an alternative indicator of monetary policy.

A discussion and estimate of the monetary policy indicator in Croatia is given by Lang and Krznar (2004). They note that in the case of Croatia it is extremely difficult to construct a valid and reliable indicator that would reflect monetary policy actions. They stress the problem of the lack of a benchmark rate and a large number of monetary policy instruments and structural breaks in short time series. They also point out that an appropriate monetary policy indicator for a small and open economy such as Croatia could be found in the so-called "monetary condition index" (MCI),[13] but even that indicator was described as suboptimal as it had certain deficiencies.

Apart from discussing limitations, Lang and Krznar estimate the indicator of monetary policy stance on the basis of a structural VAR model. They use the nominal exchange rate and excess liquidity in the system as the main monetary policy variables. Administrative measures of the CNB were not included in the construction of the indicator used to estimate the lending channel. They estimate two separate models to analyse banks' heterogeneous characteristics in the adjustment of credit supply to monetary policy changes. The results are not unambiguous and do not indicate a robust presence of the credit channel.

In estimating monetary transmission channels in Croatia, Vizek (2006) analyses the influence of the exchange rate, interest rate and direct monetary transmission channels. The monetary variables used are the HRK/EUR exchange rate, the overnight money market interest rate and money (M1). However, none of these variables is an adequate indicator of monetary policy in terms of the measures the CNB used to influence loans. The HRK/EUR exchange rate was kept stable and its stability was not aimed at controlling credit expansion. Money is a monetary aggregate that includes currency and demand deposits in banks so that it weakly reflects the decisions of the central bank. Finally, Vizek (2006) confirms that monetary policy in Croatia does not affect real activity through the interest rate channel and is therefore not used to influence loans.

In the context of this paper, the monetary policy indicator should appropriately reflect the effects of measures to control credit developments. As described in the second section, monetary policy in Croatia relied on various forms of reserve requirements in preceding years. Combined with the effect of higher regulatory costs, these reserves immobilised some sources of funds (bank liabilities) and prevented their use for lending purposes. It should be added that control over lending is not the main purpose of reserve requirements. They have a much broader role in the control of the overall money supply, which, particularly in the case of Croatia, was used systematically to influence conditions in the money and foreign exchange markets. This was done to maintain the stability of the exchange rate and prices in conditions of abundant foreign capital inflows. For this reason, the indicator will be based on a simple balance sheet approach to reflect changes in immobilised bank funds, which the CNB sterilised or, more recently, released by means of monetary policy measures.

With this in mind, the monetary policy indicator is defined by the following formula:

$$MP = (RR + FA)/L. \tag{4}$$

RR denotes all reserve requirement funds that commercial banks have to set aside with the CNB or maintain in special accounts. *FA* denotes foreign assets of banks. They may be seen as (foreign currency) reserves as banks were forced during the entire reference period to hold minimum foreign currency liquidity in line with the prescribed ratio between liquid foreign currency claims and total foreign currency liabilities. *L* stands for total liabilities of banks (deposit base and capital). Although bank capital may be seen as a monetary policy variable in terms of preserving the system's financial stability, it is also a long-term funding source. In the

13 MCI is usually defined as the weighted index that shows the relative influence of interest and exchange rates on real economic developments and/or prices, and is most often calculated according to the following formula:

$$MCI_t = \alpha(i_t - i_0) + \beta(e_t - e_0), \alpha + \beta = 1$$

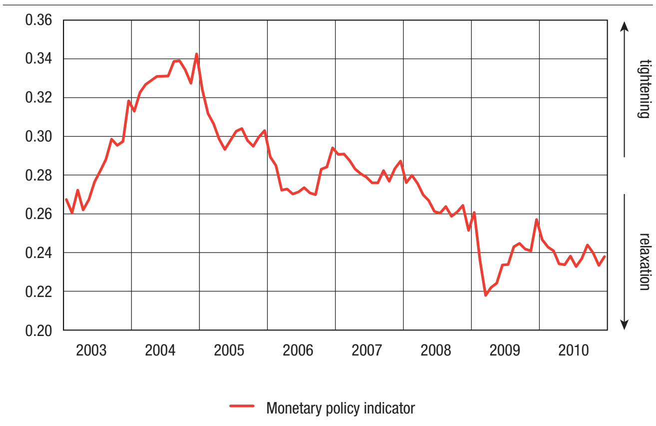
where i is the interest rate, e is the exchange rate, α is the weight of the interest rate and β is the weight of the exchange rate. Values of interest and exchange rates in a selected base period are i_0 and e_0.

context of an econometric estimate of the impact of central bank actions on bank lending, the indicator constructed in this way represents bank liabilities that are unavailable for credit placements.

Banks also maintain foreign assets for the purpose of investing abroad or for managing internal liquidity, so they are not fully determined by monetary policy requirements. However, in the course of the period under review, the total amount of foreign currency assets was on average needed to meet the minimum foreign currency liquidity requirement. Immediately after the requirement was cut banks reduced their foreign assets. In addition, foreign liabilities of banks were always larger than foreign assets. Therefore, it would not make sense for banks to borrow abroad and place these funds back abroad, most often with parent banks (a large portion of foreign assets consists of time deposits with foreign banks, which cannot be considered as true placements). All this justifies the inclusion of banks' foreign assets into the monetary policy indicator, particularly in the context of CNB actions to limit credit growth of banks.

Other modifications to the basic construction were made in the process of indicator identification. In one instance capital was excluded from bank liabilities as it is a long-term source and is not included in the base for the calculation of reserve requirements. Other adjustments were also applied for excess kuna and foreign currency liquidity in the banking system (their subtraction from bank assets). As none of the modifications to the relation (4) provided an indicator that would significantly differ from the basic indicator (correlation between all indicators was high), and as they did not reflect CNB actions better or more precisely, the originally defined ratio given in the relation (4) was maintained.

Figure 5 Monetary policy indicator



Source: Author's calculations.

Figure 5 shows developments in the monetary policy indicator in the 2003-2010 period; its increase indicates a tightening and its reduction indicates a relaxation of the monetary policy stance. By definition, an increase denotes growth in immobilised funds of banks and is viewed as a restrictive action of the central bank. By contrast, a fall in the indicator indicates a release of the funds previously set aside and signals an expansionary monetary policy.

Developments of the indicator properly illustrate the direction of CNB actions. The indicator steadily grew from the time administrative limits on credit growth (purchase of compulsory CNB bills) were introduced in 2003. With the introduction of marginal reserve requirements in 2004, the growth continued, albeit at a slightly slower pace. The indicator dropped in 2005 and early 2006 largely due to the cut in the reserve requirement rate. In late 2006, the indicator again jumped as the central bank adopted a decision to include foreign currency-indexed kuna liabilities into the base for the maintenance of minimum required foreign currency claims, which forced banks to increase their liquid foreign currency assets. In 2007 and the first half of 2008, the indicator again fluctuated around levels somewhat higher than in early 2003, but was much lower than in late 2003 and 2004, when the reserve requirement rate and the minimum foreign currency liquidity ratio were higher by 2 percentage points and 3 percentage points respectively. Furthermore, although the CNB reintroduced the purchase of compulsory CNB bills in 2007, there were no changes in other instruments that would indicate a restrictive stance of the CNB in 2007 and throughout most of the first half of 2008.[14]

With the spillover effects of the global crisis on domestic developments, which culminated in late 2008 and early 2009, the indicator decreased as the CNB relaxed or abolished a number of instruments to release substantial funds. The set of CNB instruments did not change in the remainder of 2009 and in 2010 and was much less demanding than in the pre-crisis period.

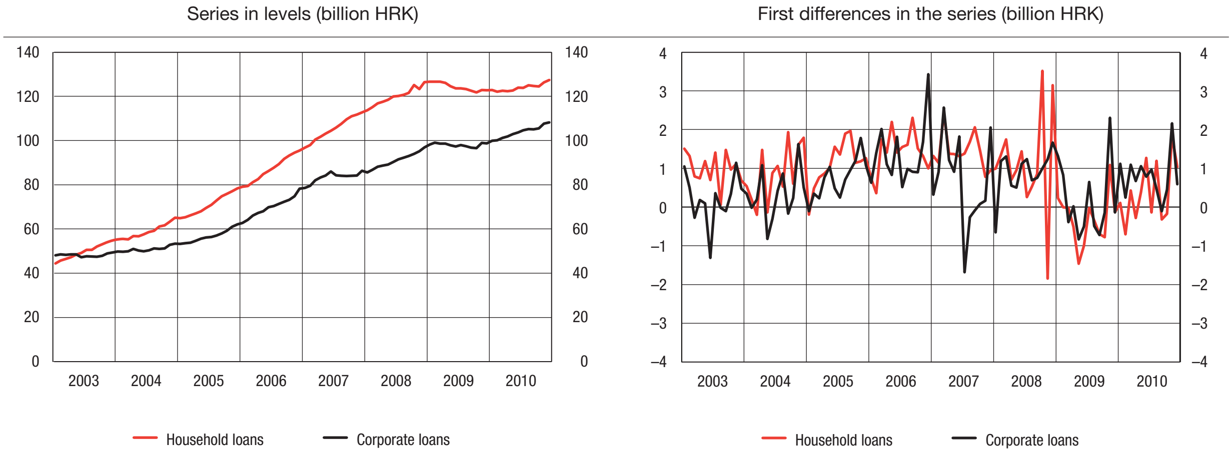
The late 2009 changes in this indicator point to its deficiency. Its increase at that time was due to the high kuna and foreign currency liquidity of banks and not to the actual tightening of the monetary policy stance. The CNB created significant liquidity surpluses to alleviate the conditions in the domestic money market and create more favourable financing terms. However, against the backdrop of weaker demand as well as supply by banks, liquidity surpluses remained in the system without significant credit growth, which pushed the indicator up.[15] As this problem was observed only in the second half of 2009 it may be viewed as an exceptional phenomenon.

4.2 Cointegration testing

Before applying the Johansen procedure one should consider the stationarity and order of integration of the time series. If series are non-stationary, cointegration will be used to test whether it is possible to find their stationary linear combination. In that case, it would represent a long-term equilibrium between variables.

A graphical analysis provides a basic insight into the stationarity of the series. Figure 7 shows developments in household and corporate loans in levels and first differences. The series in levels are not stationary and exhibit an upward trend through most of the period under review. This trend came to a stop only in late 2008 and 2009. A slight recovery began in 2010 (even a little earlier for the corporate sector). Nevertheless, one may conclude that these are definitely not stationary series that return to their average or fluctuate around it.

Figure 6 Household and corporate loans, in levels and first differences

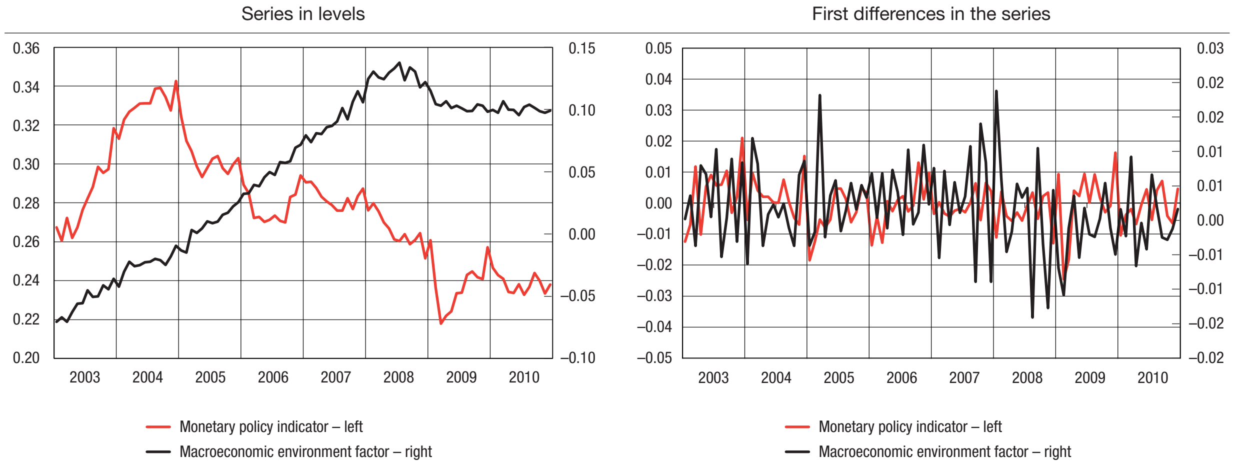


Source: Author's calculations.

14 The rate of reserve requirements (17%) and marginal reserve requirements (55%) stayed the same, while the minimum foreign currency liquidity ratio was reduced from 32% to 28.5% in May 2008.

15 The surplus kuna liquidity of banks is reported in banks' settlement accounts with the central bank. It is included in the numerator of the monetary policy indicator (*RR*), while surplus foreign currency liquidity is maintained in foreign assets, which are also part of the numerator of the monetary policy indicator (*FA*). At the same time, in conditions of stagnant bank lending, no increase was recorded either in total assets of banks or in their liabilities, which are in the denominator of the indicator (*L*). All this pushed the indicator up although the central bank did not actually implement restrictive monetary policy measures.

Figure 7 Macroeconomic environment factor and monetary policy indicator, in levels and first differences



Source: Author's calculations.

Household and corporate loans do not exhibit upward trends after differentiation, which is in contrast with the series in levels. They now fluctuate around zero. However, fluctuations stayed in the above zero part of the figure in the period roughly from 2005 to 2007. This confirms the period of rapid credit growth.

It is obvious from Figure 7 that the stationarity of the series for the macroeconomic environment factor and the monetary policy indicator is achieved after their differentiation, as it is with loans. Factor changes in levels resemble a trend stationary process up until the crisis year of 2008, while the monetary policy indicator moves in various directions. Volatility of the differentiated factor is much larger than volatility of the monetary policy indicator. This is also expected as monetary policy decisions are characterised by large persistence. The central bank usually does not adopt decisions with opposite effects month by month.

Stationarity was formally tested by the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test.[16] The series of household and corporate loans and the macroeconomic environment factor show that a trend is present in the data. For this reason, in addition to a constant, tests included a trend component. The test results confirmed that the null hypothesis of unit root cannot be rejected for any observed variable in levels. By contrast, with regard to differentiated series, in almost all cases it is possible to reject the null hypothesis of non-stationarity at the 1% level of significance. The only exception is the ADF test for household loans where the null hypothesis cannot be rejected even after differentiating. However, results of the PP test are opposite and confirm at the 1% significance level that the variable of household loans is also first-order integrated.

Although the tests for household loans do not yield unambiguous results, the graphical presentation shows the stationarity of the series in first differences. In addition, the power and statistical significance of unit root tests are sometimes very questionable. Structural breaks can significantly disrupt the testing process. For example, a change in the (monetary) policy regime may turn a stationary into a non-stationary series. As there were indeed many changes in monetary policy instruments in Croatia in the observed period (although one may hardly say that the entire regime changed at some point in time), these changes definitely created some noise in the household loan series. Furthermore, the upward trend in household loans came to a stop at the onset of the crisis, which may indicate a structural break.[17] Finally accepted will be the assumption that the series of household loans is first-order integrated $I(1)$, particularly bearing in mind the results of the PP test and analysis of the graphical presentation.

Once it was determined that all series are first-order integrated, the Johansen procedure was run to test

16 The results of unit root tests are available on request.

17 The household loan series was further tested by the Zivot-Andrews unit root test, which shows that at the 10% significance level it is possible to reject the null hypothesis that the first differentiation of the household loan series is stationary with a structural break in the constant. Also, the test indicates a structural break in late 2008, at the time when the effects of the global crisis began to spill over onto domestic developments. Large swings in the exchange rate as well as in the nominal amount of household loans were observed, after which the rise in loans to that sector came to a standstill.

their long-term correlation on data covering the period from January 2003 to December 2010. The trace test (λ_{trace}) and the maximum eigenvalue test (λ_{max}) are used to test the presence of cointegration between corporate loans, the macroeconomic environment factor and the monetary policy indicator, as well as between household loans, the macroeconomic environment factor and the monetary policy indicator.

Before cointegration testing it is necessary to estimate a VAR model in order to select an optimum number of lags to be applied in the model. As usual, information criteria failed to provide a single answer to the question of how many lags should be used in the model estimation.[18] The AIC criterion suggests four lags and SC and HQ suggest one lag for the VAR model with corporate loans, while for household loans an optimum number of lags is six (AIC) and one (SC and HQ) respectively. The number of lags for the VEC model is one fewer than for the VAR model. In the model for corporate loans the maximum and minimum number of lags could be from three to zero (which does not make sense), while it would be from five to zero for household loans (which also does not make sense). In view of the assumption that there is a residual autocorrelation problem it seems more justified to test cointegration on a model with more lags, in line with the AIC criterion.[19] Cointegration testing is run on a model with three lags (according to the AIC criterion for corporate loans), which seems optimal as it takes account of the autocorrelation problem and preserves degrees of freedom (a larger number of lags, for example five, considerably increases the number of estimated parameters in the model).

Tables 2 and 3 show results of the trace test and the maximum eigenvalue test made to test the number of possible cointegration vectors between corporate loans, the macroeconomic environment factor and the monetary policy indicator. The model was specified with a constant in the cointegration space (long-run model) and the VAR model (short-run model), while the long-run relation also includes a trend component.[20]

Both tests show that cointegration was not confirmed between corporate loans, the macroeconomic environment factor and the monetary policy indicator on a sample from 2003 to 2010. Already in the first step, the null hypothesis, which says that there is no cointegration between variables, cannot be rejected at the 5% significance level, so that testing is stopped. This means that results for the next two null hypotheses, stating that there are at most one or two cointegration vectors, are not needed.

To check the robustness of the results, the tests were run on models with one and two lags, which is in contrast with the AIC information criterion. In no case was cointegration confirmed. This implies that with

Table 2 Testing the number of cointegration vectors between corporate loans, the macroeconomic environment factor and the monetary policy indicator (λ_{trace})

H_0 Number of cointegration vectors	Eigenvalue	Test value λ_{trace}	Critical value 0.05	Probability
None	0.1621	31.4770	42.9152	0.4171
One at most	0.0962	14.8558	25.8721	0.5865
Two at most	0.0552	5.3391	12.5180	0.5484

Source: Author's calculations.

Table 3 Testing the number of cointegration vectors between corporate loans, the macroeconomic environment factor and the monetary policy indicator (λ_{max})

H_0 Number of cointegration vectors	Eigenvalue	Test value λ_{max}	Critical value 0.05	Probability
None	0.1621	16.6211	25.8232	0.4900
One at most	0.0962	9.5167	19.3870	0.6704
Two at most	0.0552	5.3391	12.5179	0.5484

Source: Author's calculations.

18 The values for information criteria are available on request.

19 Hülsewig et al. (2002) use an equivalent approach and the same explanation of the autocorrelation problem to test a VEC model of the lending channel in Germany. Testing for residual autocorrelation will be run subsequently, when assessing the quality of the model.

20 The rationale for introducing a trend component in the long-run relation is discussed in detail in the next section.

regard to corporate loans it would be necessary to estimate the VAR model in first differences. However, as this paper aims at analysing long-run relations between loans, monetary policy and the macroeconomic environment, the modelling for corporate loans ends at this point.

Inability to confirm cointegration could in this case be related to the fact that developments in domestic loans to the corporate sector were also associated with external financing to this sector, which limited the effect of monetary policy on corporate loans. As shown in the second section, monetary policy measures to limit credit growth strongly affected the structure of total funding to enterprises. In contrast to households, enterprises had the opportunity to borrow from sources other than banks.

In contrast to the case of enterprises, results of the trace test and the maximum eigenvalue test for the model that includes household loans, the macroeconomic environment factor and the monetary policy indicator unambiguously point to the existence of one cointegration vector. In both cases the null hypothesis of non-existence of the cointegration vector can be rejected at the 5% significance level. The next hypothesis, i.e. that there is at most one cointegration vector, cannot be rejected. Therefore, in line with the Johansen procedure, the testing is interrupted and the number of cointegration vectors is no larger than one. The model was specified with a constant and a trend in the cointegration space (long-run model) and the VAR model (short-run model). To check the robustness of the results, the cointegration test was repeated with one and two lags. The presence of one cointegration vector is significantly confirmed in both cases.

Table 4 Testing the number of cointegration vectors between household loans, the macroeconomic environment factor and the monetary policy indicator (λ_{trace})

H_0 Number of cointegration vector	Eigenvalue	Test value λ_{trace}	Critical value 0.05	Probability
None*	0.2956	45.6623	42.9152	0.0259
One at most	0.0900	12.7208	25.8721	0.7597
Two at most	0.0402	3.8534	12.5180	0.7632

Note: Asterisk (*) denotes that the null hypothesis is rejected at the 5% level of significance.
Source: Author's calculations.

Table 5 Testing the number of cointegration vectors between household loans, the macroeconomic environment factor and the monetary policy indicator (λ_{max})

H_0 Number of cointegration vector	Eigenvalue	Test value λ_{max}	Critical value 0.05	Probability
None*	0.2956	32.9415	25.8232	0.0049
One at most	0.09	8.8673	19.3870	0.7380
Two at most	0.0402	3.8534	12.5179	0.7632

Note: Asterisk (*) denotes that the null hypothesis is rejected at the 5% level of significance.
Source: Author's calculations.

4.3 FAVEC model results for household loans

The tests indicated the existence of one cointegration relation between household loans, the macroeconomic environment factor and the monetary policy indicator, while this was not confirmed for corporate loans. The final estimation and specification of the FAVEC model and analysis of impulse response functions in the reminder of the paper are conducted exclusively for the household loan model. The model is specified with three lags and a trend component in the cointegration relation.

The inclusion of the trend in the cointegration space, which proved to be statistically significant, can have several econometric and theoretical implications. First, it can indicate the trend stationarity of one or several variables in the model. Second, as stated by Hendry and Juselius (2000), it is possible that the trend stationarity may be characteristic for the entire long-run cointegration relation. When two (or more) variables share the same stochastic and deterministic trends, it is possible to find a linear combination that cancels both trends. The resulting cointegration relation is not trending, even if the variables by themselves are. As Hendry and

Juselius (2000) state, this is the reason why the trend component is included in the cointegration space. In other cases, a linear combination of variables removes the stochastic but not the deterministic trend. In such cases, the deterministic trend should also be included in the cointegration space.

In addition, it is often the case that structural relations in the model are not fully explained by the model variables. Therefore, the deterministic trend could reflect the effect of some other variable or economic process, for example in this case it could reflect the impact of loan supply. Croatian banks expanded their lending activity in the reference period so as to increase their market shares against the background of enhanced competition. This is why, in addition to higher demand, loan supply certainly had a strong impact on overall credit growth. This is regardless of whether it involved interest rate policies, relaxation of loan terms for clients or aggressive marketing actions. As the effect of loan supply is not included either in the macroeconomic environment factor or in the monetary policy indicator, the trend in the cointegration space may be an approximation of the supply effect.

In this way, the deterministic trend is given a role in the interpretation of the results. In various papers, this role often has its backing in economic theory as well as practice, and serves as an additional specification to capture influences beyond basic model variables. For example, Doornik et al. (1998) separately test various model specifications depending on the inclusion/exclusion of deterministic elements, which according to them play a crucial role in the final model estimation. The authors say that preference for one model over the other may be due to purely economic reasons. In their example of UK money demand, a linear trend in the cointegration space approximates the rise in total real final consumption, which is a result of the accumulation of human and physical capital. An example in the domestic literature can be found in Malešević Perović (2009). In this cointegration analysis of inflation in Croatia, a significant linear trend approximates technological progress or the impact of economic restructuring in favour of more productive sectors.

In estimating cointegration, one should note that inclusion or exclusion of deterministic components may lead to significantly different results and conclusions. This was best illustrated by Ahking (2002) in his estimate of the US long-run money demand. Ahking shows that merely by including/excluding a linear deterministic trend one may confirm/reject the presence of cointegration between real monetary aggregates. Therefore, model mis-specification may impair the robustness of results. In the literature one may find other interesting findings illustrating that tests of various models under the Johansen procedure often lead to considerable bias in the model selection with a constant in the VAR model and the cointegration space. Actually, the true model is the one that includes a trend in the cointegration space. This is illustrated in the study by Hjelm and Johansson (2002) on the pitfalls in determining deterministic components in cointegrating models. Hjelm and Johansson suggest that when, following the so-called "Pantula principle" (the procedure of selecting one out of the five models of cointegration), one selects a model without a trend, it is necessary to test for the presence of the trend component in the cointegrating space. If the null hypothesis of no trend is rejected, one should choose a model with a trend in the cointegrating space.

With all the mentioned implications and caution, this paper showed that the inclusion of the trend in the cointegration space proved to be significant and justified. The inclusion of the trend did not change the number of cointegration relations (one cointegration equation was found in both cases) and there were no important differences in estimation results. As explained above, the trend in the cointegration space is also given an economic interpretation as it would approximate the impact of loan supply by banks on the overall increase in household loans.

Under the estimated FAVEC model, the cointegration vector, i.e. the long-run equation for household loans is as follows:

$$loans\_h_t = 73.19 + 29.70F_t - 65.61MP_t + 0.27t, \tag{5}$$

where all coefficients are statistically significant and with the expected sign. Monetary policy tightening (increase in the indicator) thus leads to a decrease in lending to households. This confirms that CNB measures aimed at slowing down excessive credit expansion in the previous years affected long-term developments in household loans. At the same time, the rise in the macroeconomic environment factor, which generally implies growth in overall economic activity, has a positive impact on household loans. This result is also expected in view of the fact that economic growth was largely spurred by the rise in personal consumption. Therefore, it illustrates well the impact of loan demand by domestic sectors, i.e. households. The estimated parameter with the trend in the long-run equation is also positive. Assuming that the trend approximates loan supply, one may conclude that the effect also has the expected sign since an increase in loan supply should definitely provide a boost to the rise in household loans.

The finally specified FAVEC model, which includes one long-run relation (6), is defined with three lags. It includes the trend and the constant in the cointegration relation and the constant outside the cointegration space. The thus defined equation of the FAVEC model for household loans with the estimated parameters is as follows:

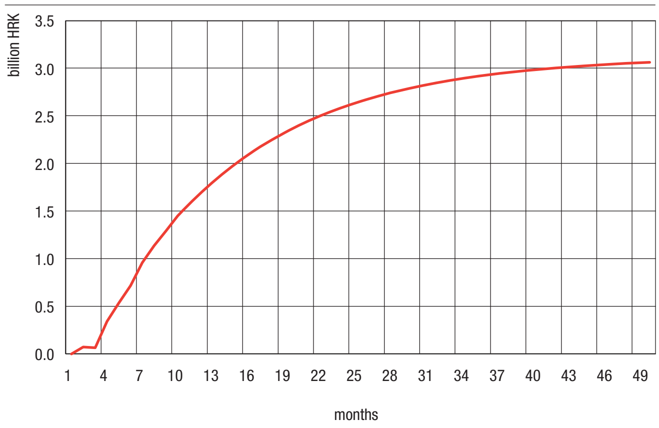
$$\Delta loans\_h_t = -\overbrace{\underset{(-5.89)}{0.24}}^{\substack{error\\correction\\factor}} \overbrace{(loans\_h - \underset{(-19.0)}{29.70}F + \underset{(4.38)}{65.61}MP - \underset{(-6.20)}{0.27}t - 73.19)_{t-1}}^{cointegration\ relation} - \underset{(-1.64)}{0.15}\Delta loans\_h_{t-1} +$$
$$+\underset{(3.40)}{0.29}\Delta loans\_h_{t-2} + \underset{(1.93)}{0.18}\Delta loans\_h_{t-3} - \underset{(-3.16)}{5.73}\Delta_{t-1} - \underset{(-3.38)}{6.02}\Delta F_{t-2} - \underset{(-1.03)}{1.59}\Delta F_{t-3} + \underset{(0.81)}{8.03}\Delta MP_{t-1} +$$
$$+\underset{(0.46)}{4.29}\Delta MP_{t-2} + \underset{(1.02)}{8.89}\Delta MP_{t-3} + \underset{5.39}{0.84} + \varepsilon_{loans\_h,t} \qquad (6)$$

where *loans_h* denotes household loans, F is the macroeconomic environment factor, MP is the monetary policy indicator and t is the deterministic trend in the cointegration space. A detailed presentation of the entire FAVEC model is given in Appendix II. In addition to the estimated coefficients given here, their corresponding t-test values are shown in the parentheses below. The error correction speed (factor) shows that the system will adjust to the equilibrium, i.e. reduce imbalances by 25% on average in each period.

Interpretation of the values of the coefficients is a little difficult since the factor has no unit of measurement but is a statistical measure that covers overall developments in the economy. However, the statistical significance of all estimated coefficients in the long-run equation and the expected signs enable an analysis of impulse response functions.

Before presenting impulse response functions it should be noted that diagnostic tests for residuals in the estimated FAVEC model confirmed the validity of the estimated model and the robustness of the results. The tests confirmed that the residuals, separately and collectively, do not impair the assumptions necessary for the model validity. This refers to testing for the presence of autocorrelation and serial correlation between the residuals, for the heteroscedasticity of the residuals and analysis of their normality.[21]

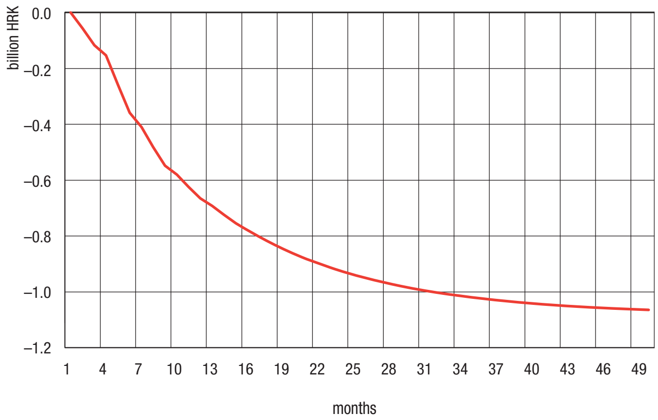
Figure 8 Impulse response function of household loans to the shock in the macroeconomic environment factor



Source: Author's calculations.

21 The results of diagnostic tests are given in Appendix III.

Figure 9 Impulse response function of household loans to the shock in the monetary policy indicator



Source: Author's calculations.

Figures 8 and 9 show impulse response functions of household loans on the shock in the macroeconomic environment factor and the monetary policy indicator of one standard deviation. The shocks represent an improvement in the macroeconomic environment in terms of increased economic activity and the resultant growth in domestic demand (rise in the factor), and monetary policy tightening (an increase in the monetary policy indicator). The response of household loans to these shocks is shown for a period of 50 months. In contrast with the VAR model, for the validity of impulse response functions based on the VEC model it is important that values of the variable response converge to a specific value over time.

Responses of household loans to shocks are of the expected direction and in line with the estimated parameters of the FAVEC model. A positive shock in the macroeconomic environment factor leads to the rise in household loans. It is evident that loans do not respond to shocks immediately but only after several months. The strongest increase in loans occurs in the next two years, after which response begins to fade away. In line with the given statistical characteristics, the impulse response function in the VEC model does not return to zero, but converges to a specific level. Finally, this impulse response function clearly confirms the long-run relation that leads to the positive growth in loans to the household sector during periods of growth in domestic economic activity.

The response is also expected with regard to the shock in the monetary policy indicator (Figure 9). Household loans decrease in response to monetary policy tightening. The response is most prominent during the first year and a half and fades away over time. This result confirms that the monetary policy measures of the CNB, which were more based on administrative limits to credit growth than on market restrictions (interest rates), did indeed influence bank lending to households.

It is difficult to interpret and quantify precisely impulse response functions as shocks are defined in terms of standard deviations while factor values have no reasonable economic interpretation. Still, observing the levels to which the response of household loans converges, one may notice that these loans react more strongly to a shock in the macroeconomic environment than to a monetary policy shock.

5 Conclusion

In preceding years, the Croatian National Bank influenced bank lending by a number of measures and instruments. Until recently, the main objective of these measures was to curb and contain loan growth within limits sustainable in the long run so as to reduce the country's external imbalances. In late 2008 and 2009, the motivation for central bank actions turned around as the entry into the crisis period was accompanied by a halt in bank lending. The CNB found itself in a situation in which it wanted to spur credit growth that would help to bring about economic recovery. In the context of these two divergent motivations, this paper tested the presence of cointegration and long-run correlation between the impact of monetary policy and household and corporate loans, while taking account of the effects of the entire macroeconomic environment.

Cointegration testing was made using the Johansen procedure based on a factor-augmented vector error correction model (FAVEC model) for the period from January 2003 to December 2010, where the factor represents developments in the macroeconomic environment. The tests confirmed significantly the existence of the cointegration relation between household loans, the macroeconomic environment factor and the monetary policy indicator. At the same time, no such relation was confirmed for corporate loans. This is probably due to the fact that, in contrast with households, enterprises had raised substantial funds from other sources (particularly abroad) in preceding years, and not only from commercial banks. This limited the impact of monetary policy on corporate loans.

The estimated FAVEC model and the related impulse response functions showed that a restrictive monetary policy shock leads to a decrease in household loans. This confirms that CNB measures do indeed influence bank lending to households in the long run. At the same time, a positive shock in the macroeconomic environment factor, which implies growth in overall economic activity, has a favourable effect on bank loans to households. This is expected in view of the fact that economic growth was largely spurred by the rise in personal consumption, which was in turn financed by loans. Impulse response functions indicate that household loans react more strongly to a shock in the macroeconomic environment than to a monetary policy shock. The further specification of the model approximated the impact of banks' credit supply and also confirmed the positive influence of larger supply on the rise in household loans.

The monetary policy indicator, which takes into account the complexity of CNB measures, was constructed and showed as an adequate representation of central bank actions. Factor analysis was used to estimate the macroeconomic environment factor that faithfully illustrates the changes in domestic demand based on information from numerous time series of the Croatian economy. This illustrated the usefulness of factor analysis in summarising a large number of data, which enabled an empirical estimate of the FAVEC model.

Finally, based on the identification of the long-run impact of central bank actions on household loans, one may conclude that CNB measures were justified; without them, credit growth would certainly have been larger, which means that external imbalances in the Croatian economy would have been worse. The economy would have entered the crisis period in a more difficult position. Still, this is not to play down the structural problems faced by the domestic economy. Circumstances and structural relations in the economy have considerably changed in the crisis period. Therefore, it will be interesting to see how bank lending will change and what the impact of the CNB will be in the forthcoming period, as well as whether the estimated long-run relation will stay the same or change.

Appendix I List of the time series used to calculate the macroeconomic environment factor

No.	Name	Seasonally adjusted	Source
	Prices and the exchange rate		
1.	Consumer price index	Yes	CBS
2.	Price index – food and non-alcoholic beverages	Yes	CBS
3.	Price index – alcoholic beverages and tobacco	Yes	CBS
4.	Price index – clothing and footwear	Yes	CBS
5.	Price index – housing, water, electricity and other fuels	Yes	CBS
6.	Price index – furnishings	Yes	CBS
7.	Price index – health	Yes	CBS
8.	Price index – transport	Yes	CBS
9.	Price index – communications	Yes	CBS
10.	Price index – recreation and culture	Yes	CBS
11.	Price index – education	Yes	CBS
12.	Price index – catering and accommodation services	Yes	CBS
13.	Price index – other goods and services	Yes	CBS
14.	Price index – goods	Yes	CBS
15.	Price index – services	Yes	CBS
16.	Producer price index	Yes	CBS
17.	Producer price index of industrial products	Yes	CBS
18.	Price index of intermediate goods	Yes	CBS
19.	Price index of capital goods	Yes	CBS
20.	Price index of non-durable consumer goods	Yes	CBS
21.	Price index of durable consumer goods	Yes	CBS
22.	Core inflation	Yes	CBS
23.	HRK/CHF exchange rate – average monthly	Yes	CNB
24.	HRK/CHF exchange rate – end of month	Yes	CNB
25.	HRK/EUR exchange rate – average monthly	Yes	CNB
26.	HRK/EUR exchange rate – end of month	Yes	CNB
27.	HRK/USD exchange rate – average monthly	Yes	CNB
28.	HRK/USD exchange rate – end of month	Yes	CNB
29.	Exchange rate volatility	Yes	CNB
30.	Index of the real effective exchange rate of the kuna deflated by consumer prices	Yes	CNB
31.	Index of the real effective exchange rate of the kuna deflated by producer prices	Yes	CNB
	Real sector		
32.	Manufacturing	Yes	CBS
33.	Industry – energy	Yes	CBS
34.	Industry – intermediate goods	Yes	CBS
35.	Industry – capital goods	Yes	CBS
36.	Industry – non-durable goods	Yes	CBS
37.	Industry – durable goods	Yes	CBS
38.	Industrial production	Yes	CBS
39.	Electricity, gas and water supply	Yes	CBS
40.	Volume index of construction works on buildings	Yes	CBS
41.	Volume index of construction works on civil engineering buildings	Yes	CBS
42.	Construction	Yes	CBS
43.	Mining and quarrying	Yes	CBS
44.	Trade	Yes	CBS
45.	Newly-registered vehicles – natural persons	Yes	CBS
46.	Newly-registered vehicles – legal persons	Yes	CBS
47.	Newly-registered vehicles	Yes	CBS
	Wages and employment		
48.	Average monthly nominal gross wage	Yes	CBS
49.	Average monthly nominal net wage	Yes	CBS
50.	Average monthly real gross wage	Yes	CBS
51.	Average monthly real net wage	Yes	CBS

52.	Employed persons	Yes	CBS
53.	Unemployed persons	Yes	CES
54.	Administrative unemployment rate	Yes	CBS
	Tourism		
55.	Tourist arrivals	Yes	CBS
56.	Tourist arrivals – domestic	Yes	CBS
57.	Tourist arrivals – foreign	Yes	CBS
58.	Tourist nights	Yes	CBS
59.	Tourist nights – domestic	Yes	CBS
60.	Tourist nights – foreign	Yes	CBS
	External sector		
61.	External debt – banks	Yes	CNB
62.	External debt – government	Yes	CNB
63.	External debt – foreign direct investment	Yes	CNB
64.	External debt – enterprises	Yes	CNB
65.	External debt – total	Yes	CNB
66.	Exports	Yes	CBS
67.	Imports	Yes	CBS
68.	Exports (excluding ships and oil)	Yes	CBS
69.	Imports (excluding ships and oil)	Yes	CBS
70.	Imports of road vehicles	Yes	CBS
71.	International reserves	Yes	CNB
	Monetary and financial sector		
72.	Reserve money (M0)	Yes	CNB
73.	Money (M1)	Yes	CNB
74.	Total liquid assets (M4)	Yes	CNB
75.	Demand deposits	Yes	CNB
76.	Foreign currency deposits	Yes	CNB
77.	Currency	Yes	CNB
78.	Kuna deposits	Yes	CNB
79.	Free reserves of banks	Yes	CNB
80.	Money multiplier mm1 (M1/M0)	Yes	CNB
81.	Money multiplier mm4 (M4/M0)	Yes	CNB
82.	EMBI spread on Croatian government debt	Yes	JP Morgan
83.	Crobex – value of the Zagreb Stock Exchange index	Yes	ZSE
	Interest rates		
84.	Bank interest rates on long-term corporate loans with a currency clause	No	CNB
85.	Bank interest rates on long-term household loans with a currency clause	No	CNB
86.	Bank interest rates on short-term corporate loans without a currency clause	No	CNB
87.	Bank interest rates on short-term household loans without a currency clause	No	CNB
88.	Bank interest rates on time deposits without a currency clause	No	CNB
89.	Bank interest rates on foreign currency time deposits	No	CNB
90.	Bank interest rates on savings deposits without a currency clause	No	CNB
91.	Bank interest rates on foreign currency savings deposits	No	CNB
92.	Interest rates on 182-day T-bills of the Ministry of Finance	No	CNB
93.	Interest rates on 91-day T-bills of the Ministry of Finance	No	CNB
94.	Overnight interest rate in interbank demand deposit trading	No	CNB
95.	Bank interest rates on giro and current accounts	No	CNB
96.	Interest rates on kuna deposits	No	CNB
	Fiscal sector		
97.	Government budget revenue	Yes	MoF
98.	Government budget expense	Yes	MoF
99.	Central government debt	Yes	CNB
100.	Excises on alcohol	Yes	MoF
101.	Excises on cars	Yes	MoF
102.	Excises on non-alcoholic beverages	Yes	MoF
103.	Excises on tobacco products	Yes	MoF
104.	Excises on coffee	Yes	MoF
105.	Excises on luxury goods	Yes	MoF
106.	Excises on refined petroleum products	Yes	MoF
107.	Excises on beer	Yes	MoF
108.	Excises – total	Yes	MoF

Note: Time series were seasonally adjusted by the X-12 ARIMA method with the default settings of Eviews7.

Appendix II Detailed presentation of the estimated FAVEC model

Sample: January 2003-December 2010
Number of observations: 94
Standard errors in ( ), t-statistics in [ ]

Cointegration equation:			
LOANS_H (–1)	1.00000		
F (-1)	–29.69921		
	(1.56643)		
	[–18.9598]		
MP (–1)	65.60875		
	(14.9648)		
	[4.38420]		
TREND	–0.26790		
	(0.04314)		
	[6.20970]		
C	–73.1949		
VEC models:	**D(KRED_ST)**	**D(F)**	**D(MP)**
Coint. relation	–0.239415	–0.003231	–0.000177
	(0.04062)	(0.00352)	(0.00046)
	[–5.89345]	[–0.91793]	[–0.38364]
D(LOANS_H(–1))	–0.152073	–0.007685	0.00081
	(0.09259)	(0.00802)	(0.00105)
	[–1.64251]	[–0.95802]	[0.77193]
D(LOANS_H (–2))	0.28651	–0.001537	–0.002572
	(0.08411)	(0.00729)	(0.00095)
	[3.40655]	[–0.21086]	[–2.69951]
D(LOANS_H(–3))	0.179513	0.017117	1.50E–04
	(0.09304)	(0.00806)	(0.00105)
	[1.92941]	[2.12329]	[0.14240]
D(F(–1))	–5.73382	–0.41124	0.024522
	(1.81630)	(0.15737)	(0.02058)
	[–3.15687]	[–2.61313]	[1.19163]
D(F(–2))	–6.02269	–0.101611	0.00996
	(1.78183)	(0.15439)	(0.02019)
	[–3.38006]	[–0.65816]	[–0.49338]
D(F(–3))	–1.59132	0.226877	–0.006071
	(1.53774)	(0.13324)	(0.01742)
	[–1.03485]	1.70279]	[–0.34846]
D(MP(–1))	8.02690	0.203239	–0.003395
	(9.87034)	(0.85522)	(0.11183)
	[0.82323]	[0.23765]	[0.03035]
D(MP(–2))	4.28828	–0.568994	0.060386
	(9.28064)	(0.80413)	(0.10515)
	[0.46207]	[–0.70759]	[0.57429]
D(MP(–3))	8.88693	1.349128	0.20192

	(8.70684)	(0.75441)	(0.09865)
	[1.02068]	[1.78832]	[2.04687]
C	0.843889	0.013651	0.000612
	(0.15670)	(0.01358)	(0.00178)
	[5.38534]	[1.00541]	[0.34474]
R^2	0.55378	0.28103	0.19867
Adjusted R^2	0.50001	0.19441	0.10212
Residual square sum	34.40246	0.25828	0.00442
Equation standard error	0.64381	0.05578	0.00729
F-statistics	10.30047	3.24435	2.05772
Log likelihood	–86.13738	143.78000	335.01110
Akaike AIC	2.03375	–2.82510	–6.89385
Schwarz SC	2.36437	–2.52749	–6.59623

Note: Abbreviations of variables are as follows: LOANS_H – household loans, F – macroeconomic environment factor, MP – monetary policy indicator, TREND – trend component and C – constant. Letter D denotes the first difference, while the numbers in parentheses next to the variables show the number of lags.

Appendix III Results of diagnostic tests of the estimated FAVEC model

Ljung-Box autocorrelation test

Number of lags (n)	Q-stat.	p-value	Adjusted Q-stat.	p-value	Degrees of freedom
1	1.27	–	1.29	–	–
2	2.08	–	2.11	–	–
3	6.21	–	6.38	–	–
4	19.94	0.27	19.67	0.24	16
5	24.71	0.48	25.77	0.42	25
6	30.42	0.64	31.86	0.57	34
7	38.19	0.68	40.26	0.59	43
8	48.47	0.61	51.50	0.49	52
9	51.08	0.81	54.38	0.71	61
10	56.94	0.87	60.94	0.77	70
11	62.44	0.91	67.17	0.83	79
12	74.80	0.84	81.34	0.68	88

Note: The null hypothesis assumes the absence of autocorrelation of residuals up to lag n. The test is valid only for lags larger than the VAR lag order, i.e. the short-run equation (n = 3 in the estimated FAVEC model). The degrees of freedom for Chi-square distribution (approximately).
Source: Author's calculations.

LM test of residual serial correlation

Number of lags (n)	LM-stat.	p-value
1	11.27	0.26
2	7.33	0.60
3	11.63	0.23
4	17.62	0.04
5	6.83	0.65
6	6.32	0.71
7	7.80	0.55
8	10.24	0.33
9	2.84	0.97
10	6.25	0.71
11	5.66	0.77
12	12.84	0.17

Note: The null hypothesis assumes that there is no presence of residual serial correlation at lag n. Probabilities calculated using the Chi-square distribution with 9 degrees of freedom.
Source: Author's calculations.

Residual normality test

Component (equation)	Asymmetry coefficient	χ^2	Degrees of freedom	p-value
1	0.06	0.06	1	0.81
2	–0.21	0.68	1	0.41
3	0.12	0.23	1	0.63
Total		**0.98**	**3**	**0.81**
Component (equation)	Kurtosis	χ^2	Degrees of freedom	p-value
1	3.81	2.64	1	0.10
2	2.78	0.19	1	0.67
3	3.21	0.17	1	0.68
Total		**3.00**	**3**	**0.39**
Component (equation)	Jarque – Bera			p-value
1	2.70		2	0.26
2	0.87		2	0.65
3	0.40		2	0.82
Total	**3.98**		**6**	**0.68**

Note: The null hypothesis assumes that the residuals are normally distributed.
Source: Author's calculations.

Test of residual homoscedasticity

Collective test:					
χ^2	**Degrees of freedom**	**p-value**			
399.99	**390**	**0.35**			
Separate components:					
Dependent	**R^2**	**F(65.28)**	**p-value**	**χ^2(65)**	**p-value**
res1*res1	0.80	1.72	0.06	75.13	0.18
res2*res2	0.64	0.75	0.82	59.84	0.66
res3*res3	0.65	0.79	0.79	60.81	0.62
res2*res1	0.70	0.99	0.52	65.62	0.46
res3*res1	0.67	0.84	0.68	62.92	0.55
res3*res2	0.71	1.07	0.43	67.11	0.40

Note: The null hypothesis assumes that the residuals are homoscedastic.
Source: Author's calculations.

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