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A VAR Analysis of the Effects of Macroeconomic Shocks to the Quality of the Aggregate Loan Portfolio of the Czech Banking Sector

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Effects of Macroeconomic Shocks to the Quality of the Aggregate Loan Portfolio

Ivan Babouček and Martin Jančar *

Abstract

The paper concerns macro-prudential analysis. It uses an unrestricted VAR model to empirically investigate transmission involving a set of macroeconomic variables describing the development of the Czech economy and the functioning of its credit channel in the past eleven years. Its novelty lies in the fact that it provides the first systematic assessment of the links between loan quality and macroeconomic shocks in the Czech context. The VAR methodology is applied to monthly data transformed into percentage change. The out-of-sample forecast indicates that the most likely outlook for the quality of the banking sector's loan portfolio is that up to the end of 2006 the share of non-performing loans in it will follow a slightly downward trend below double-digit rates. The impulse response is augmented by stress testing exercises that enable us to determine a macroeconomic early warning signal of any worsening in the quality of banks' loans. The paper suggests that the Czech banking sector has attained a considerable ability to withstand a credit risk shock and that the banking sector's stability is compatible both with price stability and with economic growth. Despite being devoted to empirical investigation, the paper pays great attention to methodological issues. At the same time it tries to present both the VAR model and its results transparently and to openly discuss their weak points, which to a large degree can be attributed to data constraints or to the evolutionary nature of an economy in transition.

JEL Codes: G18, G21, C51.
Keywords: Czech Republic, Macro-prudential analysis, Non-performing loans, VAR model.

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Nontechnical Summary

The paper concerns macro-prudential analysis. It uses an unrestricted VAR model to empirically investigate transmission involving a set of macroeconomic variables describing the development of the Czech economy and the functioning of its credit channel in the past eleven years. Its purpose is threefold: firstly, to create a forecast of the quality of the Czech banking sector's loan portfolio; secondly, to offer an insight into the functioning of the Czech economy and to determine the macroeconomic factors that influence the quality of the loan portfolio by impulse response analysis; and finally, to perform stress tests in order to assess the banking sector's vulnerability to credit risk as far it can be detected on a macroeconomic level, as well as to determine macroeconomic early warning indicators of any worsening in loan portfolio quality. These goals are empirically justified by the size of this problem during the transformation process: between 1995 and the first quarter of 2001 the share of non-performing loans (NPLs) fluctuated around 30%, and only thereafter did it begin to decrease, falling rapidly to below 5% at the end of the investigated period.

The novelty of the paper lies in the fact that it provides the first systematic assessment of the links between loan quality and macroeconomic shocks in the Czech context. More specifically, the paper attempts to fill the gap between standard macroeconomic modelling, which has been done at the CNB for some time and is at a relatively advanced level, and bank-by-bank stress testing, which the CNB started doing only recently.

Despite being devoted to empirical investigation, the paper pays attention to methodological issues. It elaborates a macro-prudential concept of credit risk linked to financial stability indicators and tries to transparently present the results of simulations. In addition to applying the standard battery of tests for stationarity of time series, exogeneity of the variables included in the model and autocorrelation of the model's residuals, it discusses data constraints and the robustness of the simulation results with respect to both re-ordering of the variables of the VAR model and break-points in the investigated time series. These robustness tests reveal numerous weak responses that are excluded from the set of tested empirical hypotheses.

The VAR model is based on transmission that includes the following nine endogenous variables: the real effective exchange rate, exports, monetary aggregate M2, imports, aggregate bank loans to clients, the unemployment rate, the consumer price index, the domestic real three-month interest rate and the share of non-performing loans in aggregate bank loans to clients i.e. the NPL ratio as a financial stability indicator. Worthy of mention is that the monetary aggregate is used as a proxy for GDP and that this substitution is supported both theoretically and by a satellite model. Besides the endogenous variables the model includes seven exogenous variables, among them the two-week nominal interest rate, which is the Czech National Bank's principal monetary policy tool, and six dummies that control for break-points in the NPL ratio time series caused by institutional factors. The time series of variables include monthly data transformed into percentage change.

The application of VAR methodology to the investigated transmission yields results that are worth considering.

The most likely outlook for the quality of the banking sector's loan portfolio is that up to the end of 2006 the NPL ratio will follow a slightly downward trend below double-digit rates. This forecast is conditional on an absence of large idiosyncratic shocks on the micro-level. At the same time it is underpinned by stress testing, which on an aggregate level demonstrates that in recent years the loan portfolio has gained a considerable ability to absorb macroeconomic shocks without endangering the banking sector's capital base. Furthermore, for those variables that are included both in this VAR and in the CNB's standard models, the VAR model leads to forecasts that are similar to those obtained from the CNB's standard macroeconomic models.

The most interesting results of the impulse response analysis are as follows:

i. The empirical findings agree broadly with the theoretical assumptions underlying the investigated transmission and with the empirical findings that have been presented in the VAR literature so far. The simulations support 38 (i.e. 85%) of the 45 basic hypotheses on the causal relations in the investigated transmission. Needless to say, failure to support a hypothesis can often be reasonably explained by country-specific features revealing the aforementioned evolutionary nature of an economy in transition.

ii. Therefore, the results of the impulse response analysis do not depart dramatically from the findings of similar studies for other countries and mostly reflect cross-country similarities in banking systems. At the same time the results for the relevant variables agree broadly both with some of the basic concepts underlying the CNB's standard models, namely the scenario of convergence towards the more developed EU countries, and with some of the conclusions of the CNB's Financial Stability Report regarding the functioning of the credit channel and the supply side of the Czech economy.

iii. Appreciation causes effects that support the theory of the real exchange rate. The responses to an export shock, as well as out-of-sample information, suggest that a shift towards growth supported by exports has recently emerged in the Czech economy.

iv. The simulations support Okun's Law, indicating that GDP growth can help to reduce unemployment. On the other hand they fail to support the trade-off between unemployment and inflation which has been established for well developed countries with a long and unbroken tradition of a market economy.

v. The problem with allocation of domestic savings via the credit channel seems to be passing thanks to healthy credit expansion, which is contributing to GDP growth. This expansion has been driven by loans to households, which have seen double-digit growth rates in recent years.

vi. The adverse impact of inflation on the dynamics of foreign trade probably demonstrates the crucial importance of relatively low labour costs to the Czech economy's competitiveness. An international comparison of labour costs, as well as the persisting high ERDI relating to the Czech koruna's nominal exchange rate, shows that this advantage is supported to a larger degree by low prices of most non-tradable goods and services. Both these and some other findings are consistent with the Balassa–Samuelson effect.

vii. Both external stability and price stability are compatible with banking sector stability, because an increasing NPL ratio causes a rising trade deficit, and the simulations reject the hypothesis that rising inflation helps to improve the ability of borrowers to repay their bank loans.

viii. A rise in the NPL ratio mitigates growth in unemployment, as it postpones market cleaning of inefficient domestic capacities. Unlike the trade-off between inflation and unemployment growth, the causality between loan portfolio quality and a descending rate of unemployment is robust. From the methodological point of view this means

that although on a macroeconomic level the main explanatory line has to be drawn from standard economic variables to credit risk, this analysis indicates significant feedback that is worth analysing.

ix. The simulations fail to support the hypothesis that a slowdown in credit expansion is a response to a deterioration in the quality of loans. In contrast they indicate weak feedback between the NPL ratio and the growth of bank loans and consequently also the widespread occurrence of soft loan policies on a microeconomic level, which, despite the shift to prudent credit policies in recent years, remains inscribed in the memory of the time series.

The stress testing results suggest that the Czech banking sector has attained a considerable ability to withstand a credit risk shock and that the banking sector's stability is compatible both with price stability and with economic growth.

However, caution is necessary when using the above-mentioned results: firstly because of the incomplete lag structure of the model, which reflects data constraints, and secondly because the structural changes in the Czech economy and the resolution of the aforementioned credit crisis weaken the robustness of the simulations.

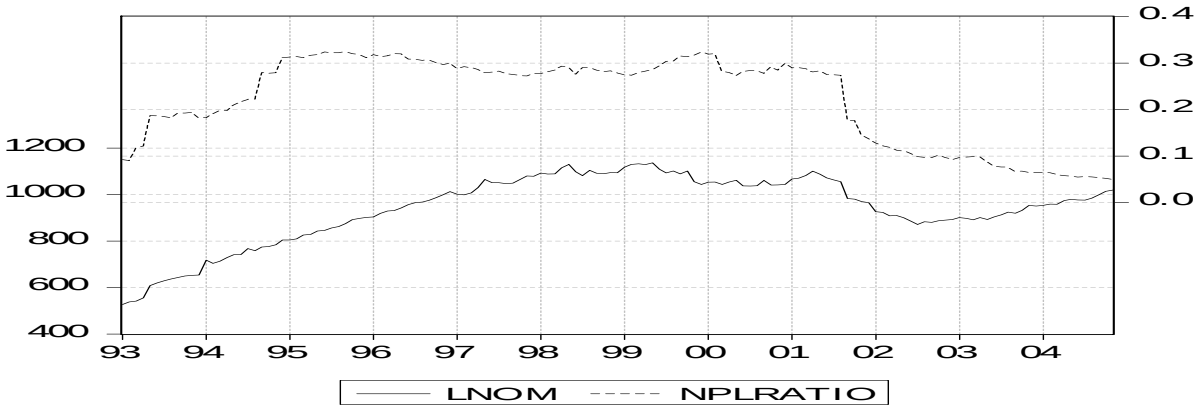
On the other hand, the model has a promising outlook for further development, as in the long term it will be possible to complete its lag structure without over-fitting the model. Thanks to a gradually increasing number of observations the model will advance towards this goal every year until reaching it in the next decade.

1. Introduction

1. The subject of the paper. Using VAR methodology this paper empirically investigates transmission involving a set of macroeconomic variables describing the development of the Czech economy and the functioning of its credit channel in the past eleven years. Its purpose is threefold: firstly, to create a forecast of the quality of the Czech banking sector's loan portfolio; secondly, to offer an insight into the functioning of the Czech economy and to determine the macroeconomic factors that influence the quality of the loan portfolio by impulse response analysis; and finally, to perform stress tests in order to assess the banking sector's vulnerability to credit risk as far it can be detected on a macroeconomic level, as well as to determine macroeconomic early warning indicators of any worsening in loan portfolio quality.

2. The focus on loan portfolio quality is empirically justified by the size of this problem. Figure 1 displays the development of the aggregate loan portfolio of the Czech banking sector and the share of non-performing loans (NPLs) in it between January 1993 and November 2004. It demonstrates that for six years, from 1995 to the first quarter of 2001, the NPL ratio fluctuated around the 30% level, and only thereafter did it begin to decrease, falling rapidly to below 5% at the end of the investigated period (see Figure 1).

Figure 1: The aggregate loan portfolio and the NPL ratio



Source: Czech National Bank.

Notes: LNOM stands for nominal volume of loans to clients in CZK billion, left-hand scale. NPLRATIO denotes the share of non-performing loans, right-hand scale. For an explanation of the concept of non-performing loans, see para. 24.

Seen from a global perspective the development described above represents one of the many cases of banking sector instability recorded in many countries in the past two decades. The direct costs of banking crises are high: according to IMF estimates they exceeded 10% of GDP in more than a dozen cases in the past 20 years. The indirect costs, including the impact on economic activity over time, would obviously be higher (see Crocket, 2000). Consequently, addressing banking sector instability has risen to the top of the political agenda. At the same time it has prompted research into the macro-prudential dimension of financial system soundness. This research is called macro-prudential analysis.

3. During the investigated period the Czech economy saw huge changes in its macroeconomic parameters, which underlines the relevance of macro-prudential analysis of the Czech banking sector. Although between 1995 and 2004 real GDP rose by only a modest average yearly rate of about 2%[1], exports have seen average y-o-y growth of 11.5% and imports nearly 13% in real terms. Since 1995 the ratio of foreign trade turnover to GDP in nominal terms has increased by nearly 40%, reaching 143% in 2004. Thus, the Czech economy has become very open. The Czech koruna has steadily appreciated: on average its real effective exchange rate against the German mark/euro has risen by 2.7% yearly. Since 1993 the unemployment rate has more than quadrupled and in recent years has reached the 10% level. This indicates considerable structural changes in the economy. The three-month nominal interest rate was double digit until the end of 1998, and during the monetary turbulence in mid-1997 it peaked at 26%. Thereafter it has been following a steady downward trend and is currently fluctuating between 2% and 3%.

4. Macro-prudential analysis is a field of economic research that was developed in order to support the assessment of banking sector stability[2]. The International Monetary Fund has played a pivotal role in its development on an empirical level. The Fund has been building up experience with it in past years as a part of its surveillance, technical assistance and policy development work and more recently in the context of the Financial Sector Assessment Program (IMF, 2001).[3] The initial list of macro-prudential indicators was presented by Evans, Leone et al. (2000). See also IMF (2001). The IMF expanded it into a huge compendium, and the macro-prudential indicators were renamed the financial stability indicators (FSIs).[4] Using this experience Sundararajan et al. (2002) clarify that "Macro-prudential analysis is the assessment and monitoring of the strengths and vulnerabilities of financial systems. This encompasses quantitative information from both financial stability indicators (FSIs) and indicators that provide a broader picture of economic and financial circumstances, such as GDP growth and inflation, along with information on the structure of the financial system, qualitative information on the institutional and regulatory framework – particularly through assessments of compliance with international financial sector standards and codes, and the outcome of stress tests." The ECB's approach is similar to that of the IMF and at the same time is closely related to the statutory goals of the ECB (see Grande and Stubbe, 2002).

[1] For GDP time series, see the Czech Statistical Office website: www.czso.cz. Consistent GDP data are not available for 1993 and 1994.

[2] More generally, to the assessment of financial sector stability.

[3] The FSAP was launched jointly by the IMF and the World Bank in May 1999. The program is designed to identify financial system strengths and vulnerabilities and to help to develop appropriate policy responses. Financial System Stability Assessments (FSSAs) are prepared by the IMF staff in the context of Article IV consultations, by drawing on the FSAP findings, for discussion in the IMF Executive Board. In the World Bank, the FSAP reports provide the basis for producing Financial Sector Assessments and formulating financial sector development strategies.

[4] See IMF (2004). According to Sundararajan et al. (2002) financial stability indicators (FSIs) are indicators compiled to monitor the health and soundness of financial institutions and markets, and of their corporate and household counterparts. FSIs include both aggregated information on financial institutions and indicators that are representative of the markets in which financial institutions operate. Macro-prudential indicators include both FSIs and other indicators that support the assessment and monitoring of the strengths and vulnerabilities of financial systems, most notably macroeconomic indicators.

5. The macroeconomic perspective and the distinction between macroeconomic and idiosyncratic shocks are distinguishing features of macro-prudential analysis. Crocket (2000) clarifies the macroeconomic approach to credit risk and its links to macroeconomic modelling.[5] Following these ideas Borio (2003) summarises the distinctions between the macro- and micro-prudential concepts of credit risk in a table and at the same time explains the two sources of systemic risk. Common exposures to macroeconomic risk factors across banks are the first source. This is the type of systemic risk that underlies most of the major banking crises experienced around the globe. An idiosyncratic shock, e.g. the failure of a systemically important bank, is the second source. This shock can be propagated through inter-bank exposures and loss of public confidence in banks' solvency. A domino effect is the outcome. This mechanism characterises the traditional or canonical concept of systemic risk, for which Diamond and Dybvig (1983) is the classical reference. For a broader survey of the underlying causes of financial instability see also White (2000), for a synoptic table characterising the main approaches to financial crises see Timmermans (2001), and, finally, for an instructive list of factors that can trigger a banking crisis see South African Reserve Bank (2001).

6. Macro-prudential analysis is of great importance to central banks and recent years have seen them paying increased attention to it. This reflects a wide consensus that the central bank bears responsibility for the stability of the banking sector and shares responsibility for financial stability regardless of whether or not it performs banking supervision.[6]

7. The paper adheres to the idea of investigating the relations between macroeconomic variables on the one hand and financial stability indicators on the other. This idea is part of the analytical framework for macro-prudential analysis. Grande and Stubbe (2002) explain its background as follows: "Assuming that banking sector stability depends on the situation of banks' operating environment, banks' risk exposures, and their ability to manage risks and withstand adverse outcomes this framework consists both of macroeconomic indicators, which relate to operational environment and of aggregate prudential data describing general risk exposures of banks and their financial buffers to withstand materialisation of risks". Nevertheless, an investigation of the relations between macroeconomic variables and FSIs does not exhaust the subject of macro-prudential analysis. In addition, macro-prudential analysis involves bank-by-bank stress testing, sectoral analysis and integrated analysis using the value at risk (VaR) framework and other concepts. See Cihak (2003) and Sorge (2004).

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[5] In terms of conceptions of the functioning of the economy, the macro-prudential dimension can be defined as viewing system outcomes as critically determined by the collective behaviour of individual institutions; in economic jargon, as "endogenous". Correspondingly, the micro-prudential dimension can be seen as regarding those outcomes as "exogenous" or given to the individual firms. As a corollary, so defined it also disregards any feedback of collective actions on the condition of individual institutions.

[6] "Monetary and financial stability are inter-related. It is inconceivable that the monetary authorities could quietly pursue the stability-oriented monetary policy objectives if the financial system through which policy is carried on – and which provides the link with the real economy – were collapsing. The liabilities of banks in particular are money, and you cannot be concerned with preserving the value of money without being concerned also with preserving public confidence in money in this broader sense. Equally though, the financial system is much less likely to be collapsing around the ears of the monetary authorities in an environment of macroeconomic stability than in one of exaggerated boom and bust and volatile asset values. This inter-relationship means that, whatever the precise institutional arrangements for financial regulation and supervision, central banks necessarily have a vital interest in the soundness of the financial system." (George, 1994)

8. Such an investigation can be based on the macro-prudential concept of credit risk, whose essential feature consists in the treatment of credit risk as an endogenous variable of a macroeconomic model. In line with the ideas mentioned in paragraph 5, such a concept involves a mathematical structure that captures a stochastic process, transmission, which marries macroeconomic variables with an FSI, and, finally, time series for a given banking sector and given time period. Therefore, the idea of investigating the relations between macroeconomic variables and FSIs leads to various macro-prudential concepts of credit risk depending on the choice of:

- mathematical structure, e.g. unrestricted VAR model, cointegrating equations specified by a VEC model, etc.;
- the set of macroeconomic variables included in the transmission and the set of FSIs describing the quality of the aggregate loan portfolio – see the literature survey in Section 2;
- data sample e.g. use of monthly data versus use of quarterly data for various countries and various time periods.

The macro-prudential concept of credit risk applied in this paper puts together unrestricted vector auto-regressions, transmission composed of eight macroeconomic variables, the share of NPLs in the aggregate loan portfolio, and time series describing the development of the Czech economy and banking sector in the past decade or so.

9. The macro-prudential approach to credit risk is dissimilar to the micro-prudential one … Unlike the macro-prudential approach, the starting point for the micro-prudential approach is indicators describing the financial situation and performance of individual borrowers, and its core element is the external or internal rating of borrowers. While the macro-prudential approach attempts to assess the stability of the banking sector on an aggregate level, the micro-prudential approach measures the credit risk exposures of an individual bank. Marrying the macro-prudential approach to credit risk with the micro-prudential one is a complex issue that goes beyond the subject of this paper. For information on its methodological background see Borio et al. (2001), Borio (2003), Cihak (2003) and Sorge (2004).

10. ... and has its advantages and disadvantages. The main advantages are:

- it has a clear focus on macroeconomic shocks as distinct from idiosyncratic shocks;
- it supports links to well established macroeconomic theories and to research in the area of monetary policy;
- it enables dynamic analysis of credit risk on a macroeconomic level;
- it facilitates stress testing of the stability of the banking sector both in the form of sensitivity analysis, which covers shocks caused by a single factor, and in the form of scenario analysis, which covers a combination of shocks, i.e. multiple factors;
- it makes possible dynamic forecasting of macroeconomic credit risk factors and the quality of the aggregate loan portfolio itself;
- it is cost effective, because it is based on data that are collected on a regular basis and for various purposes, e.g. for conducting monetary policy or performing banking supervision.

The main disadvantages are:

- there is no coverage of differences in the reactions of individual institutions to macroeconomic shocks and consequently no ability to produce early warning signals of idiosyncratic shocks;
- there is no coverage of propagation of credit risk through the inter-bank market.

Thus, the macro-prudential approach to credit risk can substitute neither for micro-prudential analysis nor for supervision of individual banks on a solo and consolidated basis.

12. The rest of the paper is structured in six sections. Section 2 includes a survey of the literature and Section 3 explains the transmission mechanism and describes the VAR model for it. Section 4 presents the VAR model's baseline for the NPL ratio and the forecast of this FSI up to December 2006, and Section 5 is devoted to impulse response analysis. Stress testing exercises are performed in Section 6, and some concluding remarks are made in Section 7.

2. Literature Survey

13. This survey covers three topics that are related to the transmission to be investigated. As the literature devoted to the subject and scope of macro-prudential analysis was discussed in the previous section, the following survey covers empirical findings on the relations between macroeconomic variables and the NPL ratio, foreign trade theories, and the investigation of monetary policy shocks.

14. Internationally, the number of empirical studies trying to link macroeconomic factors and the asset quality of the banking sector has been growing rapidly in recent years. Blaschke et al. (2001) propose applying the VAR methodology to investigate the transmission from output (GDP), inflation, the money interest rate and the terms of trade to an FSI indicator, for example the ratio of NPLs to the total loans or total assets of the banking sector. A macroeconomic framework for studying the impact of GDP growth or the business cycle on credit risk and consequently also on the quality of bank loans is represented by two competitive theories. Whereas the first one stresses that credit risk is pro-cyclical, the second one defends the countercyclical view. See Bikker and Metzemakers (2002) for a more detailed description.[7] More specifically, Sorge (2004) refers to several studies that use non-performing loans, loan loss provisions or composite indices as the metrics to assess the vulnerability of the banking sector over time. Hoggarth, Logan and Zicchino (2005) apply the VAR approach to investigate the link between loan write-offs and the UK output gap, retail and house price inflation, the nominal short-term interest rate and the real exchange rate. Furthermore, Gambera (2000), using bivariate VAR models, investigates the influence of the development of the US economy on the loan portfolio quality of a large sample of US banks. Whereas economic developments are characterised by the unemployment rate, non-farm income, farming income, bankruptcy filings, car sales and building permits, the ratio of NPLs to total loans serves as the indicator of the quality of the loan portfolio, which is broken down into agricultural, commercial, industrial and real estate loans. Within this

[7] "The common view is that an economic upswing and rising incomes indicate improving conditions for firms and reduce the likelihood of loan defaults, whereas a recession will have the opposite effect… According to this common view, the banks' provisioning behaviour is pro-cyclical, meaning that it reinforces the current development of the business cycle. However, an alternative, countercyclical view states that credit risk is built up in a boom and materialises in a downturn. The favourable conditions of an economic expansion could lead to an excessive increase in credit lending and a less critical assessment of creditworthiness. The countercyclical view associates this with higher risks and the build-up of financial imbalances that increase the likelihood of economic contraction."

framework Gambera finds a considerable number of significant relationships. She also presents stress testing exercises and out-of-sample forecasts. And finally, Keeton (1999) investigates the relationship between the growth of business loans granted by US banks on the one hand and the banks' credit standards and the share of NPLs in business loans on the other.[8] The VAR model involves growth in business loans, the share of NPLs in business loans and non-farm earnings. It supports the hypotheses that faster loan growth leads to higher loan losses, that an increase in earnings reduces the delinquency rate and that an increase in the delinquency rate causes a decrease in loans. In addition, a deterioration in the quality of loan portfolio causes a subsequent increase in the ratio of NPLs.

The latter finding is in line with Gizycki's (2001) conclusion that Australian banks' share of impaired assets in total on-balance sheet assets exhibits strong autocorrelation.[9] Moreover, a panel regression analysis shows that Australian banks' aggregate credit risk varies directly with the rate of real credit growth as well as with real interest rates and corporate and households' interest burden, which in turn varies indirectly with real GDP growth. On the other hand, movements in the exchange rate, the terms of trade and share prices exhibit no well-determined relationship with Australian banks' impaired assets. Shu (2002) examines the impact of macroeconomic developments on the asset quality of the Hong Kong banking sector and concludes that the increase in non-performing loans between 1995 and 2002 was largely attributable to changes in macroeconomic conditions.[10] Single-equation regression analysis indicates that the NPL ratio rises with increasing nominal interest rates and faster growth in bankruptcies, but decreases with higher CPI inflation, economic growth and property price inflation. He also finds that unemployment is not significant after controlling for output growth. Arpa et al. (2001) present a single-equation regression analysis focusing on the risk provisions and operating income of Austrian banks, and conclude that the share of risk provisions in the total loans of the Austrian banking sector varies indirectly with real GDP growth and real interest rates and directly with CPI inflation and real estate price inflation. Quagliariello (2003) presents a regression between the evolution of credit quality as the dependent variable and a set of explanatory variables that include the real GDP growth rate, growth of real gross fixed investment and consumption, change in the

[8] The investigation is limited to business loans because of the well developed secondary market for consumer loans and real estate loans in the USA, which can cause the volume of such loans on banks' books to fluctuate solely due to loan sales. Keeton presents aggregate results for the US banking sector based on quarterly data for the period 1982–1996 for each of the 50 US states and the District of Columbia.Non-performing loans are defined in Keeton's article as loans 90 days or more overdue or failing to accrue interest. Banks are allowed to count as income any interest that is due but not received, provided that the interest and principal are less than 90 days overdue or the loan is well secured and in the process of collection. Non-accruing loans are overdue loans that do not meet either of these conditions. From the end of 1982 until the middle of 1985, banks with less than $100 million in assets reported loans 90 days or more overdue by category but did not report non-accruing loans by category. For these banks, non-accruing business loans were estimated by multiplying the amount of overdue business loans by the ratio of total non-accruing loans to total overdue loans.

[9] Following the definition specified by the Australian Prudential Regulation Authority (APRA), impaired assets are taken to be the sum of non-accrual items, restructured items and assets acquired through security enforcement.

[10] The Hong Kong Monetary Authority (HKMA) uses two sets of asset duality indicators. The first set is based on the loan classification system. Non-performing loans (in HKMA terminology "classified loans") are those that are classified as substandard, doubtful or loss. The second set of asset quality indicators is based on loan arrears and rescheduling. In the investigated period these indicators behaved in the same way.

unemployment rate, the CPI, the real exchange rate and the M2 growth rate. He finds that decreasing real GDP growth and increasing unemployment have a significantly adverse effect on loan portfolio quality, whereas the real exchange rate and the CPI fail to significantly affect it. Kadlcakova and Keplinger (2003) focus on Czech banks' corporate lending and apply the IRB approach to the credit risk attributed to it. Although the main focus of their study is on the microeconomic level, the paper presents a macroeconomic VAR model involving three variables, i.e. losses on CZK-denominated bank loans, losses on euro-denominated bank loans and the Czech koruna's exchange rate. They investigate the impact of exchange rate dynamics on loan quality and suggest that currency exposure (in euro) is significant for the quality of loans to export industries, but is rather weak for loans to importing industries.

15. The high openness of the Czech economy justifies attention paid to investigation of foreign trade. The traditional view of the trade balance, reviewed, for example, by Dunn and Mutti (2000), begins with an accounting identity stating that the trade balance is defined as the world price of exports times the volume exported minus the world price of imports times the volume imported, and then it adopts a demand-driven or Keynesian approach to explain that identity. According to this approach imports are a positive function of domestic incomes and the real exchange rate, measured as the foreign price of domestic money. Imports rise with local incomes and when the domestic currency appreciates in real terms. On the other hand exports are positively related to foreign incomes and negatively to the real exchange rate. An increase in foreign incomes causes rising purchases of a range of goods, some of which will be exports from the home country.[11]

Other theories are worthy of mention, too. Ramos (2002) summarises the export-led growth hypothesis, a neoclassical trade theory that stresses the causality that runs from home-factor endowments and productivity to the supply of exports, as well as the theory suggesting a two-way causal relationship between growth and foreign trade, whose principal idea is that increased trade generates GDP growth, which facilitates more imports.[12] He uses a VEC model to investigate the Portuguese economy and foreign trade and concludes that the empirical results confirm feedback between both exports and imports on the one hand and output growth on the other, but fail to support causality between import and export growth. Benacek, Prokop and Visek (2003) analyse Czech foreign trade on a desegregated level and conclude that the balance of trade is primarily influenced by the real exchange rate aggregate demand and tariff changes. The secondary fundamental factors, relevant for structural adjustments, a sustainable trade balance and an equilibrium exchange rate, rest, however, on supply-side characteristics such as changes in endowments of physical and human capital, inflows of FDI and growing competitiveness of domestic production.

16. The VAR approach originated in empirical research supporting monetary policy, and the bulk of the VAR literature remains devoted to empirical investigation of monetary policy shocks. Since the seminal work of Sims (1980) this research has gained momentum. The

[11] Dunn and Mutti (2000), p. 375–376.

[12] The most interesting economic scenarios suggest a two-way causal relationship between growth and trade. According to Bhagwati (1988), increased trade produces more income (increased GDP), and more income facilitates more trade – the result being a virtuous circle (Ramos, p. 606).

extensive literature has used VAR models to study the monetary policy transmission mechanism in the United States. This research is reviewed and enlarged by Leeper, Sims and Zha (1996). They present five VAR models for the US economy. The simplest model includes the consumer price index, output and either the money stock M1 or banks' reserves. A more complex model includes six variables, namely the consumer price index, output, a commodity prices index, the federal funds rate, non-borrowed reserves and total reserves. The most complex models include as many as thirteen or eighteen variables and are designed to examine the monetary policy rules of the Federal Reserve. Hall (1996) emphasises that the principal result is that the spontaneous element of monetary policy is small and is not a major determinant of movements of US real GDP. Kim (1999) presents a VAR model which includes real GDP, the CPI, a broad monetary aggregate, a short-term interest rate which the monetary authority can freely adjust, and the real effective exchange rate. He applied this model to data for the G-7 countries. This specification works well and is "probably the most used in monetary policy analysis".[13]

Not surprisingly it serves as starting point for research focusing on the euro area monetary policy transmission mechanism – see Mojon and Peersman (2001); Peersman and Smets (2001); Calsa, Manrique, Sousa (2003); and Sousa and Zaghini (2004). Mojon and Peersman (2001) present a family of three models covering the EMU states. The benchmark model is designed for Germany and consists of real GDP, the CPI, the domestic short-term nominal interest rate and the real effective exchange rate. This model does not include money. On the other hand it contains three exogenous variables, namely a world commodity index, US real GDP and the US short-term nominal interest rate. Models for other countries modify the benchmark model primarily by replacing the real effective exchange rate with the nominal bilateral exchange rate versus the German mark. This structure reflects the major role of the mark before the introduction of the euro. And finally, the authors augment their analysis with the response of broad money (M3) and bank loans to a monetary policy shock. For each of ten EMU countries Mojon and Peersman (2001) report a lagged decrease in GDP. The effects of a monetary policy shock on output and prices are for each country usually qualitatively similar to those obtained when the model is estimated on the aggregate euro area economy. The responses of the aggregate loan portfolio of each country indicate that a contractionary monetary policy shock is accompanied by a decline in loans and this effect is not significantly different across countries.[14] On the other hand, the responses of the real effective exchange rate are less consistent. The authors find appreciation of the real effective exchange rate for Germany and appreciation of the bilateral nominal rate versus the German mark for Austria, France, Ireland and Greece. For Belgium and the Netherlands they notice a lack of response in the aforementioned nominal exchange rate. In Italy and Spain they find a so-called exchange rate puzzle, i.e. a tightening of the monetary policy stance leads to depreciation of the exchange rate. Furthermore, the different patterns in the bilateral nominal exchange rates' responses are not reflected in the responses of prices and output. The authors suggest that the responses of the bilateral nominal exchange rate for one country often coincided with a similar change in other European countries, so that the effective exchange rate of the country was less affected. Recently, Arnostova and Hurnik (2005) have slightly modified one of

[13] Sousa and Zaghini (2004), p. 15.

[14] Mojon and Peersman (2001), p. 19.

these VAR models and applied it to investigate monetary policy transmission mechanisms in the Czech Republic. They find that a monetary policy shock causes a temporary fall in output, that the response of the nominal exchange rate consists in a counterintuitive depreciation, and that the response of the CPI is sluggish and retail prices are quite persistent. Depreciation causes rising prices and an initial output rise and a subsequent decline. A price shock causes an immediate monetary policy reaction, e.g. an increase of the domestic short-term nominal interest rate. The price shock is accompanied by an output decline.

Peersman and Smets (2001) present two alternative benchmark models for the euro area. The first one involves real GDP, consumer prices, the domestic nominal short-term interest rate and the real effective exchange rate, the second one is augmented by the inclusion of monetary aggregate M3 in the block of endogenous variables. Thereafter they augment the model with a set of labour market variables which includes employment, labour productivity, unit labour costs and nominal wages. For the euro area as a whole they argue that a monetary policy shock tends to be followed by real appreciation of the exchange rate and a temporary fall in output. Prices start to fall several quarters after the fall in output. Employment declines with decreasing GDP growth. A monetary policy shock has an immediate negative effect on credit to the private sector. Calsa et al. (2003) investigate transmission consisting of real GDP, nominal loans to the private sector, a composite lending rate, which is a real interest rate *sui generis*, and inflation. Unlike previous research, their analysis uses a vector error correction model. For the euro area they discover a long-run relationship between real GDP, the stock of real loans to the private sector and the real lending rate. In the long run, real loans are positively related to real GDP and negatively to the real lending rate.

Citu (2004) examines the effects of a monetary policy shock on the New Zealand economy using a VAR model that includes the same four endogenous variables as the above-mentioned benchmark model for Germany, and finds that a monetary policy shock causes appreciation of the real effective exchange rate, a decrease in GDP growth but an increase in the CPI, known as the price puzzle. Fung (2002) presents VAR models to analyse the effects of a monetary policy shock in Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan and Thailand. He distinguishes policy endogenous variables, e.g. the short-term nominal interest rate and the nominal effective exchange rate, from non-policy endogenous variables, e.g. the world commodity price index, industrial production, the narrow monetary aggregate M1 and the CPI. Three US variables – the CPI, industrial production and the federal funds rate – are the exogenous variables. The responses are broadly consistent with those that economic theory assumes for open economies. Following a contractionary monetary shock, the interest rate rises, the price level and money decline, and the local currency tends to appreciate.

17. The numerous empirical findings that have been presented in the literature are an important source of the hypothesis for impulse response analysis, although they are only broadly comparable. VAR analysis of monetary policy shocks is well established and there is a broad consensus about the benchmark model. Analysis of the quality of the banking sector's loan portfolio seems to be less advanced and the investigated transmissions remain country specific. Nevertheless, the list of frequently investigated variables includes real GDP, a monetary aggregate, loans to the business sector and households, the unemployment rate, the CPI, the real effective exchange rate, the terms of trade, exports, imports and the quality of the loan portfolio itself. The VAR literature also presents some empirical findings which demonstrate theoretically

unexpected effects. The most prominent of them is the so-called price puzzle, i.e. the empirical finding that a price rise often follows an interest rate tightening, or, conversely, that after an expansionary monetary policy shock prices initially decrease rather than increase. The price puzzle is subject to extensive discussions that suggest it may be due to the omission of the central bank reaction function from the specification of the VAR model or to limited size of such a model.[15]

3. Transmission and the VAR model

18. The selection of the variables included in the transmission is inspired by the previously reviewed literature, and their ordering reflects both the openness of the Czech economy and economic theory. The transmission involves three parts. The first characterises the competitiveness of the Czech economy, the second describes the credit channel and the utilisation of domestic capacities, and the third covers consumer price inflation and the impact of real interest rates on the quality of the aggregate loan portfolio.

19. As the Czech economy is small and very open, the departure point for the investigated transmission is the real effective exchange rate, followed by exports and imports, while real money is used as an indicator of domestic demand instead of GDP. This part of the transmission characterises the competitiveness of the economy and refers both to the theory of the real effective exchange rate and to the other theories mentioned in para. 15. The substitution of real money for GDP has two advantages. Firstly, it sidesteps the GDP time series, which are subject to relatively frequent revisions and offer only a limited data sample, and secondly, it facilitates modelling of monthly data. Given that standard statistical data describing the Czech economy have been available for only a decade or so, the advantage offered by monthly observation is clear.[16] Theoretically, assuming constant velocity of money, the substitution of GDP by real money follows from the Fisher equation. In the case of the Czech economy and under the aforementioned assumption, it is possible to create an ARIMAX (1,4) model which relates real money to final consumption, investment and the trade deficit for the period 1995–2004.[1] The model is represented by equation (1):

$$(1) \qquad dm_t = 0.68dc_t + 0.35dinv_{t-4} + 0.03dtb_t - 0.06dtb_{t-4} + 0.005 - 0.88\ AR(1) - 0.91MA(4) + \varepsilon_t$$

[15] In comments and discussion on Leeper, Sims and Zha (1996), Bernanke argues that the VAR literature treats monetary policy shocks as a policy innovation under the assumption that this policy is truly exogenous with respect to the state of the economy. If what is in such a way identified as a policy innovation is, in fact, a reaction by the Fed to information about the economy, then incorrect inferences will be drawn about the effect of policy. This problem presumably underlies the price puzzle. Friedman argues that the authors' price puzzle finding is a misinterpretation related to a small VAR. A rise in the interest rate presages a rise in prices exactly because the rise in the interest rate is not really an unpredictable event, but instead a reaction of the market or the Fed to a forecast of future inflation that is not captured in the VAR model. If variables are left out, many misinterpretations analogous to the price puzzle still arise.

[16] Generally speaking, the relatively short history of a market economy and of collecting data complying with international statistical standards seems to be a major factor limiting the application of the VAR methodology to transition economies because of the problem of "over-fitting" that is connected with the rapidly decreasing number of degrees of freedom in a VAR model.

where d denotes the quarterly percentage change measured in percentage points, m stands for real money measured by monetary aggregate M2, c denotes final consumption expenditure, inv means gross capital formation, tb denotes the deficit of the external balance of goods and services, AR(1) denotes the AR term for the residuals, MA(4) corresponds to the fourth-order moving average term for the residuals and finally ε_t stands for the residuals, which are assumed to be serially uncorrelated and homoscedastic. Whereas the monetary aggregate is deflated by the CPI in order to ensure identity with the variable included in the principal VAR model, the explanatory variables are deflated by the GDP deflator in order to ensure identity with the Czech national accounts statistics. Each time series includes seasonally adjusted quarterly data.

The intercept equals 0.5 percentage points and indicates a growing trend in demand for real money. This quarterly change implies approximately 2% yearly growth, i.e. the rate equal to the average y-o-y GDP growth over the investigated period (see para. 3). Real money varies directly with final consumption expenditure and with gross capital formation. The latter effect is, however, considerably lagged. The sum of these two elasticity coefficients is slightly more than 1. The demand for real money immediately slightly accelerates with an acceleration in the trade deficit, but this effect is slightly outperformed at one year by the lagged elasticity. Consequently, the trade deficit exhibits the theoretically expected negative impact on demand for real money, which corresponds to its negative impact on GDP growth. However, this effect is only minor and equals -0.3% at one year. The main result is that real money can reflect fluctuations in the components of GDP around the rising trend and that the sum of the elasticity coefficients expressing these fluctuations is at one year practically equal to 1. This result supports the substitution of GDP by real money when monitoring growth in the former variable. Despite the small sample of available data and the only modest fit to the data as expressed by adjusted $R^2 = 0.6$, the model seems to be statistically significant, as its residuals are not significantly autocorrelated, the t-statistics of the coefficients are highly significant, and the mean of the time series of its residuals is reasonable small at 1 basis point. Moreover, Jarque–Bera tests indicate that the residuals are normally distributed. See the annex for details.

20. The second part of the transmission includes aggregate bank loans and the rate of unemployment, and establishes a link between competitiveness and allocation of savings into investment, which is theoretically supported by the concept of the bank lending channel, by the theory of financial cycles and by Okun's Law. As the Czech economy has a bank-based financial system, the credit channel plays a dominant role in channelling savings into investment. Unlike in most developed countries, the bulk of bank loans have been granted to the corporate sector. In spite of a huge inflow of foreign direct investment, a considerable volume of commercial loans, a growing corporate bond segment of the capital market and a rising trend in leasing operations, bank loans remain the most important factor influencing utilisation and changes in structure of domestic capacities. From the macroeconomic point of view this fact supports the hypothesis presented by Bernanke and Blinder (1988), namely that supply effects should play a particularly significant role in the market for loans via the so-called bank lending channel. They argue that while it is difficult to think of or identify major shocks to credit demand,

shocks to the credit supply are easy to conceptualise.[17] The concept of the bank lending channel is connected with the idea that bank lending is pro-cyclical, i.e. that periods of robust economic growth tend to be associated with credit expansion, and recession with credit contraction, and that in such a way the banking lending channel amplifies the business cycle. Borio et al. (2001) state that this hypothesis is well supported by the empirical evidence. Both parts of the transition are also bound by Okun's Law, which in the transmission is represented by the relationship between real money growth as a proxy for GDP growth on the one side and growth in the rate of unemployment on the other.

21. The third part of the transmission connects the real economy with inflation, interest rates and the quality of the aggregate loan portfolio. It includes the consumer price index, the short-term real interest rate and the share of NPLs in the aggregate loan portfolio, and it is theoretically underpinned both by the assumed trade-off between unemployment and inflation, i.e. by the Phillips curve, and by the hypothesis that economic growth tends to improve the quality of banks' loan portfolios, whereas a rise in interest rates tends to worsen it. Needless to say, unlike the structural modelling strategies, the VAR methodology refers to an original, i.e. purely empirical, interpretation of the Phillips curve. Furthermore, assuming the pro-cyclical concept of aggregate credit risk presented in para. 19, GDP growth and rising incomes of firms and/or households will strengthen their ability to meet their debt obligations. And finally, there is a wide consensus that interest rates, especially real interest rates, influence the capacity of borrowers to serve bank loans and other debts.

22. The NPL ratio is a straightforward aggregate indicator of credit risk, especially when the concept of non-performing loans is underpinned by legally binding classification rules consistently applied by the supervisory authority … This is the case in Australia, the Czech Republic, Slovenia, the USA and many other countries. IMF (2004) includes the NPL ratio in its core set of FSIs for macro-prudential analysis.[18]

IMF (2001) points out that "in many countries, including most G-10 countries, assets are considered to be non-performing when (1) principal or interest is due and unpaid for 90 days or more; or (2) interest payment equal to 90 days or more have been capitalised, refinanced or rolled over… For countries that are using the standard classification system, NPLs are often defined as loans in the three lowest categories (substandard, doubtful, loss). Nevertheless, the classification criteria vary across countries… meaningful cross-country comparisons of national NPL figures would require a common definition of NPLs." The ECB (2004) uses a very similar definition of

[17] For references to this approach in the VAR literature see Garretsen and Swank (1998) and Calsa, Manrique and Sousa (2003).

[18] FSI No. 6.54. Non-performing loans to total gross loans: This FSI is intended to identify problems with asset quality in the loan portfolio. It can be interpreted in combination with NPLs less specific provisions for the capital ratio described above. An increasing ratio may signal a deterioration in credit portfolio quality, although this is typically a backward looking indicator in that NPLs are identified when problems emerge. Appropriate recognition of NPLs is essential for this ratio to be meaningful. The indicator can be viewed side-by-side with those for the non-financial corporate sector, as a deteriorating financial position for non-financial corporations in particular might well be mirrored in this ratio. See IMF (2004).

NPLs.[19] The NPL ratio is one of the FSIs used for regular assessment of credit risk that might challenge EU banking sector stability. At the same time, the ECB also points out that the definitions of NPLs can differ significantly between EU member states.

23 … but also has considerable disadvantages. The NPL ratio has the weaknesses inherent in any macroeconomic concept of credit risk mentioned in para. 10. The particular disadvantages of this FSI are (1) that NPLs tend to be lagging indicators of loan portfolio quality compared to indicators such as corporate or household sector leverage, and (2) that unlike the amount of loan loss provisions the NPL ratio itself indicates the impact of loan quality on neither profitability nor capital adequacy of banks.

24. The share of NPLs in the Czech banking sector's loan portfolio reflects classification rules that adhere to the internationally widespread concept of NPLs and that, unlike the provisioning rules, have been very stable throughout the investigated period. Since September 1994 the concept of NPLs has covered substandard, doubtful and loss loans, and since January 2002 it has also included loan loss provisions for loans assessed under the portfolio approach (see the next paragraph). Equation (2) defines the NPL ratio as follows:

$$(2) \qquad nplratio = (sub + doubt + loss + llppa)/ lnom$$

where sub denotes the nominal gross value of substandard loans, doubt stands for the nominal gross value of doubtful loans, loss symbolises the nominal gross value of loss loans and llppa denotes the nominal value of loan loss provisions created for loans, whose expected loss is determined by a statistical model under the portfolio approach, and lnom stands for the gross nominal value of loans. Until January 2002 the llppa equalled zero. The NPL ratio is measured in percentage points.[20]

[19] Assets are defined as non-performing when either the obligor has filed for bankruptcy or similar protection from creditors, or the obligor is past due more than 90 days on any material credit obligation to the banking group. Doubtful assets are defined as all other irrevocable commitments that could give rise to risk. It should be noted that the definitions of non-performing and doubtful loans can differ significantly between countries. ECB (2004), p.14.

[20] It is first necessary to clearly distinguish the concept of NPLs from the sample of data that empirically describe the NPL ratio, or rather its dynamics. Whereas changes in the NPL concept refer to the development of regulatory rules for loan classification described in this paragraph, changes in the data sample refer to the development of the aggregate loan portfolio of the Czech banking sector, which can reflect either changes in classification rules or changing economic conditions. In 1993, Czech banks classified loans and created loan loss provisions (LLPs) according to a circular issued by the former State Bank of Czechoslovakia. This circular divided loans into four categories – standard, substandard, doubtful and loss – whose definitions were broadly comparable with the categories defined in CNB Provision No. 165/1994 Coll., which came into force in September 1994. However, unlike the former SBCS circular this provision was a legally binding by-law. It stipulated two basic criteria for loan classification, namely assessment of a borrower's creditworthiness and repayment of the debt in compliance with the agreed conditions. The first criterion implied that each loan a bank granted to a particular client had to be included in the same category as the worst performing loan with this client. According to the second criterion loans were divided into five categories. Basically, standard loans were less than 31 days past due, watch loans more than 30 days but less than 91 days past due, substandard loans more than 90 days and less than 181 days past due and doubtful loans more than 180 days and less than 361 days past due, and finally loans that were more than 360 days past due together with loans with bankrupt borrowers fell into the category of loss loans. The provision strictly distinguished rules for loan assessment and classification from rules for creating LLPs, because it stipulated that the assessment of a particular loan depended neither on its

25. Testing on break points reveals how changes in the classification rules and state interventions to stabilise the banking sector influenced the dynamics of the NPL ratio. For this purpose the NPL ratio is modelled as a pure autoregressive process isolated from the impact of the remaining variables included in the transmission. The idea is that such segregation enables detection of those periods when changes in the classification rules and state interventions to stabilise banking sector particularly strongly influenced the quality of the loan portfolio. Break point tests are applied to the ARIMA(10,2) model, which is expressed by the following equation:

$$(3) \qquad dnpl = 0.39dnpl_{t-10} - 0.01 - 0.23AR(10) + 0.28\ MA(2) + \varepsilon_t$$

where d denotes the monthly percentage change measured in percentage points, npl means the NPL ratio, AR(10) stands for the tenth-order autoregressive term and MA(2) corresponds to the second-order moving average term and ε_t stands for the residuals, which are assumed to be serially uncorrelated and homoscedastic.

The adjusted sample includes 122 monthly observations and covers the period from October 1994 to November 2004. Owing to the a priori restriction ruling out improvement of the estimates by including more explanatory variables, the model poorly fits the data and the adjusted R^2 is only 0.12. Nevertheless, the estimates are consistent, because the residuals of the model are homoscedastic and not significantly auto-correlated with the mean, which, although not normally distributed, is reasonably close to zero. See the annex for details. Table 1 summarises the results of the analysis. There are seven break points and four of them can be attributed to tightening of the classification rules.

value nor on the liquidity of the collateral securing it. The provision stipulated that LLPs should amount to the adjusted value of a classified loan multiplied by the coefficients 0.05 for watch loans or 0.20, 0.50 or 1 for the three NPL categories. The adjusted value of a classified loan was basically its principal and interest accrued minus the collateral value and minus LLPs that had already been created. Until 2003 this principle remained untouched and the provisioning rules did not influence the concept of NPLs. Effective 1 January 1998 this provision was replaced by Provision No. 272/1997 Coll. It tightened the classification rules with respect to rolled-over loans and stipulated that they had to be classified in the same or a worse category than the original loan. Whereas this change affected the concept of NPLs, another new rule, namely that unsecured foreign exchange loans that were otherwise classified as standard loans had to be classified as watch, did not, because watch loans are not considered NPLs. In July 1998 the CNB issued the new Provision No. 193/1998.Coll. It further tightened the classification rules for rolled-over loans and considerably tightened the provisioning rules for those loans which were put in the loss category and which were secured by real estate. Again, the latter tightening did not affect the concept of NPLs. Since January 2003 the new CNB Provision No. 9/2002/CNB Bull. has been in force. It has introduced the concept of non-performing loans as a legal term, substantially modernised the methodological base for the classification rules and widened its scope to cover receivables from all licensed banking activities. At the same time it has considerably relaxed the criteria for standard and watch loans, because for the first time the classification rules take into account high quality collateral. Thus, these rules are no longer as strictly separated from the provisioning rules as was the case before. Besides the assessment of individual loans the provision allows the portfolio approach, i.e. the use of a statistical model to calculate expected losses connected with a loan portfolio. In order to make the picture complete, we should mention that the coefficient for calculating the LLP for watch loans has decreased from 0.05 to 0.01. Effective January 2005 this valid CNB provision has been amended to include a refining of the portfolio approach and the introduction of some technical changes. Nevertheless, this amendment goes beyond the investigated period.

The remaining break points reflect either a change in the statute of Konsolidační banka or state interventions to stabilise the banking sector.[21] All in all, these results determine the choice of dummy variables to be included in the VAR model in order to address the impact of institutional factors.

Table 1: Significant break points in the dynamics of the NPL ratio

Date	Type of change	Explanation	Case for a dummy ?
1993:Mar	Acceleration	Implementation of the SBCS circular	Yes
1994:Sep	Acceleration	CNB Provision No. 165/1994 Coll. came into force	Yes
1997:Jan	Acceleration	CNB Provision No. 272/1997 Coll. came into force	Yes
1998:Jul	Acceleration	CNB Provision No. 193/1998 Coll. came into force	Yes
2000:Mar	Deceleration	Clean-up of the loan portfolio of a large state-controlled bank before its privatisation	Yes
2000:Dec	Acceleration	Ring-fencing operations in a large bank before its privatisation	Yes
2001:Sep	Deceleration	Konsolidační banka[22], which specialises in the management and work-out of non-performing assets, was converted into a non-bank state agency. This institutional change caused a sudden decrease both in the total volume of bank loans and in the NPL ratio.	Yes

Note: The break points in March 1993 and September 1994 are out of the adjusted sample of the ARIMA model.

26. The VAR model has a symmetric structure, which supports OLS estimations. It is represented by the following formula:

$$(4) \qquad dy_t = A_1 dy_{t-1} + A_2 dy_{t-2} + A_3 dy_{t-8} + A_4 dy_{t-10} + A_5 dy_{t12} + c + Bx_t + \varepsilon_t$$

where d denotes the monthly percentage change, measured in percentage points, y_t stands for the vector of nine endogenous variables, x_t means the vector of exogenous variables, A_1 , A_2, A_3, A_4, A_5 and B are the symbols of the matrices of the coefficients to be estimated, and ε_t is a vector of non-autocorrelated disturbances (innovations) with zero means and a contemporaneous covariance matrix E. Owing to the data constraints discussed in para. 28, the model includes only 5 of the 12 lags. The model is presented in the annex.

As indicated by the description of the transmission, the vector of endogenous variables, y_t , includes the CZK real effective exchange rate (eur_t), exports (exp_t), CZK monetary aggregate M2 (m_t), imports (imp_t), aggregate bank loans to clients (l_t), the unemployment rate (un_t), the consumer price index (cpi_t), the domestic (real) three-month interest rate (i_t) and finally the share of non-performing loans in aggregate bank loans to clients (npl_t) as the FSI indicator. The data sample includes 142 monthly observations for the period February 1993–November 2004, while the adjusted sample includes 130 observations. Owing to a lack of data for the period 1993–1995, the real exchange rate is calculated only with respect to the euro/mark. It is quoted in eurocents per CZK, i.e. according to the convention used in the UK, because this convention fits the theory

[21] In September 2001, when Konsolidační banka was converted into a non-bank state agency, loans concentrated in this "bank hospital" ceased to be included in the bank loan statistics, and both the total amount of the aggregate loan portfolio and, to an even greater extent, the amount of non-performing loans suddenly decreased.

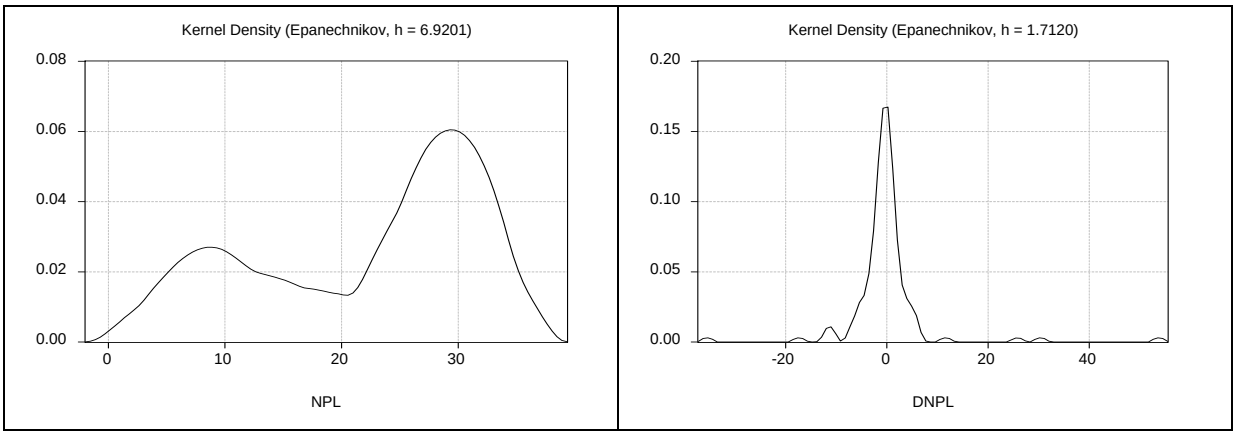
[22] For more information on Konsolidační banka and its successor, see: http//www.kob.cz.

of the real exchange rate better than the usually used quotation of the CZK exchange rate in terms of number of domestic currency units per unit of foreign currency.

Exports and imports are expressed in real terms, and the deflator is export and import prices. Money, loans and the interest rate are also expressed in real terms. They are deflated by the CPI. The time series of exports, imports, real money, unemployment and the CPI are seasonally adjusted. The vector of exogenous variables contains seven of them. The first one is the two-week nominal interest rate, the 2W PRIBOR, marked with the symbol $p2W_t$. This rate is a policy variable because the two-week repo rate is the CNB's principal monetary policy tool. Whereas including it in the model considerably increases the fit to the data exhibited by the equation with the dependent variable $P3m_t$, the impact on the remaining equations is negligible. Furthermore, including the exogenous variable $p2W_t$ improves the information criteria for the model as a whole. This empirical evidence facilitates interpretation of the impulses generated by endogenous variable $P3m_t$ as the monetary policy impulse, because it demonstrates a significant direct impact of $p2W_t$ on the domestic real three-month interest rate. The remaining six exogenous variables are dummies that control for the break points in the NPL ratio time series discussed in para. 25.

27. In order to avoid the spurious regression problem and to deal with the bimodal empirical distribution of the NPL ratios, the time series of variables are transformed to differences or monthly percentage changes in the original time series. Augmented Dickey–Fuller tests indicate that the time series of each endogenous variable is I(1). Furthermore, the empirical distribution of the NPL time series is bimodal and gives a clear signal that the data sample lumps together two sets of data which should be kept separate. On the other hand, figure 2 demonstrates that differencing creates a fairly consistent data sample with unimodal empirical distribution and that under the given circumstances it seems to be the only feasible and safe modelling strategy. Another important point is that we do not follow the convention promoted, for example, by Friedman and Schwartz (1963), namely that difference in logarithm is practically equivalent to monthly percentage change. Since the changes in the dynamics of the NPL ratio are sometimes very large, this approximation produces a significant downward bias in the simulations, especially in the forecast. The latter finding *mutatis mutandis* agrees with Moffatt and Salies' (2003) simulations of hyperinflation, which demonstrate that logarithmic approximation is accurate only if the rates of change of the investigated variables are reasonably small. See the annex for the statistics of the original and differenced time series.

Figure 2: The NPL ratio and its differences – Kernel density



28. The lag structure of the model compromises data constraints with the requirement to have a sufficiently long lag structure in order to deal with effects that on a macroeconomic level are often well delayed. Normally, at least three or four quarters are taken into account to deal with macroeconomic relationships. Using monthly observations this requirement leads to a VAR model containing 9–12 lags. On the other hand, the number of observations available is limited, and with increasing number of lags a VAR model quickly exhausts degrees of freedom. Consequently, the number of lags has to be limited to avoid over-fitting. A pragmatic solution is to restrict the number of lags and choose the lag structure by minimising the SIC (Schwarz information criterion).[23] In this case the outcome is a symmetric lag structure which includes the 1^{st}, 2^{nd}, 8^{th} and thereafter the 10^{th} and 12^{th} lags. Such a structure complies with a weak variant of the conventional rule that a VAR model could suffer from a small number of degrees of freedom if the number of lagged endogenous variables exceeds one third of the size of the sample of observations. It is definitely "over-fitted" if this number reaches one half of the sample size. The model contains 45 lagged explanatory endogenous variables, which means a 35% share in the adjusted sample of observations.

29. All the model's variables are relevant and the model fits the data reasonably well. Since the model includes a considerable number of variables it is necessary to test each of them for exogeneity. From the econometric point of view, the distinction between "exogenous" and "endogenous" variables in a model is a subtle and sometimes controversial issue. Nevertheless, Zellner (1962) proved that OLS estimates of a symmetric VAR system are consistent and efficient provided that they do not leave any significant autocorrelations. Furthermore, Kuszczak and Murray (1987) argue that this structure make it possible to apply the OLS method to individual equations. And finally, Greene (2003, p. 582) clarifies that the tests for exogeneity can be based on the concept of Granger causality applied to individual equations and thereafter interpreted to cover the whole system in such a way that if the lagged values of a variable x_t have no explanatory powers for *any* of the variables in the system, then x_t is seen as *weakly* exogenous to the system. Granger causality is examined by the Wald test. They reject, at the 5% significance level, the null hypothesis of Granger non-causality for each endogenous variable with the exception of growth of loans and real money. However, from the less technical point of view presented also by Greene (2003, p. 381), including the aforementioned variables in the model is appropriate because they do not vary independently of the other endogenous variables. With respect to goodness of fit, it is possible to say that, given the density of the data and the relatively large sample of observations, the model exhibits satisfactory adjusted R square statistics (see the annex).

30. Analysis of the residuals shows that the results of the OLS estimations are unbiased and suggests that the model is correctly specified, but at the same time indicates that some of the estimations may be inefficient and that there are significant correlations in the model's covariance matrix. Contemporary modelling strategies stress the importance of testing residuals. Such testing has two key aspects with respect to a VAR model with a symmetric structure. Firstly, testing on autocorrelations in residual time series indicates whether or not the OLS estimations of the individual equations are the best ones. And secondly, analysing the residuals' covariance

[23] Canova (2003, p. 14) points out that the SIC is a better tool than the Akaike criterion (AIC), because the AIC, although more popular, is inconsistent.

matrix facilitates assessment of the robustness of the impulse analysis to re-ordering of variables. While correlograms and Q-statistics fail to indicate any significant autocorrelations in the residuals of the individual equations, the stronger and more general LM tests detect significant autocorrelation in the residuals of the regressions estimating the real exchange rate, the CPI, the interest rate and the NPL ratio.

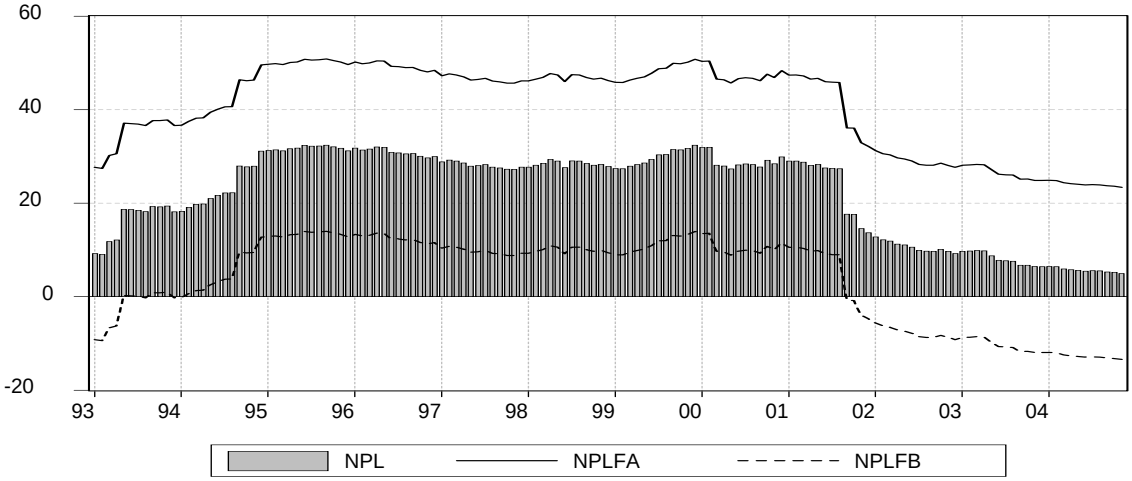
Thus, although all the estimated coefficients are unbiased, those that suffer from residual autocorrelations are not the most efficient in the class of all linear unbiased estimators. In other words, other unbiased and more efficient estimators can be found for the four above-mentioned equations. Given the incomplete lag structure of the model, problems with estimate efficiency can be expected. On the other hand White tests fail to indicate any significant heteroscedascity. Therefore, the model is probably correctly specified, because the White test can be interpreted as a general test for model misspecification thanks to the fact that the null hypothesis underlying this test assumes that the residuals are both homoscedastic and independent of the regressors, and that the linear specification of the model is correct. Moreover, the mean of each time series of residuals is very close to zero, and, not surprisingly, the mean tests also confirmed the hypothesis of zero means at a very high significance level. However, with the exception of exports, imports, the CPI and the real interest rate, Jarque–Bera tests at the 5% significance level reject the hypothesis of normality of residual time series. At the same time, the statistics of the residuals demonstrate that violation of the condition of normality is caused by excess kurtosis in the respective residuals, which points to the fact that most of the investigated time series are leptokurtic (see the annex). And finally, taking into account that endogenous variables are measured in percentage points, the determinant of the covariance matrix is small but the matrix contains significant correlations that may challenge the robustness of the impulse response analysis. This issue is addressed in section 5.

4. Forecast of the share of NPLs in the aggregate loan portfolio

31. The in-sample forecast of the NPL ratio fits the data sample well. The forecast expresses a truly dynamic statistical interpretation of the macro-prudential concept of credit risk created by simulating interactions between all the variables included in the model. It is drawn from data using the forecasted dynamics of the NPL ratio for indexing the NPL ratio observed in January 1993.

Figure 3 demonstrates that under the normality assumption the forecasted values vary within the boundaries determining the 95% confidence interval for two tailed tests. Therefore, the in-sample forecast of the NPL ratio is unbiased. Needless to say, the same holds *mutatis mutandis* for the in-sample forecasts of the remaining endogenous variables.

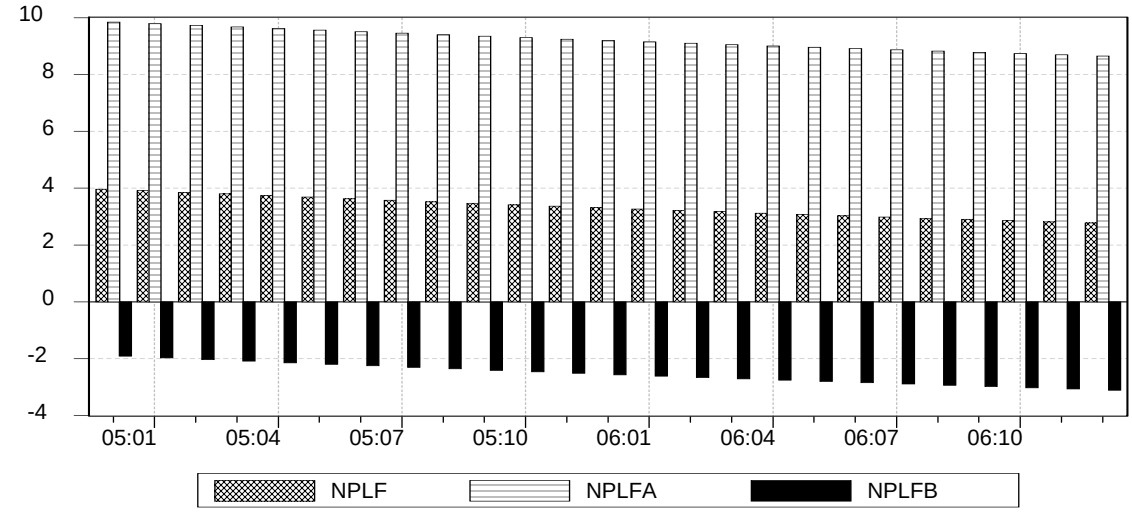
Figure 3: In-sample forecast of the NPL ratio



Notes: NPL stands for the observed NPL ratio, NPLF denotes the forecasted NPL ratio, and NPLFA and NPLFB denote the forecasted NPL ratio for a longer period plus and minus, respectively, 1.96 standard deviations of the NPL ratio time series. Standard deviation is 9.40%. Data are measured in percentage points.

32. The most likely outlook for the quality of the banking sector's loan portfolio is that up to the end of 2006 the NPL ratio will follow a slightly downward trend below double-digit rates. Figure 6 presents this out-of-sample forecast. From para. 10 it follows that a macro-prudential forecast like this one is conditional on the absence of large idiosyncratic shocks. The forecast's robustness to huge macroeconomic shocks is supported by stress testing, which indicates that neither individual huge macroeconomic shocks nor a combination thereof in a worst case scenario are likely to cause the NPL ratio to rise beyond the forecasted band or to reach a double-digit rate (see section 6).

Figure 6: Out-of-sample forecast of the NPL ratio up to December 2006



Notes: NPLF denotes the forecasted NPL ratio, NPLFA and NPLFb stand for the forecasted NPL ratio plus and minus, respectively, 1.96 standard deviations of the time series. Data are measured in percentage points. It is obvious that the part of the confidence interval containing negative values has no economic interpretation.

The forecast is based on 95% confidence. Owing to the bimodal distribution of the NPL ratio time series mentioned in para. 27, the boundaries of the confidence interval are determined by the standard deviation of the sub-sample of this time series, which includes data from October 2001 to November 2004, and not by the standard deviation of the whole sample. In such way the data sample is reduced with respect to the latest break point indicated in Table 1 and it excludes the bulk of data that reflect the development and resolution of the credit crisis. This adjustment considerably narrows the forecast's confidence interval, because the standard deviation of the reduced data sample is around 3%, i.e. more than two times smaller than the standard deviation of the whole sample. From the economic point of view the latter interval reflects the assumption that the resolution of the banking crisis and the privatisation of large systemically important banks created conditions for an essential improvement in loan policies and credit risk management on a microeconomic level. At the same time it is obvious that the forecast has to be systematically back-tested for the impact of an increase in the data sample.

5. Impulse response analysis

33. The responses gained within the framework of impulse response analysis are tested for robustness to re-ordering of variables as well as for robustness to reduction of the data sample. Since there are significant correlations between some residuals (see the annex) and since such correlations challenge the robustness of the responses to shocks, it is necessary to examine the sensitivity of the responses to re-ordering of the variables.

Table 2: Robustness of the responses

Impulse /response	DEUR	DEXP	DM	DIMP	DL	DUN	DCPI	DI	DNPL
DEUR	R	R	R	R	R	R	R	W	R
DEXP	R	R	R	R	R	R	W	R	W
DM	W	R	R	R	W	R	R	R	R
DIMP	R	W	R	R	R	R	R	W	R
DL	R	W	R	R	R	W	R	R	R
DUN	R	R	R	R	R	R	W	W	R
DCPI	R	R	R	R	R	R	R	R	R
DI	R	W	R	R	W	R	R	R	R
DNPL	W	R	R	W	R	R	R	R	R

Notes: R: Fairly robust responses; W: Weak responses

While the aforementioned aspect of robustness is related to Cholesky decomposition[24], the second set of robustness tests reflects the evolutionary nature of the investigated time series, which challenges the time invariance of statistical estimations with break points in them. Robustness to break points is usually tested by reducing the data sample. Owing to data constraints the data sample is reduced only by excluding about 12 observations. All in all, the robustness tests demonstrate firstly that 15 (18%) of the 81 responses are weak, secondly that the findings presented in the following sections reflect the aforementioned evolutionary nature of the Czech economy, and finally that these findings need to be systematically back-tested for the impact of an increase in the data sample and that they have to be taken *cum grano salis*.

34. The selection of the basic hypotheses for the impulse response analysis reflects the results of the robustness tests, some relevant theories and the empirical findings presented in the literature reviewed in Section 2. The VAR model produces 81 responses including the autoregressive ones. The responses are divided into the following three sets: the set of basic hypotheses, the set of other findings and the set of weak responses.

The first set includes 45 responses that express the theories underlying the investigated transmission and/or are derived from other relevant theories and/or, finally, have been investigated in the literature surveyed in section 2. Therefore, the basic hypotheses are characterised by a theoretical or empirical background that suggests the expected sign of the cumulative responses. Table 3 presents a list of basic hypotheses, points to their background and indicates whether or not each hypothesis is supported by the simulations. The second set of responses contains 21 responses whose expected sign is not clear enough either, owing to the lack of such a background. They are presented mainly in order to promote further research. Whereas the responses included in these two sets are fairly robust, the remaining 15 responses are weak (see the previous paragraph). These responses are mentioned both to promote further research and to make the picture complete.

Within the framework of the VAR methodology, the reaction of a variable to an impulse generated by another variable is assumed to reveal the causal relationship between them. Each impulse or shock equals one standard deviation of the time series of the respective variable and causes other time series to respond. These responses are a really dynamic representation of the investigated transmission, because each of them is mediated through interactions between all the variables included in the VAR model. Simulations of the responses have to be performed for a sufficiently long period in order to detect regularity in them. Normally, 30 or more periods are

[24] Smant (2002) explains the so-called identification problem which is related to the VAR methodology and clarifies that the residuals of the VAR reduced form are not the structural shocks needed for impulse response analysis. To derive them, some identifying assumptions are required. Recursive identification, which separates the residuals into orthogonal shocks using Cholesky factorisation of the covariance matrix of residuals, is the standard way to meet these requirements. See also Canova (2003) and Leeper, Sims and Zha (1996). Recursive identification attributes all the contemporaneous correlations of the residuals to the variable that is ordered first in a model. In such a way it challenges the robustness of the impulse response analysis, because the responses depend on the ordering of the variables, whose variety expands very quickly with their growing number. Nevertheless, Kuszczak and Murray (1987) suggest inspecting the correlations of the residuals, identifying those that might pose a problem, switching the order of any variables that are highly correlated and checking the sensitivity of the results of the impulse response analysis.

taken into account; in this case the simulations are performed for 36 periods. Table 1 shows the cumulative responses in the 12th, 24th and 36th period. Figures showing the responses throughout the simulated period are presented in the annex. It is worth mentioning that the quotation of the real exchange rate defined in para. 26 implies that appreciation is expressed by rising growth in the variable deur.

Table 3: Basic hypotheses

Hypothesis	Theoretical or empirical background.	Supported
1. Appreciation causes deceleration in export growth.	Theory of real effective exchange rate.	Yes
2. Appreciation causes acceleration in import growth.	Theory of real effective exchange rate.	Yes
3. Appreciation causes deceleration in GDP growth.	Literature reviewed in para.16.	No
5. Appreciation causes deterioration in quality of banks' loan portfolios.	Literature reviewed in para. 14.	No
6. Appreciation decelerates inflation.	Theory of real effective exchange rate.	Yes
7. Rising export growth causes rising import growth.	Theories of exports-imports-output causality.	Yes
8. Rising export growth causes GDP growth.	Export-led growth hypothesis.	Yes
9. Faster GDP growth is autoregressive.	Business cycle theory.	Yes
10. Faster GDP growth generates trade deficit.	Literature reviewed in para 15.	Yes
11. Faster GDP growth causes decrease in unemployment growth.	Okun's Law.	Yes
12. Faster GDP growth causes increase in CPI.	Demand-pull inflation.	No
13. Faster GDP growth causes interest rates to rise.	Literature reviewed in para. 16.	Yes
14. Faster GDP causes decrease in growth of NPL ratio.	Theory of financial cycle.	No
15. Rising import growth does not cause deceleration in GDP growth.	Export-led growth hypothesis: imports contribute to growth of domestic capacities.	Yes
16. Rising import growth does not cause increasing unemployment.	Export-led growth hypothesis: imports contribute to growth of domestic capacities.	Yes
17. Rising import growth causes decrease in CPI.	Theory of one price of tradable good; impact of global competitive pressures on domestic prices of tradable goods.	Yes
18. Credit expansion supports GDP growth.	Theory of financial cycle.	Yes
19. Dynamics of credit growth are autoregressive.	Theory of financial cycle.	Yes
20. Faster loan growth causes rising NPL ratio.	Literature reviewed in para.14.	No
21. Increase in unemployment growth supports exports.	Growing competitiveness due to rising productivity.	Yes
22. Rising unemployment has negative impact on economic growth.	Rising unemployment limits growth of domestic demand.	Yes
23. Rising unemployment decelerates growth of demand for loans.	Negative expectations of households and entrepreneurs.	Yes

24. Increase in growth of unemployment is autoregressive.	Structural changes in domestic capacities.	Yes
26. Rising unemployment causes NPL ratio to increase.	Deterioration in household's ability to service loans; decreasing incomes of business sector owing to decrease in domestic demand.	Yes
27. Rising CPI fails to cause depreciation.	Balassa–Samuelson effect.	Yes
28. Rising CPI causes deceleration in export growth.	Decrease in competitive advantage of relatively low wage costs.	Yes
29. Rising CPI causes deceleration in GDP growth.	Adverse impact of inflation on exports, final consumption and investment.	Yes
30. Rising CPI causes deceleration in import growth.	Decreasing intra-industry trade; decreasing domestic demand due to rising inflation.	Yes
31. Rising CPI decelerates demand for loans.	Increasing real interest rates responding to rising inflation	Yes
32. Rising CPI causes rate of unemployment to decrease.	Phillips curve.	No
33. Rising CPI causes increase in interest rates.	Literature surveyed in para. 16.	Yes
34. Rising CPI causes NPL ratio to rise.	Literature reviewed in para. 14.	Yes
35. Following monetary policy shock currency appreciates.	Literature surveyed in para. 16.	Yes
36. Following monetary policy shock GDP growth decelerates.	Literature surveyed in para. 16.	Yes
37. Following monetary policy shock growth in unemployment rate rises.	Literature surveyed in para 16.	Yes
38. Following monetary policy shock growth of CPI may indicate price puzzle.	Literature surveyed in para. 16.	Yes
39. Acceleration in NPL ratio fails to support exports.	Soft loan policies mitigate market cleaning and restructuring of domestic capacities.	Yes
40. Acceleration in NPL ratio supports GDP growth in short term.	Soft loan policies mitigate market cleaning and restructuring of domestic capacities.	Yes
41. Acceleration in NPL ratio supports demand for imports.	Rising domestic demand due to soft loan policies implies rising demand for imports.	Yes
42. Slowdown in growth of loans is response to credit risk shock.	Theory of financial cycle; literature surveyed in para. 14.	No
43. Acceleration in NPL ratio causes deceleration in rate of unemployment.	Soft loan policies push supply curve on the labour market up.	Yes
44. Acceleration in NPL ratio causes inflationary pressures.	Demand-pull inflation.	Yes
45. Credit risk shock causes NPL ratio to accelerate.	Literature surveyed in para. 14.	Yes

Table 4: Cumulative responses

DEUR	DEUR	DEXP	DM	DIMP	DL	DUN	DCPI	DI	DNPL
12 months	1.28	-0.81	0.05	0.02	-0.03	-1.63	-0.20	-0.15	0.45
24 months	0.88	-0.56	0.04	1.01	0.24	-2.05	-0.28	0.02	-0.44
36 months	1.05	-0.73	0.10	0.79	0.33	-2.32	-0.31	0.12	-1.20
DEXP									
12 months	0.14	1.88	0.19	1.43	0.02	0.20	0.03	0.59	0.10
24 months	0.12	1.95	0.17	1.66	-0.09	0.35	0.04	0.51	0.23
36 months	0.14	1.79	0.17	1.30	-0.11	0.33	0.04	0.59	0.33
DM									
12 months	-0.03	0.06	0.84	0.69	0.27	-0.55	-0.11	0.05	0.30
24 months	0.17	0.13	0.85	1.13	0.20	-1.08	-0.13	0.40	0.44
36 months	0.13	0.14	0.89	1.27	0.26	-1.22	-0.14	0.49	0.12
DIMP									
12 months	0.05	-0.15	0.07	1.70	0.03	-0.81	-0.04	-0.78	0.15
24 months	0.17	-0.10	0.14	1.90	0.16	-1.31	-0.05	-0.35	0.01
36 months	0.14	-0.06	0.15	2.03	0.22	-1.37	-0.05	-0.42	-0.34
DL									
12 months	-0.11	-0.16	0.11	0.43	1.16	-0.21	-0.07	0.07	-0.16
24 months	-0.07	-0.10	0.08	0.54	1.31	-0.17	-0.09	-0.43	-0.51
36 months	-0.08	0.01	0.06	0.68	1.34	-0.10	-0.11	-0.61	-0.54
DUN									
12 months	-0.69	0.37	-0.32	0.06	-0.15	2.62	0.07	-0.03	-0.41
24 months	-0.36	0.29	-0.48	-0.73	-0.44	3.13	0.09	-0.32	0.93
36 months	-0.41	0.17	-0.54	-0.66	-0.54	3.18	0.12	-0.41	1.34
DCPI									
12 months	0.27	-0.12	-0.13	-0.38	-0.30	0.49	0.54	0.76	0.41
24 months	0.29	-0.03	-0.13	-0.87	-0.33	1.15	0.69	0.60	1.68
36 months	0.31	-0.16	-0.15	-1.03	-0.41	1.37	0.75	0.57	2.67
DI									
12 months	0.11	0.05	-0.24	-0.19	-0.14	0.11	0.17	3.10	0.55
24 months	0.07	-0.02	-0.19	-0.40	-0.14	0.48	0.23	2.89	0.54
36 months	0.11	-0.01	-0.21	-0.45	-0.18	0.62	0.25	2.88	0.96
DNPL									
12 months	-0.29	0.07	0.15	0.22	0.28	-0.21	0.06	0.83	3.56
24 months	-0.09	-0.25	0.19	0.26	0.20	-0.51	0.15	0.96	3.85
36 months	-0.07	-0.30	0.20	0.21	0.24	-0.57	0.18	0.96	3.97

Note: Responses are measured in percentage points

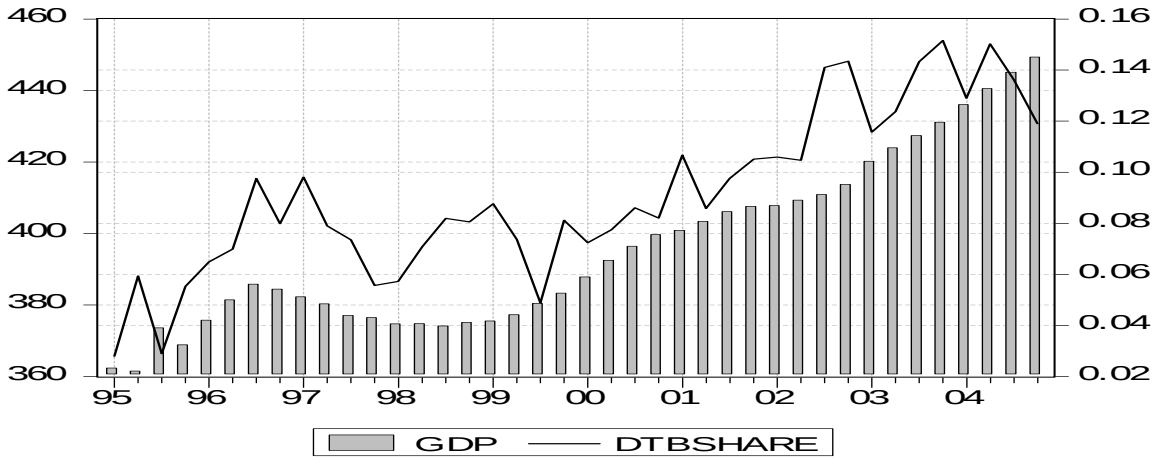
All the responses are discussed more in detail in the following paragraphs. Needless to say, the c*eteris paribus* assumption applies to each hypothesis, and, in line with para. 19, growth of real money approximates GDP growth.

35. The responses to appreciation support the theory of the real exchange rate as well as the other basic hypotheses. Generally speaking, an exchange rate impulse is either an appreciation or depreciation generated by world financial markets. It can be triggered either by fundamental factors such as steadily increasing foreign direct investment or change in the trade balance, or by institutional factors such as a large privatisation project or a surprising negative political event. Financial contagion across previously separated financial markets can cause large exchange rate

shocks, too. The impact of appreciation on foreign trade is the starting point for the investigated transmission. Appreciation causes responses that fit the theory of the real exchange rate, i.e. export growth decreases and import growth rises. The out-of-sample information suggests that the former effect may express in particular competitive pressures on small and medium-sized enterprises, which, unlike large companies, neither sufficiently benefit from intra-industry trade nor can afford relatively costly hedging against exchange rate risk. See for example, Grund (2005) for information on the problems faced by small and medium-sized enterprises. The small response, suggesting that appreciation slightly accelerates GDP growth, differs from the findings presented in the literature reviewed in para. 16, but corresponds with the fact that, as mentioned in para. 3, throughout the investigated period the Czech economy saw GDP growth accompanied by appreciation. The CPI response suggests that the appreciation succeeds in decreasing consumer prices. This response is consistent both with the theory of the real exchange rate and with the high openness of the Czech economy. Appreciation causes the NPL ratio to accelerate during the first year, but thereafter it decelerates. Whereas the first trend corresponds with the literature cited in para. 20, the following one obviously does not. The other findings are as follows. The autoregressive response probably indicates monthly and consequently also daily fluctuations around the long-term appreciation trend of the CZK real exchange rate. At the same time it seems that the appreciation itself does not accelerate growth of unemployment. With respect to the above-mentioned competitive pressures on small and medium-sized enterprises, this response is counterintuitive and deserves further investigation. And finally, the response of real interest rates is not robust.

36. While rising exports cause imports to accelerate, the trade deficit decelerates and GDP growth accelerates. Faster export growth is a foreign demand impulse. In the case of the Czech economy this impulse should be ascribed primarily to rising demand in EU economies, which are its principal foreign trade partners.

Figure 7: GDP growth and the trade deficit



Source: Czech Statistical Office, quarterly data.

Notes: GDP stands for real GDP in CZK bn, and DTBSHARE is the ratio of the trade deficit to real GDP.

Import growth varies directly with export growth. Although it is one of the largest responses, it is noticeably smaller than export growth and indicates a decreasing trade deficit. Therefore, rising exports contribute to GDP growth. The findings about the impact of exports on the growth of the Czech economy presented in para. 15 and in figure 7 demonstrate that the positive contribution of exports to GDP growth is a recent phenomenon speaking in favour of the export-led growth hypothesis. In addition to the basic hypotheses there are the following findings. On the one hand rising exports are autoregressive and cause appreciation, but on the other hand they decelerate demand for loans and accelerate real interest rates. While the two former results are intuitive both from the point of view of economic theory and with respect to the long-term trends in the Czech economy, the two latter results seem to be a puzzle, even though they support each other. And last but not least, the responses of both the CPI and the NPL ratio are not robust.

37. The responses to faster GDP growth support Okun's Law, and the other responses either support the remaining basic hypotheses or reflect some country-specific features. Within the framework of the VAR model, a rise in real money is a money supply impulse that indicates an acceleration in GDP growth (see para. 19). The acceleration in imports agrees with the theory of the real effective exchange rate and with the theories of exports-imports-output causality. Moreover, GDP growth causes exports to accelerate too, although unlike the effects described in the previous paragraph, rising exports are outperformed by import growth and the outcome is a trade deficit. The latter findings can be interpreted as feedback of GDP growth into foreign trade, which considerably lessens the evidence in favour of growth supported by exports. The positive and relatively large autoregressive response of GDP conforms to the theory of the business cycle. Faster GDP growth causes the growth in the rate of unemployment to decrease significantly. This response, which is one of the largest ones, empirically supports Okun's Law. In line with the theoretical assumptions, real interest rates vary directly with GDP growth, especially within a two or three-year timescale. The simulations fail to detect inflationary pressures and the CPI response suggests a rather deflationary reaction. Although unexpected from the point of view of demand-pull inflation theory, this finding agrees with the empirical evidence that since the beginning of this century the Czech economy has been enjoying noteworthy GDP growth accompanied by low inflation. And finally, the accelerating NPL ratio dynamics do not support the hypothesis that GDP growth fosters an improvement in loan portfolio quality or the assumption that GDP growth improves borrowers' ability to serve their bank loans. It might support the countercyclical view of credit risk mentioned in para. 19. Nevertheless, a more appropriate hypothesis seems to be that it reflects some country-specific features of the supply side of the economy, namely the financial fragility of an important part of the corporate sector, which persists despite the general improvement in the performance of the economy as a whole (see Czech National Bank, 2004, p. 21[25]).

[25] The weak link between change in profitability and change in the number of active economic agents suggests that elimination mechanisms to remove unsuccessful corporations are still not fully functional in the economy… Another reason for the weak link between the dissolution of economic agents and their financial results is the trend in the total number of economic agents according to the CZSO's Business Register. This number has been increasing steadily and has almost doubled since the mid-1990s… A significant increase in the number of businesses, even if it is due to an improved business environment, could have an adverse impact on financial stability, and specifically on small and medium-sized enterprises' ability to borrow. This is linked to the short financial history of these entities and to the ensuing complications in assessing credit risk. Nevertheless, the slower growth in the number of new economic agents in the register has fostered an improvement. At the end of

GDP growth causes a small and well delayed appreciation. However, this response is included in the set of other findings because in the short term the relation between GDP and the real exchange rate is not clear enough to facilitate formulation of a basic hypothesis. It is unpleasant that the simulations fail to clarify the impact of economic growth on the credit channel because the response of the growth of real loans is not robust. On the other hand, it is possible to say that the responses to the GDP growth impulse provide additional evidence justifying substitution of GDP by real money, as the empirical findings mostly fit the theoretical assumptions about GDP growth and, where this is not the case, they probably reflect some specific features of the Czech economy.

38. Increasing import growth causes neither a deceleration in GDP growth nor rising unemployment and at the same time somewhat suppresses inflation. An acceleration of import growth is a domestic demand impulse related to a growing propensity to import. Both the slightly rising GDP growth and considerably decreasing unemployment rate seem to support the hypothesis that "export growth allows the importation of capital goods, which, in turn, increase the production potential of an economy" (see Ramos, 2000, p. 613–614). On an empirical level these responses may be linked to large investments in infrastructure, real estate and manufacturing capacities, which have been financed to a large degree by inflow of foreign capital and have helped to mitigate the rising unemployment. The simulations also show that rising import growth causes a decrease in CPI growth. Although minor, this effect can be attributed to global competitive pressures in the markets for tradable goods produced by large exporters enjoying the competitive advantage of low wages. Out-of-sample information suggests that these pressures have been especially strong with respect to textile and leather products (including shoes). The other findings are as follows. Rising imports are autoregressive. They stimulate appreciation. This finding is hard to reconcile with the theory of the real effective exchange rate, but it is compatible both with some of the other theories of foreign trade discussed in para. 15 and with the trends in the Czech economy presented in para. 3. Rising imports cause a significant acceleration in demand for loans and worsening loan portfolio quality. These responses are not counterintuitive, but seem to cover a complex chain of causalities that requires analysis on a disaggregated level. And finally, the responses of both exports and interest rates are not robust.

39. Credit expansion supports GDP growth and positively influences loan portfolio quality, and the autoregressive response seems to support the theory of business cycle amplification by the financial cycle. Although in the literature the credit channel impulse is usually treated as a sudden decrease of loans, not to mention a credit crunch in the case of the Czech economy, within the framework of macro-prudential analysis it is useful to take into account first a credit expansion and only thereafter a decrease in loans. The finding that a credit expansion is significantly autoregressive may support the theory of amplification of the business cycle by the financial cycle. However, the weak response of the credit channel to GDP growth in lessens this

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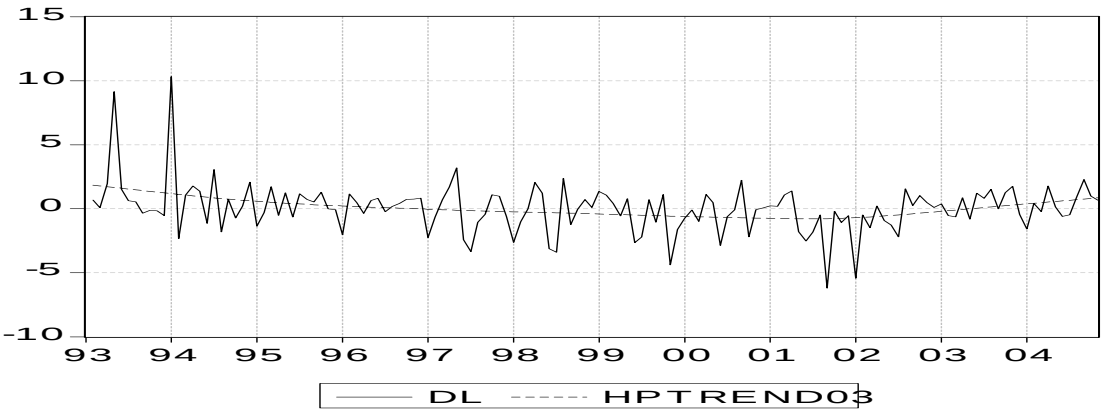
the first half of the 1990s, roughly one-quarter of corporations were less than two years old, compared to less than 10% at present. Although the overall situation in the corporate sector has improved from the point of view of financial stability, some risks persist. We have already mentioned the risks connected with the problem of interpreting the link between improved corporate results and the probability of corporations' survival, which have been present throughout the transformation period. These risks are also linked with certain institutional problems in the Czech economy – generally low debt enforceability, excessively long bankruptcy proceedings, slow operation of the courts, persisting corruption and so on.

evidence. The credit expansion has begun to support economic growth, which was not necessarily the case in the 1990s. The simulations fail to support the hypothesis that a credit expansion itself causes a deterioration in the quality of loans, because the response of the NPL ratio is significantly negative, especially in the longer term. Both responses indicate an overcoming of the credit crisis through the gradual restoration of growth in the loan portfolio roughly since 2002, when the downward trend in loan growth was broken (see figure 8). This change has been driven by double-digit y-o-y growth rates of loans to households (see CNB 2004, p. 18). Such a credit expansion contributes to GDP growth by increasing households' demand for real estate and consumer goods. Furthermore, it fosters an improvement in loan portfolio quality, as traditionally the NPL ratio in loans to households has been much lower than in loans to businesses.[26] Besides findings related to the basic hypotheses, there are some other findings. In line with the acceleration in import growth, a credit expansion causes a relatively small depreciation. At the same time, the nearly negligible and rather deflationary than inflationary response of the CPI indicates that a credit expansion does not generate inflationary pressures. In line with the latter finding, real interest rates decrease. Needless to say, the responses of exports and unemployment are not robust and it is obvious that the effects that would be caused by a credit crunch are the opposite of those caused by a credit expansion.

Figure 8: Growth of real loans and underlying HP trend



40. Following labour market shock exports, GDP and demand for loans decrease whereas the NPL ratio rises in longer run. Rising unemployment is a labour market shock. It chiefly reflects the impact of changes in the structure of domestic capacities on the labour market. Rising unemployment fosters export growth, probably because it expresses growing productivity, which enhances competitiveness in foreign markets. On the other hand it seems that this effect is more

[26] "In aggregate, the quality of all types of loans has risen considerably over the past few years… The situation is improving in the case of corporate clients… Nevertheless, loans to corporations remain the poorer quality component of the loan portfolio. Loans to households are still among the least problematic ones in the Czech Republic… However, a future deterioration in quality cannot be ruled out in the medium term due to their dynamic growth. The quality of these loans differs considerably depending on their purpose." Czech National Bank (2004), p. 38.

than offset by the negative impact of unemployment on domestic demand, which results in a deceleration in GDP growth. Rising unemployment also limits demand for loans. This response seems to go well with the previous one and can be explained both by the negative expectations of households with respect to mortgage and consumer loans and by the similar expectations of entrepreneurs with respect to domestic demand growth. The response of rising unemployment is strongly autoregressive and demonstrates both the price paid for huge structural changes and the great inertia in the labour market. On the other hand, the NPL ratio shifts from deceleration to a noticeable acceleration after 12 months. In such a way it seems to indicate both the fact that the NPL ratio is a lagged indicator of loan quality and the above-mentioned adverse effect of unemployment on domestic demand, which may also be lagged, because rising unemployment reduces household demand and the incomes of a considerable part of the corporate sector depending on this demand gradually rather than suddenly. Moreover, this finding agrees with some of the results presented in the literature reviewed in para. 16.

A labour market shock causes depreciation and in the longer term it curbs import growth. While the former of these other findings is difficult to explain – because, although not being counterintuitive, it probably reflects a complex set of factors – the latter finding corresponds with the responses that support the basic hypotheses and completes the picture of the negative impact of unemployment on domestic demand. As the response of the CPI is not robust, it fails to support the hypothesis about the trade-off between unemployment and inflation underlying the Phillips curve. The response of interest rates is weak, too.

41. All the responses to a consumer price shock are robust; they support most of the basic hypotheses and the same time offer a reasonable explanation for the absence of a trade-off between inflation and unemployment. Theoretically, a consumer price shock primarily reflects the "demand-pull" or "cost-push" theories of inflation. Both theories are reconcilable with the empirical phenomena summarised by the Phillips Curve: as unemployment decreases, wage inflation (and price inflation) rises, or, more generally, there is the trade-off between unemployment and inflation. In an open economy which is heavily dependent on imports of oil, gas and other raw materials, this shock can also be caused by an increase in world prices of these commodities. And finally, in the Czech Republic it can also be caused by autonomous political decisions about indirect taxes or prices that are still regulated, especially housing rents. So much for clarification of the nature of this shock. Now we turn our attention to the results of the simulations. The model suggests that rising inflation causes appreciation. This result is not consistent with the theory of the real effective exchange rate, but it might be linked to the Balassa–Samuelson effect, although the empirical evidence gained on a more disaggregated level indicates that this link is significantly modified by various country-specific and other factors (see Cihak and Holub, 2003, 2003 b). A rising CPI decelerates growth in both exports and imports, and as the latter effect is much larger it causes the trade deficit to decrease considerably. Decreasing imports can be attributed to decreasing dynamics in intra-industry trade, because in a labour market where downward rigidity of wages prevails a rising CPI indicates wage growth, and because the latter factor reduces the competitive advantage of relatively low wage costs, which has probably been the most important factor behind the rapid development of this foreign trade channel. Although according to the basic national accounts identity a decrease in the trade deficit can contribute to GDP growth, this is not the case here. On the contrary, GDP growth decelerates. Therefore, rising inflation adversely influences both final consumption growth and investment growth: firstly, the decrease in imports probably indicates not only diminishing intra-industry

trade, but also declining final consumption, and secondly, given the large role of foreign capital in the Czech economy, it is probable that a rising CPI causes a decrease in investment activity, as it generates expectations that the expected wage growth will reduce the return on foreign direct investment. At the same time these responses provide a tentative explanation of the absence of a trade-off between rising inflation and rising unemployment, i.e. that as the rising inflation challenges the Czech economy's competitive advantage of low wages, it decelerates economic growth and, owing to Okun's Law (see para. 37), it does not mitigate growth in the unemployment rate. The remaining responses are intuitive. A consumer price shock causes an acceleration in real interest rates. This effect is accompanied by decreasing growth in demand for loans. Since rising inflation makes borrowing more expensive, it is not surprising that it causes a considerable deterioration in the quality of the loan portfolio. This finding is also supported by the relevant response to the monetary policy shock presented in the next paragraph. And finally, with exception of the real exchange rate, a positive autoregressive response is the rule. However, the CPI autoregressive response is considerable smaller than the responses of the other variables and indicates that inflationary pressures are subdued.

42. The responses to a monetary policy shock support the basic hypotheses derived from the findings that have been already presented in the VAR literature. In this model the monetary policy impulse is represented by an increase in the real interest rate. Seeing that the VAR literature defines a monetary policy shock in terms of the nominal interest rate rather than in terms of the real interest rate, the impulse response exercise with the nominal interest rate is presented, too. Table 5 shows that with one exception, the responses in terms of the nominal interest rate are practically the same as the responses in terms of real interest rates. Whereas the nominal interest rate impulse causes a counterintuitive depreciation, which in the literature reviewed in para. 16 is sometimes called the exchange rate puzzle, the response to the real interest rate exhibits appreciation, which corresponds with the theoretical assumptions. This result deserves further investigation. Furthermore, following a contractionary monetary policy shock, GDP growth decelerates and unemployment growth accelerates. These two responses can be interpreted as additional evidence supporting Okun's Law mentioned in para. 37. An increase in real interest rates also causes an intuitive acceleration in the NPL ratio. On the other hand, the response of the CPI indicates a price puzzle. Despite being counterintuitive from the point of view of monetary policy, it corresponds to some of the findings presented in the literature (see para. 16). Since neither the export nor import response is robust, the impact of an interest rate shock on the trade balance is not clear enough. The same goes for the credit channel.

Table 5: Cumulative responses to real and nominal interest rate impulse

DI	**DEUR**	**DEXP**	**DM**	**DIMP**	**DL**	**DUN**	**DCPI**	**DI**	**DNPL**
12 months	0.11	0.05	-0.24	-0.19	-0.14	0.11	0.17	3.10	0.55
24 months	0.07	-0.02	-0.19	-0.40	-0.14	0.48	0.23	2.89	0.54
36 months	0.11	-0.01	-0.21	-0.45	-0.18	0.62	0.25	2.88	0.96
DInom	**DEUR**	**DEXP**	**DM**	**DIMP**	**DL**	**DUN**	**DCPI**	**DInom**	**DNPL**
12 months	-0.11	0.04	-0.24	-0.19	-0.13	0.09	0.17	3.22	0.58
24 months	-0.06	-0.03	-0.18	-0.39	-0.14	0.45	0.22	3.05	0.56
36 months	-0.11	-0.02	-0.20	-0.44	-0.18	0.59	0.25	3.06	0.97

Note: D inom stands for decimal change in nominal 3M PRIBOR interest rate

43. The responses to a credit risk shock demonstrate that soft loan policies can support economic growth and lessen unemployment, but there is a price paid in terms of decreasing competitiveness, inflationary pressures and financial instability. A credit risk shock consists of rising dynamics in the NPL ratio. It can be triggered by a macroeconomic or idiosyncratic shock (see section 1) or by a tightening of regulation and supervision (see para. 24). Loan portfolio quality is the core topic of this paper, and all responses to the credit risk shock are included in the set of basic hypotheses, with the exception of the real exchange rate response, which is not robust. On the grounds that the NPL ratio is a lagged indicator of borrowers' capacity to repay their loans, all robust responses to the credit risk shock can be qualified as feedback of credit risk into the Czech economy. The simulations demonstrate that an acceleration in the NPL ratio does not contribute to export growth, probably because non-performing loans delay market cleaning of uncompetitive domestic capacities. Whereas export growth decelerates in the longer term, import growth accelerates and the credit risk shock causes the trade deficit to rise. On the other hand, a rising NPL ratio can mitigate growth of unemployment through the above-mentioned delaying of market cleaning. Thus, soft loan policies can distort relations between inflation and unemployment from the expected Phillips curve effect.

A rising NPL ratio causes an acceleration in GDP growth. Given the deceleration in unemployment growth and the adverse impact on exports, the GDP growth probably reflects growth of final consumption. Not surprisingly, the credit risk shock triggers inflationary pressures. At the same time, the simulations fail to support the hypothesis that a slowdown in credit expansion is a response to a deterioration in the quality of loans. In contrast, they indicate weak feedback between the NPL ratio and growth of bank loans and a widespread occurrence of soft loan policies on a microeconomic level, which, despite the shift to prudent credit policies in recent years, remains inscribed in the memory of the time series. Both the former and the latter responses support the idea about the compatibility between price stability and banking sector stability, and the increasing real interest rates correspond with them. Responses to the credit risk shock are dominated by the direct negative impact of the credit risk impulse on the quality of the loan portfolio itself. The response is especially large at the beginning of the simulated period; it dwindles, however, in the second half. This indicates considerable inertia in the deterioration of loan portfolio quality, which agrees with the findings presented in the literature reviewed in para. 14.

6. Stress testing of the quality of the aggregate loan portfolio

44. Stress-testing augments the impulse response analysis by testing the responses of the NPL ratio to extreme events. While the forecast is drawn from the data sample in order to predict the most likely outlook for the quality of the loan portfolio, stress testing is concerned with unlikely events, or so-called "fat tail events", that – if realised – could lead to severe consequences (see Sorge, 2004). As the Jarque–Bera statistics for the endogenous variable time series indicate that, with the exception of export growth, they do not follow a normal distribution, and as the other relevant statistics demonstrate that they are leptokurtic, the occurrence of a fat tail event is more probable than under the normality assumption. How can we calibrate the shocks for stress testing under these circumstances? Generally speaking, the shocks can be based on straightforward use of the maximum of the time series, on the normality assumption that responses to impulses equal to

2 or 3 standard deviations fall within the 95% or 99% confidence interval, or on the quantiles of the empirical cumulative distribution functions of the time series. The last-mentioned approach seems to be the best choice, because the first one uses only a small part of the information contained in the time series and the second one is questionable because the time series are leptokurtic. On the other hand, table 6 demonstrates that the third approach effectively uses the information contained in the time series both in order to determine sufficiently large shocks and in order to limit their magnitude with respect to the maxima of the time series.

Table 6: Scope of shocks

	DEUR	DEXP	DM	DIMP	DL	DUN	DCPI	DI	DNPL
95th quantile	2.84	14.16	2.13	17.58	2.14	5.17	1.23	9.31	5.15
99th quantile	3.76	20.58	3.50	44.33	9.25	6.81	2.91	27.34	32.26
Std. dev.	1.49	7.44	1.16	10.33	1.92	2.08	0.54	9.15	7.34
95th quantile/Std.d.	1.90	1.90	1.84	1.70	1.12	2.49	2.28	1.02	0.70
99th quantile/Std.d.	2.51	2.76	3.02	4.29	4.83	3.28	5.37	2.99	4.39
Maximum	5.18	23.59	4.60	52.54	10.32	8.13	3.01	69.00	53.77
Maximum/Std.d.	3.47	3.17	3.96	5.09	5.39	3.91	5.56	7.54	7.33

Note: Values are measured in percentage points.

45. The most prominent early warning signals of worsening loan portfolio quality are rising growth in the NPL ratio itself, followed by consumer price inflation and rising unemployment. The trends in the responses of the growth in the share of non-performing loans in total loans are identical to the trend produced by standard impulse response analysis, but the responses are much greater.

If we take into account the 99th quantile, then table 7 shows that the acceleration in the growth of the NPL ratio can immediately cause the latter to rise by 16% and that this acceleration does not die. The same is valid for the CPI, whose impact is, however, much more delayed. Rising unemployment, appreciation and rising real interest rates complete the set of early warning indicators. On the other hand, it seems that neither GDP growth accompanied by rising growth in foreign trade turnover nor a credit expansion represents a major challenge to loan portfolio quality.

Table 7:Sensitivity stress tests – responses of the DNPL

95th quantile	DEUR	DEXP	DM	DIMP	DL	DUN	DCPI	DI	DNPL
12 months	-0.81	0.17	0.55	0.28	-0.18	-1.02	0.91	0.57	2.50
24 months	0.95	0.40	0.82	0.03	-0.57	2.30	3.79	0.54	2.69
36 months	2.41	0.58	0.23	-0.58	-0.60	3.30	6.03	0.97	2.78
99th quantile									
12 months	-1.07	0.24	0.90	0.72	-0.78	-1.35	2.13	1.66	15.64
24 months	1.26	0.58	1.34	0.08	-2.47	3.03	8.93	1.58	16.89
36 months	3.19	0.84	0.37	-1.45	-2.57	4.34	14.21	2.83	17.42

Note: Both impulses and responses are indicated in percentage points. The responses indicate the cumulative growth rate of the respective variable for the given period.

46. The scenarios for stress testing represent the combined impact of several variables on the dynamics of the NPL ratio, and, given the historical experience on the one hand and some desirable scenario for the development of the Czech economy on the other, four of them deserve particular attention. The first scenario is scenario A, which combines a depreciation with a monetary policy shock. The second one is scenario B. It is the worst-case scenario and includes a mixture of a credit risk shock with a rise in inflation and unemployment. Whereas the first scenario is related to the external balance of the economy and simulates exchange rate turbulence and a monetary policy tightening, the second simulates a deterioration in loan portfolio quality accompanied by inflationary pressures and unemployment and in such a way addresses the interactions between price instability, banking sector instability and stressful times for households. The third scenario is scenario C, which combines economic growth with decreasing unemployment. And finally, the fourth scenario – scenario D –combines faster growth of exports and imports with an acceleration in CPI inflation. This is the EU convergence scenario, whose essential feature is a combination of growing openness of the economy caused by integration into the single European market with faster CPI inflation caused by rising prices of non-tradable goods and/or wage-cost inflation. Unlike the two previous scenarios, materialisation of the third and fourth scenarios is desirable.

Scenarios A and C both indicate that the moderate acceleration in the NPL ratio switches in the longer term to a deceleration. Whereas the first result suggests that the quality of the banking sector's loan portfolio is sufficiently resistant to appreciation and monetary policy tightening, the second result indicates that the plausible combination of economic growth and job creation is likely to influence loan portfolio quality positively in the longer term.

Table 8: Scenario analysis – responses of the DNPL

Scenario/responses	**A**	**B**	**C**	**D**
95th quantile				
12 months	1.37	2.38	1.57	1.36
24 months	-0.41	8.78	-1.48	4.22
36 months	-1.44	12.11	-3.07	6.04
99th quantile				
12 months	2.73	16.43	2.25	3.28
24 months	0.32	28.84	-1.69	10.85
36 months	-0.35	35.97	-3.97	15.42

Note: Both impulses and responses are indicated in percentage points. The responses indicate the cumulative growth rate of the respective variable for the given period.

On the other hand, the convergence scenario D seems to trigger a considerable deterioration in the quality of the banking sector's loan portfolio, especially if the shocks are modelled using the 99th quantile. In this case the NPL ratio might after two years rise by roughly 11% and after three years by more than 15%. The worst-case scenario also demonstrates a rising trend in the NPL ratio. However, the acceleration here is more than twice as high as in the convergence scenario. On the other hand, as the NPL ratio was approximately 5% in November 2004, even the worst-case scenario indicates that it might rise to no more than around 7%. These two scenarios show a

considerable worsening of the Czech banking sector's aggregate loan portfolio, which could have a significant adverse impact on the aggregate net profit of the banking sector.[27] On the other hand, neither scenario indicates a destabilisation of Czech banking sector with losses comparable to those that it saw during the transition in the 1990s. In addition, the scenario analysis suggests that the banking sector has attained a considerable ability to withstand a credit risk shock and that the banking sector's stability is compatible both with price stability and with economic growth.

7. Concluding remarks

The application of VAR methodology to the investigated transmission yields results that are worth considering.

The most likely outlook for the quality of the banking sector's loan portfolio is that up to the end of 2006 the NPL ratio will follow slightly downward trend below double-digit rates. This forecast is conditional on an absence of large idiosyncratic shocks on the micro-level. At the same time it is underpinned by stress testing, which on an aggregate level demonstrates that in recent years the loan portfolio has gained a considerable ability to absorb macroeconomic shocks without endangering the banking sector's capital base. Furthermore, for those variables that are included both in this VAR and in the CNB's standard models, the VAR model leads to forecasts that are similar to those obtained from the CNB's standard macroeconomic models.

The most interesting results of the impulse response analysis are as follows:

i. The empirical findings agree broadly with the theoretical assumptions underlying the investigated transmission and with the empirical findings that have been presented in the VAR literature so far. The simulations support 38 (i.e. 85%) of the 45 basic hypotheses on the causal relations in the investigated transmission. Needless to say, failure to support a hypothesis can often be reasonably explained by country-specific features revealing the aforementioned evolutionary nature of an economy in transition.

ii. Therefore, the results of the impulse response analysis do not depart dramatically from the findings of similar studies for other countries and mostly reflect cross-country similarities in banking systems. At the same time the results for the relevant variables agree broadly both with some of the basic concepts underlying the CNB's standard models, namely the scenario of convergence towards the more developed EU countries, and with some of the conclusions of the CNB's Financial Stability Report regarding the functioning of the credit channel and the supply side of the Czech economy.

[27] At the end of 2004 the aggregate loan portfolio of the Czech banking sector amounted to around CZK 1,000 bn. The NPL ratio was around 5% and the aggregate net profit of banking sector was about CZK 33 bn. This implies that an increase in NPLs of 10% generates a 5.5% share of NPLs in the banking sector's loan portfolio or an increase of CZK 5 bn in the amount of NPLs, from CZK 50 bn to CZK 55 bn. Under the assumption that the expected losses attributed to such an increase in NPLs equals CZK 2.5 bn, they represent around 7.5% of aggregate net profit. Therefore, the worst-case scenario suggests a decrease in aggregate net profit of around CZK 10 bn. Such an amount considerably reduces the return on the assets of banking sector, but leaves the capital base of the banking sector untouched.

iii. Appreciation causes effects that support the theory of the real exchange rate. The responses to an export shock, as well as out-of-sample information, suggest that a shift towards growth supported by exports has recently emerged in the Czech economy.

iv. The simulations support Okun's Law, indicating that GDP growth can help to reduce unemployment. On the other hand they fail to support the trade-off between unemployment and inflation which has been established for well developed countries with a long and unbroken tradition of a market economy.

v. The problem with allocation of domestic savings via the credit channel seems to be passing thanks to healthy credit expansion, which is contributing to GDP growth. This expansion has been driven by loans to households, which have seen double-digit growth rates in recent years.

vi. The adverse impact of inflation on the dynamics of foreign trade probably demonstrates the crucial importance of relatively low labour costs to the Czech economy's competitiveness. An international comparison of labour costs, as well as the persisting high ERDI relating to the Czech koruna's nominal exchange rate, shows that this advantage is supported to a larger degree by low prices of most non-tradable goods and services. Both these and some other findings are consistent with the Balassa–Samuelson effect.

vii. Both external stability and price stability are compatible with banking sector stability, because an increasing NPL ratio causes a rising trade deficit, and the simulations reject the hypothesis that rising inflation helps to improve the ability of borrowers to repay their bank loans.

viii. A rise in the NPL ratio mitigates growth in unemployment, as it postpones market cleaning of inefficient domestic capacities. Unlike the trade-off between inflation and unemployment growth, the causality between loan portfolio quality and a descending rate of unemployment is robust. From the methodological point of view this means that although on a macroeconomic level the main explanatory line has to be drawn from standard economic variables to credit risk, this analysis indicates significant feedback that is worth analysing.

ix. The simulations fail to support the hypothesis that a slowdown in credit expansion is a response to a deterioration in the quality of loans. In contrast they indicate weak feedback between the NPL ratio and the growth of bank loans and consequently also the widespread occurrence of soft loan policies on a microeconomic level, which, despite the shift to prudent credit policies in recent years, remains inscribed in the memory of the time series.

However, caution is necessary when using the abovementioned results: firstly because of the incomplete lag structure of the model, which reflects data constraints, and secondly because the structural changes in the Czech economy and the resolution of the aforementioned credit crisis weaken the robustness of the simulations.

On the other hand, the model has a promising outlook for further development, as in the long term it will be possible to complete its lag structure without over-fitting the model. Thanks to a gradually increasing number of observations the model will advance towards this goal every year until reaching it in the next decade.

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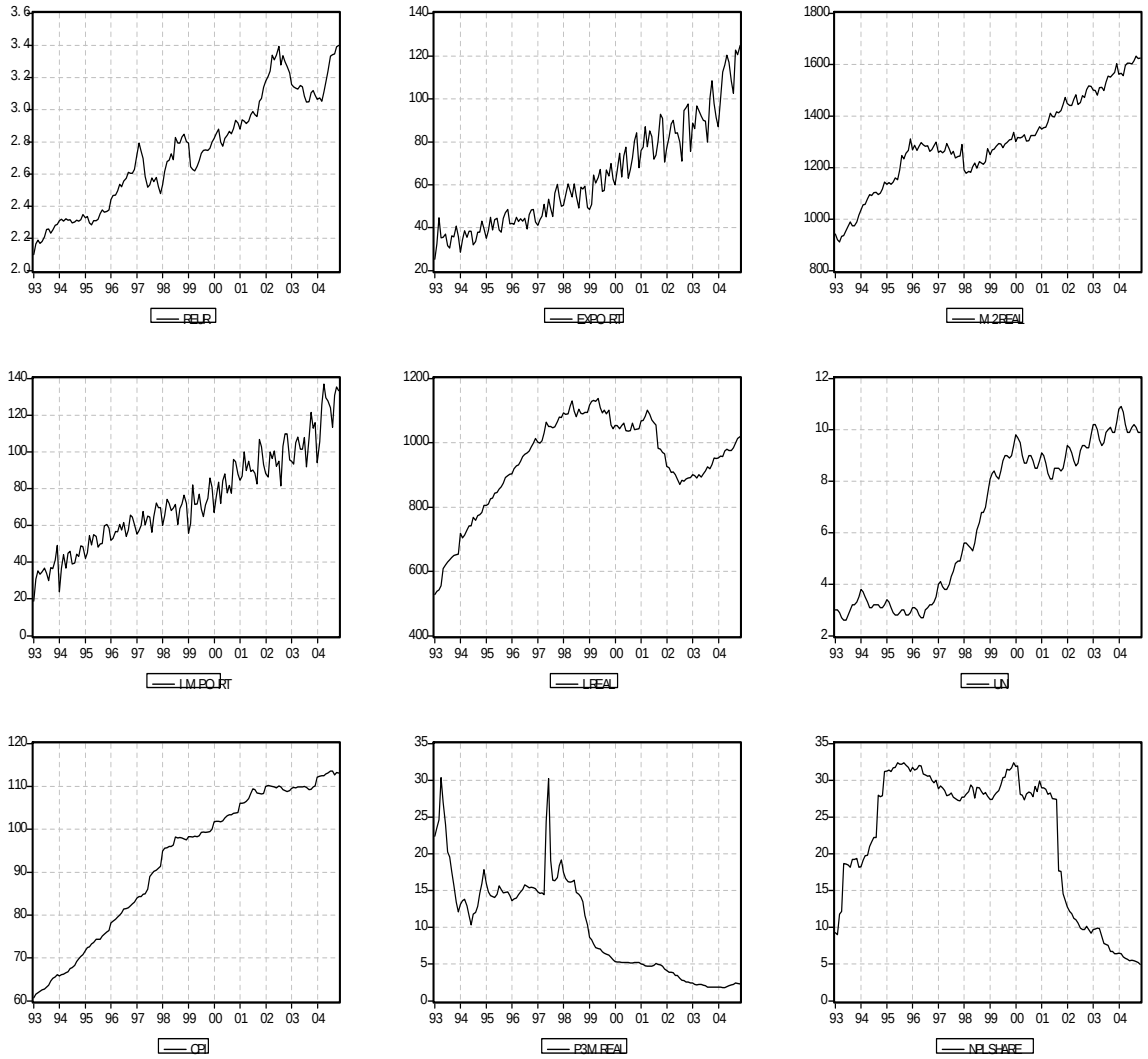
Appendix

1. Time series of endogenous variables and their unit roots

Figure 1 demonstrates that the time series of each endogenous variable includes a trend.

Figure 1: Time series of endogenous variables



Notes: Monthly data for the period January 1994–November 2004. The CZK real effective exchange rate is measured in eurocents per 1 koruna. While exports, real money, imports and real loans are measured in CZK bn, the rate of unemployment, the CPI, the real interest rate and the NPL ratio are measured in percentage points.

An augmented Dickey–Fuller test is used in order to test the hypothesis of a unit root in the time series. In the case of real loans and the NPL ratio, as an increasing trend switches into a decreasing one the test regression includes both the intercept and the trend.[28] The ADF statistics of the remaining variables are based on test regressions that include only the intercept.

Table 1: Statistics of time series of endogenous variables of VAR model

	REUR	EXPORT	M2REAL	IMPORT	LREAL	UN	CPI	P3MREAL	NPLSH.
Mean	2.74	63.43	1299.17	73.88	940.45	6.50	92.53	10.17	22.25
Median	2.75	58.89	1288.41	71.40	967.70	7.50	98.12	10.32	27.72
Maximum	3.40	125.05	1632.89	136.80	1136.56	10.90	113.57	30.33	32.39
Minimum	2.10	25.37	910.89	18.81	527.41	2.60	60.75	1.83	4.97
Std. Dev.	0.35	24.25	176.34	26.40	146.51	2.91	16.81	6.83	9.40
Skewness	0.12	0.63	-0.11	0.33	-0.96	-0.10	-0.46	0.55	-0.65
Kurtosis	1.91	2.47	2.54	2.49	3.31	1.28	1.76	2.63	1.79
Jarque–Bera	7.43	10.99	1.54	4.17	22.60	17.85	14.08	7.92	18.73
Probability	0.02	0.00	0.46	0.12	0.00	0.00	0.00	0.02	0.00
Observations	143	143	143	143	143	143	143	143	143

For notes see figure 1.

Table 2: ADF statistics

Time series		Time series transformed into percentage change	
REUR	-0.60	DEUR	- 5.06
EXPORT	1.48	DEXP	- 7.76
M2REAL	-1.21	DM	-5.19
IMPORT	0.48	DIMP	-6.42
LREAL	-1.91	DL	-4.83
UN	-0.70	DUN	-2.89
CPI	-2.83	DCPI	-3.63
P3MREAL	-2.12	DI	-5.09
NPLSHARE	-1.59	DNPL	-6.38

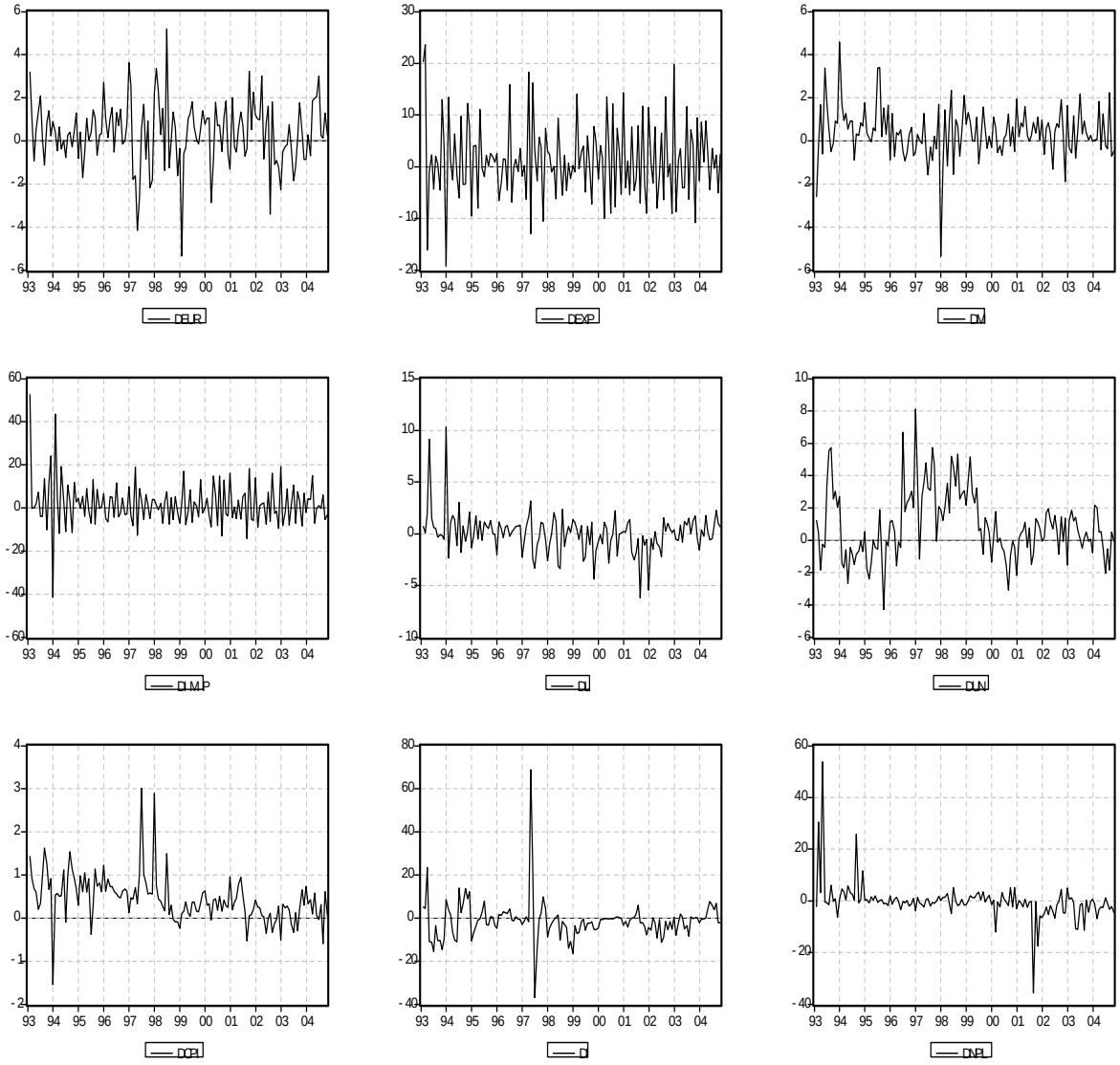
Note: The critical values for the 10%, 5% and 1% significance levels are -2.58, -2.88 and -3.48 respectively.

[28] See the *E-views* manual, which says: There still remains the problem of whether to include a constant, a constant and a linear trend, or neither in the test regression. One approach would be to run the test with both a constant and a linear trend since the other two cases are just special cases of this more general specification. However, including irrelevant regressors in the regression reduces the power of the test, possibly concluding that there is a unit root when, in fact, there is none. The general principle is to choose a specification that is a plausible description of the data under both the null and alternative hypotheses. If the series seems to contain a trend (whether deterministic or stochastic), you should include both a constant and trend in the test regression. If the series does not exhibit any trend and has a nonzero mean, you should only include a constant in the regression, while if the series seems to be fluctuating around a zero mean, you should include neither a constant nor a trend in the test regression. Table 1a presents the ADF statistics for the original time series.

The null hypothesis of a unit root is rejected against the one-sided alternative if the t-statistic is less than – i.e. lies to the left of – the critical value. The test fails to reject the null hypothesis of a unit root in each of the original time series at the 5% significance level. Nevertheless, in the case of the CPI and real interest rate time series it does not reject it at the 10% level.

Worthy of mention is that these results correspond with the results of the PP test. On the other hand, the ADF statistics at the 5% significance level – and, with the exception of the time series for unemployment growth, also at the 1% significance level – show that each transformed time series is stationary. Thus, all time series of endogenous variables are I(1), and in order to avoid spurious regression an unrestricted VAR model has to consist of transformed time series.

Figure 2: Time series of endogenous variables of VAR model



A comparison of the transformed time series with the original time series shows firstly that normally distributed time series are exceptions and secondly that whereas the former time series are mostly platykurtic the later are leptokurtic. Leptokurtosis is associated with empirical distributions that are simultaneously less "peaked" than normally distributed time series and have "fat tails".

Table 3: Statistics of transformed time series of VAR model's endogenous variables

	DEUR	**DEXP**	**DM**	**DIMP**	**DL**	**DUN**	**DCPI**	**DI**	**DNPL**
Mean	0.350857	1.269741	0.386458	1.738000	0.044298	0.932255	0.446967	1.210945	0.185774
Median	0.408791	0.941646	0.324331	0.909261	0.112610	0.566774	0.398536	1.070593	0.312051
Maximum	5.182503	23.59376	4.595111	52.53918	10.31931	8.131222	3.009681	68.99625	53.77087
Minimum	5.337702	19.25706	5.354993	41.63835	6.194684	4.291230	1.546894	36.80332	35.55918
Std. Dev.	1.494856	7.442491	1.159395	10.32549	1.915658	2.077428	0.541721	9.148218	7.340602
Skewness	0.348168	0.373930	0.303814	0.941035	1.221763	0.678745	1.108514	2.996596	2.687412
Kurtosis	4.675092	3.331961	7.628917	9.254871	11.70816	3.679443	9.061916	27.69005	28.44387
Jarque–Bera	19.47066	3.961173	128.9602	252.4381	483.9999	13.63451	246.5003	3819.309	4001.319
Probability	0.000059	0.137988	0.000000	0.000000	0.000000	0.001095	0.000000	0.000000	0.000000
Observations	142	142	142	142	142	142	142	142	142

2. Transmission

2.1 Satellite model – regression between real money and GDP

The ARIMAX (1,4) model presented in Table 4 estimates the regression of real money on final consumption, investment and the trade deficit in the period 1995–2004.

Table 4: Regression between real money and GDP

Dependent Variable: DM
Method: Least Squares
Sample (adjusted): 1996:3 2004:4
Included observations: 34 after adjusting endpoints
Convergence achieved after 21 iterations
Backcast: 1995:3 1996:2

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DC	0.680900	0.259326	2.625656	0.0141
DI(-4)	0.354843	0.068270	5.197681	0.0000
DTB	0.031250	0.011842	2.638831	0.0136
DTB(-4)	-0.059443	0.015476	-3.840850	0.0007
C	0.004639	0.001609	2.882490	0.0076
AR(1)	-0.878254	0.146919	-5.977809	0.0000
MA(4)	-0.913107	0.027442	-33.27432	0.0000
R-squared	0.639472	Mean dependent var		0.006272
Adjusted R-squared	0.559354	S.D. dependent var		0.018117
S.E. of regression	0.012026	Akaike info criterion		-5.822168
Sum squared resid	0.003905	Schwarz criterion		-5.507918
Log likelihood	105.9769	F-statistic		7.981677
Durbin–Watson stat	1.576586	Prob(F-statistic)		0.000052
Inverted AR Roots	-.88			
Inverted MA Roots	.98			

The quarterly data represent percentage changes. The model is discussed in para. 19. All elasticity coefficients are highly significant. Although DW statistics are not an appropriate tool for testing an ARIMAX model, they might show serial autocorrelation in its residuals. Nevertheless, the appropriate and more general LM tests demonstrate high probability values that support the null hypothesis of an absence of serial correlation up to the 4th lag (see Table 5). Correlogram and Q-statistics offer further evidence in favour of this null hypothesis, but their presentation seems to be redundant.

Table 5: Breusch–Godfrey Serial Correlation LM Test

F-statistic	0.884236	Probability	0.488854
Obs*R-squared	1.215196	Probability	0.875590

2.2 Break points in the dynamics of the NPL ratio

Table 6 presents the equation underlying the analysis of break points in the dynamics of the NPL ratio discussed in para. 29 and 30, and table 7 presents the results of the LM test for autocorrelation of residuals.

Table 6: Regression for testing breakpoints in dynamics of NPL ratio

Dependent Variable: DNPL Method: Least Squares Sample (adjusted): 1994:10 2004:11 Included observations: 122 after adjusting endpoints Convergence achieved after 6 iterations Backcast: 1994:08 1994:09				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DNPL(-10)	0.386734	0.098391	3.930584	0.0001
C	-0.975902	0.423650	-2.303556	0.0230
AR(10)	-0.234832	0.101606	-2.311200	0.0226
MA(2)	0.282165	0.089062	3.168178	0.0020
R-squared	0.138179	Mean dependent var		-1.275506
Adjusted R-squared	0.116268	S.D. dependent var		4.761659
S.E. of regression	4.476294	Akaike info criterion		5.867705
Sum squared resid	2364.390	Schwarz criterion		5.959640
Log likelihood	-353.9300	F-statistic		6.306435
Durbin–Watson stat	1.991366	Prob(F-statistic)		0.000527
Inverted AR Roots	.82 -.27i	.82+.27i	.51 .70i	.51+.70i
	.00 -.87i	-.00+.87i	-.51. 70i	.51+.70i
	-.82+.27i	-.82 -.27i		

Table 7: Breusch–Godfrey Serial Correlation LM Test

F-statistic	0.115706	Probability	0.890839
Obs*R-squared	0.242846	Probability	0.885659

3. VAR model

3.1 Testing for exogeneity

The testing for exogeneity follows the methodology proposed by Greene (2003). Its starting point is the concept of Granger causality. Granger causality is inferred when lagged values of a variable, say x_t, have explanatory power in the regression of a variable y_t on the lagged variables of y_t and x_t.

Table 8: Results of Wald tests

Explanatory variable	Dependent variable				
DEUR	DEXP	F-statistic	4.821388	Probability	0.000690
		Chi-square	24.10694	Probability	0.000207
	DM	F-statistic	2.653670	Probability	0.028827
		Chi-square	13.26835	Probability	0.020990
DEXP	DM	F-statistic	2.674895	Probability	0.027789
		Chi-square	13.37448	Probability	0.020111
	DUN	F-statistic	2.748320	Probability	0.024477
		Chi-square	13.74160	Probability	0.017337
DIMP	DUN	F-statistic	3.083985	Probability	0.013683
		Chi-square	15.41992	Probability	0.008711
	DNPL	F-statistic	3.226898	Probability	0.010678
		Chi-square	16.13449	Probability	0.006470
DUN	DEUR	F-statistic	2.311457	Probability	0.051903
		Chi-square	11.55728	Probability	0.041384
	DNPL	F-statistic	2.425478	Probability	0.042698
		Chi-square	12.12739	Probability	0.033083
DCPI	DI	F-statistic	3.234143	Probability	0.010545
		Chi-square	16.17071	Probability	0.006373
DI	DM	F-statistic	4.593708	Probability	0.001015
		Chi-square	22.96854	Probability	0.000342
	DCPI	F-statistic	8.253346	Probability	0.000003
		Chi-square	41.26673	Probability	0.000000
DNPL	DL	F-statistic	2.720116	Probability	0.025701
		Chi-square	13.60058	Probability	0.018356

The symmetric structure of the tested VAR model implies that tests for Granger causality can be based on simple F tests in the single equations of the VAR model. The notion can be extended in a system of equations to attempt to ascertain if a given variable is weakly exogenous to the system.

If lagged values of a variable x_t have no explanatory powers for *any* of the variables in the system, then x_t is seen as *weakly exogenous* to the system. The above-mentioned F tests are, however wedded to the normal distribution and this fact limits their generality. This is why more general Wald tests are applied.

The Wald test computes the test statistic by estimating the unrestricted regression without imposing the coefficient restrictions specified by the null hypothesis. The Wald statistic measures how close the unrestricted estimates come to satisfying the restrictions under the null hypothesis. If the restrictions are in fact true, then the unrestricted estimates should come close to satisfying the restrictions. Under the null hypothesis H_0, the Wald statistic has an asymptotic chi-square (q) distribution, where q is the number of restrictions under H_0 . In this case q is equal to 5.

The equations tested by the Wald tests are identical to the equations of the VAR model. The null hypothesis is that five regression coefficients belonging to an explanatory variable are jointly equal to zero. If these restrictions are true, then the variable does not significantly contribute to the estimation of the dependent variable. It they are not true, then the F statistics and chi-square statistics are high and support the hypothesis that the tested variable contributes to the explanation of the dependent variable. Table 8 shows the significant Granger causal relations indicated by the Wald test. It demonstrates firstly that at the 5% significance level each variable with the exception of loan growth and real money growth contributes to the estimation of at least one other variable and that 12 (i.e. 17%) of the 72 tested relations demonstrate significant Granger causality.

3.2 VAR model

Table 9 tries to promote transparency in the presentation of the results of VAR modelling by introducing both the estimated coefficients and standard statistics of the model.

It demonstrates that according to the conventional requirement for significance expressed by t-statistics equal to 2 or more, the majority of the coefficients are not significant. In fact there are only 32 (i.e. 8%) significant coefficients of the endogenous variables, out of a total number of 405. Another 131 coefficients (i.e. 32% of the total) whose t-statistics exceed 1 can be considered as weakly significant. The remaining 242 coefficients (i.e. 60%) are insignificant.

These results could have been expected: Sims (1980) points out that a VAR model is not the appropriate tool for an analysis based on elasticity coefficients between its endogenous variables, because most of the estimated elasticities are usually insignificant. Instead, these models are used for dynamic analysis of responses of endogenous variables to impulses generated by a significant change in another endogenous variable. The idea is that these responses reveal causal links between the investigated variables. A dynamic forecast is the second principal output of VAR models. This means that the VAR methodology is designed for testing hypotheses through experiments or shocks as well as for forecasting.

Table 9: VAR model

Included observations: 130 after adjusting endpoints									
Standard errors & t-statistics in parenthese									
	DEUR	DEXP	DM	DIMP	DL	DUN	DCPI	DI	DNPL
DEUR(-1)	0.119945	-1.430227	0.077991	-0.982582	-0.038197	-0.134691	-0.051982	0.597015	0.013065
	(0.10926)	(0.40929)	(0.07708)	(0.46811)	(0.11204)	(0.12626)	(0.02817)	(0.26729)	(0.23857)
	(1.09780)	(-3.49439)	(1.01187)	(-2.09902)	(-0.34091)	(-1.06681)	(-1.84523)	(2.23362)	(0.05476)
DEUR(-2)	0.066036	-0.913655	-0.068464	-0.478793	0.145087	-0.322198	-0.008098	0.117746	-0.297921
	(0.11749)	(0.44013)	(0.08288)	(0.50339)	(0.12049)	(0.13577)	(0.03029)	(0.28743)	(0.25655)
	(0.56205)	(-2.07585)	(-0.82602)	(-0.95114)	(1.20417)	(-2.37313)	(-0.26731)	(0.40965)	(-1.16127)
DEUR(-8)	0.079799	-0.338779	-0.149358	-0.124885	-0.194646	0.112275	0.010826	-0.471301	-0.046519
	(0.10891)	(0.40798)	(0.07683)	(0.46661)	(0.11168)	(0.12585)	(0.02808)	(0.26643)	(0.23780)
	(0.73273)	(-0.83039)	(-1.94406)	(-0.26764)	(-1.74282)	(0.89214)	(0.38554)	(-1.76898)	(-0.19562)
DEUR(-10)	-0.212265	0.635409	0.196772	0.262297	0.192881	-0.020759	-0.045237	0.080745	0.356058
	(0.10544)	(0.39500)	(0.07438)	(0.45176)	(0.10813)	(0.12185)	(0.02719)	(0.25795)	(0.23024)
	(-2.01309)	(1.60864)	(2.64536)	(0.58060)	(1.78377)	(-0.17037)	(-1.66392)	(0.31302)	(1.54649)
DEUR(-12)	-0.045000	-0.315985	-0.148508	0.376786	-0.029856	-0.003939	0.018179	-0.033273	0.008742
	(0.10207)	(0.38238)	(0.07201)	(0.43733)	(0.10468)	(0.11795)	(0.02632)	(0.24971)	(0.22288)
	(-0.44085)	(-0.82637)	(-2.06240)	(0.86156)	(-0.28522)	(-0.03339)	(0.69075)	(-0.13325)	(0.03922)
DEXP(-1)	0.016048	-0.806282	0.025010	-0.273115	0.007837	-0.038606	0.007089	-0.068551	-0.016208
	(0.04479)	(0.16779)	(0.03160)	(0.19190)	(0.04593)	(0.05176)	(0.01155)	(0.10957)	(0.09780)
	(0.35829)	(-4.80531)	(0.79153)	(-1.42318)	(0.17061)	(-0.74588)	(0.61383)	(-0.62562)	(-0.16572)
DEXP(-2)	0.054345	-0.221834	0.028696	0.001482	-0.003337	0.097613	-0.006101	0.121760	0.021906
	(0.03847)	(0.14413)	(0.02714)	(0.16484)	(0.03946)	(0.04446)	(0.00992)	(0.09412)	(0.08401)
	(1.41247)	(-1.53912)	(1.05726)	(0.00899)	(-0.08458)	(2.19552)	(-0.61504)	(1.29362)	(0.26075)
DEXP(-8)	-0.000572	-0.074257	0.039465	-0.062923	-0.023688	0.043609	-0.007420	0.037939	-0.044691
	(0.03173)	(0.11885)	(0.02238)	(0.13593)	(0.03253)	(0.03666)	(0.00818)	(0.07761)	(0.06927)
	(-0.01803)	(-0.62481)	(1.76336)	(-0.46292)	(-0.72808)	(1.18953)	(-0.90708)	(0.48883)	(-0.64514)
DEXP(-10)	0.041719	-0.081346	-0.051255	-0.163261	-0.054291	0.009380	0.016488	-0.104809	-0.085808
	(0.03242)	(0.12146)	(0.02287)	(0.13892)	(0.03325)	(0.03747)	(0.00836)	(0.07932)	(0.07080)
	(1.28670)	(-0.66974)	(-2.24091)	(-1.17526)	(-1.63282)	(0.25037)	(1.97233)	(-1.32137)	(-1.21204)
DEXP(-12)	-0.053616	0.030978	0.056606	0.067186	0.006851	0.049477	-0.013444	-0.057909	-0.140477
	(0.03247)	(0.12164)	(0.02291)	(0.13912)	(0.03330)	(0.03752)	(0.00837)	(0.07944)	(0.07090)
	(-1.65119)	(0.25467)	(2.47119)	(0.48293)	(0.20576)	(1.31861)	(-1.60578)	(-0.72900)	(-1.98130)
DM(-1)	0.003155	-0.407967	0.007370	-0.611704	-0.130098	0.223681	0.074869	0.596527	-0.071511
	(0.17817)	(0.66745)	(0.12569)	(0.76338)	(0.18272)	(0.20589)	(0.04594)	(0.43587)	(0.38904)
	(0.01771)	(-0.61123)	(0.05864)	(-0.80132)	(-0.71203)	(1.08641)	(1.62974)	(1.36858)	(-0.18381)
DM(-2)	-0.252705	0.203138	0.092100	0.872931	0.233709	-0.280529	0.022163	-0.410581	0.106788
	(0.17473)	(0.65454)	(0.12326)	(0.74861)	(0.17918)	(0.20191)	(0.04505)	(0.42744)	(0.38152)
	(-1.44629)	(0.31035)	(0.74720)	(1.16607)	(1.30431)	(-1.38939)	(0.49196)	(-0.96055)	(0.27990)

DM(-8)	0.195613	-0.124995	-0.066197	0.223292	-0.067191	-0.102199	0.049879	0.017904	-0.103795
	(0.17494)	(0.65533)	(0.12341)	(0.74951)	(0.17940)	(0.20215)	(0.04511)	(0.42796)	(0.38198)
	(1.11818)	(-0.19073)	(-0.53640)	(0.29792)	(-0.37454)	(-0.50555)	(1.10583)	(0.04183)	(-0.27173)
DM(-10)	0.131972	0.646006	0.084980	0.350613	0.120267	-0.095718	-0.080862	-0.032335	0.331663
	(0.16564)	(0.62052)	(0.11685)	(0.70969)	(0.16987)	(0.19141)	(0.04271)	(0.40522)	(0.36169)
	(0.79672)	(1.04108)	(0.72724)	(0.49403)	(0.70800)	(-0.50006)	(-1.89334)	(-0.07980)	(0.91699)
DM(-12)	0.077166	0.538016	-0.038125	0.702864	-0.335938	0.078739	0.042343	0.362892	0.512776
	(0.14802)	(0.55450)	(0.10442)	(0.63419)	(0.15179)	(0.17105)	(0.03816)	(0.36211)	(0.32321)
	(0.52132)	(0.97028)	(-0.36512)	(1.10829)	(-2.21311)	(0.46034)	(1.10948)	(1.00216)	(1.58653)
DIMP(-1)	0.018206	0.010410	-0.018765	-0.530697	0.039224	0.029119	-0.007061	-0.032963	-0.087315
	(0.03511)	(0.13151)	(0.02476)	(0.15041)	(0.03600)	(0.04057)	(0.00905)	(0.08588)	(0.07665)
	(0.51862)	(0.07916)	(-0.75774)	(-3.52840)	(1.08953)	(0.71781)	(-0.78012)	(-0.38382)	(-1.13910)
DIMP(-2)	-0.010626	-0.132153	-0.015933	-0.374919	0.002143	-0.058575	-0.002703	-0.060109	-0.093762
	(0.02958)	(0.11082)	(0.02087)	(0.12675)	(0.03034)	(0.03418)	(0.00763)	(0.07237)	(0.06459)
	(-0.35921)	(-1.19252)	(-0.76350)	(-2.95806)	(0.07065)	(-1.71349)	(-0.35440)	(-0.83059)	(-1.45156)
DIMP(-8)	0.002970	-0.044456	-0.025569	-0.102372	-0.022448	-0.039873	0.003563	0.007315	-0.098873
	(0.02945)	(0.11031)	(0.02077)	(0.12616)	(0.03020)	(0.03403)	(0.00759)	(0.07204)	(0.06430)
	(0.10085)	(-0.40300)	(-1.23084)	(-0.81142)	(-0.74336)	(-1.17177)	(0.46932)	(0.10155)	(-1.53772)
DIMP(-10)	-0.048843	0.087805	0.018733	0.091933	0.072666	-0.043929	-0.009311	0.100203	0.139303
	(0.02626)	(0.09839)	(0.01853)	(0.11253)	(0.02693)	(0.03035)	(0.00677)	(0.06425)	(0.05735)
	(-1.85966)	(0.89242)	(1.01105)	(0.81696)	(2.69790)	(-1.44739)	(-1.37486)	(1.55952)	(2.42902)
DIMP(-12)	0.051081	0.089409	-0.025426	0.078656	-0.015829	-0.045355	0.007526	0.078333	0.082390
	(0.02420)	(0.09066)	(0.01707)	(0.10369)	(0.02482)	(0.02797)	(0.00624)	(0.05920)	(0.05284)
	(2.11066)	(0.98620)	(-1.48930)	(0.75858)	(-0.63780)	(-1.62179)	(1.20609)	(1.32308)	(1.55911)
DL(-1)	-0.153450	-0.311546	0.033192	0.725524	0.038845	-0.038266	-0.012892	0.222688	0.144679
	(0.10972)	(0.41102)	(0.07740)	(0.47009)	(0.11252)	(0.12679)	(0.02829)	(0.26841)	(0.23958)
	(-1.39855)	(-0.75798)	(0.42883)	(1.54336)	(0.34524)	(-0.30181)	(-0.45573)	(0.82964)	(0.60389)
DL(-2)	0.110666	-0.236519	-0.027250	-0.456438	0.033835	-0.104546	-0.000339	-0.015997	0.389940
	(0.10928)	(0.40936)	(0.07709)	(0.46820)	(0.11206)	(0.12628)	(0.02818)	(0.26733)	(0.23861)
	(1.01270)	(-0.57777)	(-0.35349)	(-0.97488)	(0.30193)	(-0.82790)	(-0.01202)	(-0.05984)	(1.63421)
DL(-8)	-0.039999	-0.272304	0.063335	-0.304941	-0.105006	0.093057	0.014178	-0.185611	-0.458649
	(0.11254)	(0.42158)	(0.07939)	(0.48217)	(0.11541)	(0.13005)	(0.02902)	(0.27531)	(0.24573)
	(-0.35542)	(-0.64591)	(0.79777)	(-0.63244)	(-0.90987)	(0.71557)	(0.48861)	(-0.67419)	(-1.86646)
DL(-10)	0.021465	0.632059	0.027884	0.858222	0.039845	0.050421	0.018632	-0.272341	-0.092338
	(0.09683)	(0.36274)	(0.06831)	(0.41487)	(0.09930)	(0.11189)	(0.02497)	(0.23688)	(0.21143)
	(0.22168)	(1.74248)	(0.40821)	(2.06866)	(0.40126)	(0.45061)	(0.74629)	(-1.14969)	(-0.43673)
DL(-12)	0.026987	0.092953	-0.055605	-0.082709	0.202869	0.099782	0.002864	-0.428065	0.012204
	(0.10503)	(0.39345)	(0.07409)	(0.44999)	(0.10771)	(0.12137)	(0.02708)	(0.25694)	(0.22933)
	(0.25695)	(0.23625)	(-0.75049)	(-0.18380)	(1.88353)	(0.82215)	(0.10574)	(-1.66603)	(0.05322)

DUN(-1)	-0.147971	-0.683222	-0.009145	-0.670755	-0.028831	0.363708	-0.001077	0.141805	-0.412571
	(0.08873)	(0.33237)	(0.06259)	(0.38014)	(0.09099)	(0.10253)	(0.02288)	(0.21705)	(0.19373)
	(-1.66773)	(-2.05558)	(-0.14611)	(-1.76448)	(-0.31687)	(3.54740)	(-0.04707)	(0.65332)	(-2.12957)
DUN(-2)	0.047710	0.082896	-0.071399	0.202605	-0.018153	0.057756	0.006299	-0.033382	0.178160
	(0.09268)	(0.34718)	(0.06538)	(0.39707)	(0.09504)	(0.10709)	(0.02390)	(0.22672)	(0.20236)
	(0.51480)	(0.23877)	(-1.09209)	(0.51025)	(-0.19101)	(0.53930)	(0.26360)	(-0.14724)	(0.88040)
DUN(-8)	-0.073764	0.407459	0.004506	0.252984	0.053124	0.199621	0.002532	0.010353	0.359960
	(0.08717)	(0.32656)	(0.06150)	(0.37349)	(0.08940)	(0.10073)	(0.02248)	(0.21326)	(0.19034)
	(-0.84618)	(1.24774)	(0.07327)	(0.67735)	(0.59426)	(1.98165)	(0.11265)	(0.04855)	(1.89109)
DUN(-10)	-0.189106	-0.485178	-0.053022	-0.352078	0.004510	-0.147814	0.025819	0.141670	0.041680
	(0.09600)	(0.35961)	(0.06772)	(0.41130)	(0.09844)	(0.11093)	(0.02475)	(0.23484)	(0.20961)
	(-1.96991)	(-1.34917)	(-0.78295)	(-0.85602)	(0.04581)	(-1.33249)	(1.04312)	(0.60326)	(0.19885)
DUN(-12)	0.261078	0.663016	-0.072357	0.478631	-0.154912	0.066174	-0.006948	-0.343121	0.275702
	(0.09300)	(0.34840)	(0.06561)	(0.39847)	(0.09538)	(0.10747)	(0.02398)	(0.22752)	(0.20308)
	(2.80716)	(1.90302)	(-1.10285)	(1.20116)	(-1.62423)	(0.61573)	(-0.28975)	(-1.50808)	(1.35762)
DCPI(-1)	0.246778	2.097244	-0.073393	-0.258192	-0.034213	0.066657	0.086362	3.856122	-0.473567
	(0.44076)	(1.65113)	(0.31093)	(1.88842)	(0.45200)	(0.50933)	(0.11364)	(1.07825)	(0.96241)
	(0.55989)	(1.27019)	(-0.23604)	(-0.13672)	(-0.07569)	(0.13087)	(0.75994)	(3.57626)	(-0.49206)
DCPI(-2)	-0.193442	-0.657995	-0.242696	0.618467	-0.449784	0.224706	0.430742	-0.854217	1.545146
	(0.39645)	(1.48512)	(0.27967)	(1.69856)	(0.40655)	(0.45812)	(0.10222)	(0.96985)	(0.86565)
	(-0.48794)	(-0.44306)	(-0.86779)	(0.36411)	(-1.10633)	(0.49050)	(4.21397)	(-0.88078)	(1.78496)
DCPI(-8)	0.106412	-1.424261	0.134413	-0.832666	-0.220535	-0.037147	0.177150	-0.535405	-0.271257
	(0.47000)	(1.76067)	(0.33156)	(2.01370)	(0.48199)	(0.54312)	(0.12118)	(1.14979)	(1.02626)
	(0.22641)	(-0.80893)	(0.40540)	(-0.41350)	(-0.45755)	(-0.06840)	(1.46183)	(-0.46566)	(-0.26432)
DCPI(-10)	0.683320	2.309239	0.264265	1.911005	0.479168	0.558269	-0.197867	-1.462415	0.516645
	(0.45687)	(1.71147)	(0.32230)	(1.95744)	(0.46852)	(0.52794)	(0.11780)	(1.11766)	(0.99759)
	(1.49566)	(1.34927)	(0.81995)	(0.97628)	(1.02273)	(1.05744)	(-1.67973)	(-1.30846)	(0.51790)
DCPI(-12)	0.113198	-0.412099	-0.015649	-2.434404	-0.162422	0.364012	0.198221	-0.639503	0.437129
	(0.43074)	(1.61360)	(0.30386)	(1.84550)	(0.44173)	(0.49775)	(0.11106)	(1.05375)	(0.94054)
	(0.26280)	(-0.25539)	(-0.05150)	(-1.31910)	(-0.36770)	(0.73131)	(1.78480)	(-0.60688)	(0.46477)

DI(-1)	0.004469	0.118797	-0.009779	0.031815	-0.013645	0.002911	0.003633	0.378256	0.019331
	(0.01671)	(0.06260)	(0.01179)	(0.07160)	(0.01714)	(0.01931)	(0.00431)	(0.04088)	(0.03649)
	(0.26744)	(1.89775)	(-0.82953)	(0.44437)	(-0.79627)	(0.15074)	(0.84310)	(9.25292)	(0.52980)
DI(-2)	0.000145	-0.071994	-0.021589	-0.004229	-0.021916	-0.013275	0.022093	-0.244449	0.023869
	(0.01829)	(0.06852)	(0.01290)	(0.07836)	(0.01876)	(0.02114)	(0.00472)	(0.04474)	(0.03994)
	(0.00795)	(-1.05074)	(-1.67318)	(-0.05397)	(-1.16842)	(-0.62810)	(4.68478)	(-5.46323)	(0.59767)
DI(-8)	0.004145	-0.075437	-0.046175	-0.086163	-0.013229	0.012353	0.015540	-0.011995	-0.033445
	(0.01771)	(0.06635)	(0.01250)	(0.07589)	(0.01816)	(0.02047)	(0.00457)	(0.04333)	(0.03868)
	(0.23399)	(-1.13688)	(-3.69537)	(-1.13536)	(-0.72826)	(0.60351)	(3.40259)	(-0.27680)	(-0.86473)

DI(-10)	0.003018	0.157251	0.010594	0.127007	0.038547	0.009852	-0.008289	-0.021330	0.046442
	(0.02123)	(0.07953)	(0.01498)	(0.09096)	(0.02177)	(0.02453)	(0.00547)	(0.05194)	(0.04636)
	(0.14217)	(1.97720)	(0.70736)	(1.39626)	(1.77049)	(0.40156)	(-1.51420)	(-0.41068)	(1.00183)
DI(-12)	0.005799	-0.025599	0.017733	-0.016599	-0.006427	0.006806	0.000421	0.018636	-0.070910
	(0.01834)	(0.06869)	(0.01294)	(0.07857)	(0.01880)	(0.02119)	(0.00473)	(0.04486)	(0.04004)
	(0.31624)	(-0.37266)	(1.37085)	(-0.21128)	(-0.34178)	(0.32117)	(0.08897)	(0.41544)	(-1.77099)
DNPL(-1)	-0.050599	-0.115266	0.015606	-0.072120	-0.040157	-0.027617	0.019411	-0.021226	0.055987
	(0.03212)	(0.12031)	(0.02266)	(0.13760)	(0.03293)	(0.03711)	(0.00828)	(0.07857)	(0.07013)
	(-1.57553)	(-0.95808)	(0.68882)	(-0.52413)	(-1.21930)	(-0.74415)	(2.34415)	(-0.27016)	(0.79838)
DNPL(-2)	-0.012212	-0.092552	0.002792	-0.119873	0.098588	0.012886	-0.013058	0.032771	0.189516
	(0.03430)	(0.12849)	(0.02420)	(0.14696)	(0.03517)	(0.03964)	(0.00884)	(0.08391)	(0.07489)
	(-0.35605)	(-0.72031)	(0.11541)	(-0.81571)	(2.80284)	(0.32510)	(-1.47651)	(0.39056)	(2.53045)
DNPL(-8)	0.018274	0.040199	0.037842	0.102265	0.062499	-0.036610	-0.013878	0.059307	0.072850
	(0.03158)	(0.11831)	(0.02228)	(0.13531)	(0.03239)	(0.03650)	(0.00814)	(0.07726)	(0.06896)
	(0.57862)	(0.33978)	(1.69851)	(0.75576)	(1.92971)	(-1.00313)	(-1.70424)	(0.76760)	(1.05640)
DNPL(-10)	-0.041650	-0.190013	-0.005157	-0.119110	-0.021965	-0.037034	0.004435	0.178560	0.109608
	(0.03007)	(0.11265)	(0.02121)	(0.12884)	(0.03084)	(0.03475)	(0.00775)	(0.07357)	(0.06566)
	(-1.38500)	(-1.68673)	(-0.24311)	(-0.92447)	(-0.71225)	(-1.06572)	(0.57200)	(2.42721)	(1.66926)
DNPL(-12)	0.006823	-0.015921	-0.014463	0.136941	-0.047938	-0.017198	0.005641	-0.065326	-0.007456
	(0.02763)	(0.10350)	(0.01949)	(0.11838)	(0.02833)	(0.03193)	(0.00712)	(0.06759)	(0.06033)
	(0.24694)	(-0.15382)	(-0.74202)	(1.15683)	(-1.69193)	(-0.53865)	(0.79181)	(-0.96650)	(-0.12359)
C	-0.271996	1.801370	0.457923	2.992122	0.342962	-0.025876	0.145002	-1.263890	-1.742410
	(0.38851)	(1.45541)	(0.27408)	(1.66458)	(0.39842)	(0.44895)	(0.10017)	(0.95044)	(0.84833)
	(-0.70009)	(1.23771)	(1.67079)	(1.79753)	(0.86080)	(-0.05764)	(1.44752)	(-1.32979)	(-2.05393)
DUMMY1	2.215239	8.750308	-1.153107	-3.008696	-0.593113	1.182005	-0.423036	-11.36043	-19.98252
	(2.04369)	(7.65585)	(1.44171)	(8.75612)	(2.09580)	(2.36161)	(0.52694)	(4.99959)	(4.46245)
	(1.08394)	(1.14296)	(-0.79982)	(-0.34361)	(-0.28300)	(0.50051)	(-0.80282)	(-2.27227)	(-4.47793)

DUMMY2	-2.979274	-1.540869	0.259433	-6.177264	0.844441	-6.968733	0.755350	-0.138817	2.784936
	(1.45114)	(5.43609)	(1.02370)	(6.21735)	(1.48814)	(1.67688)	(0.37415)	(3.54999)	(3.16859)
	(-2.05306)	(-0.28345)	(0.25343)	(-0.99355)	(0.56745)	(-4.15577)	(2.01882)	(-0.03910)	(0.87892)
DUMMY3	-5.564069	-8.087137	0.043669	-18.34788	3.471052	-3.231963	0.022775	4.540372	-4.881760
	(1.91429)	(7.17109)	(1.35042)	(8.20170)	(1.96310)	(2.21208)	(0.49357)	(4.68302)	(4.17989)
	(-2.90660)	(-1.12774)	(0.03234)	(-2.23708)	(1.76815)	(-1.46105)	(0.04614)	(0.96954)	(-1.16792)
DUMMY4	0.079407	-1.737663	0.309077	-7.151039	-0.173729	1.628960	0.011250	0.601778	-13.64399
	(1.49717)	(5.60853)	(1.05617)	(6.41457)	(1.53534)	(1.73007)	(0.38602)	(3.66260)	(3.26911)
	(0.05304)	(-0.30983)	(0.29264)	(-1.11481)	(-0.11315)	(0.94155)	(0.02914)	(0.16430)	(-4.17362)
DUMMY5	0.064721	1.225684	1.725200	2.312471	1.312508	0.083983	-0.203399	1.285857	-5.616802
	(1.49642)	(5.60573)	(1.05564)	(6.41137)	(1.53458)	(1.72921)	(0.38583)	(3.66078)	(3.26748)
	(0.04325)	(0.21865)	(1.63426)	(0.36068)	(0.85529)	(0.04857)	(-0.52717)	(0.35125)	(-1.71900)

DUMMY6	-0.141442	-1.008574	0.133386	-6.028900	-6.448686	0.053743	-1.224048	-0.222881	-29.52194
	(1.56431)	(5.86005)	(1.10353)	(6.70224)	(1.60420)	(1.80766)	(0.40334)	(3.82686)	(3.41571)
	(-0.09042)	(-0.17211)	(0.12087)	(-0.89954)	(-4.01988)	(0.02973)	(-3.03482)	(-0.05824)	(-8.64299)
DP2W	-0.008692	-0.013262	0.006734	-0.013866	0.012351	0.007908	-0.003003	0.354104	-0.005459
	(0.00704)	(0.02638)	(0.00497)	(0.03018)	(0.00722)	(0.00814)	(0.00182)	(0.01723)	(0.01538)
	(-1.23417)	(-0.50266)	(1.35539)	(-0.45950)	(1.71009)	(0.97171)	(-1.65374)	(20.5521)	(-0.35495)
R-squared	0.565513	0.699027	0.564706	0.753323	0.572886	0.677653	0.743593	0.924331	0.829345
Adj. R-squared	0.272094	0.495773	0.270742	0.586736	0.284445	0.459964	0.570434	0.873229	0.714097
Sum sq. resids	128.8976	1808.842	64.14609	2366.126	135.5545	172.1204	8.569010	771.4055	614.5549
S.E. equation	1.293830	4.846798	0.912725	5.543367	1.326819	1.495102	0.333595	3.165162	2.825108
F-statistic	1.927319	3.439174	1.921001	4.522095	1.986147	3.112941	4.294297	18.08820	7.196201
Log likelihood	-183.9085	-355.6010	-138.5479	-373.0579	-187.1816	-202.7049	-7.702160	-300.2062	-285.4307
Akaike AIC	3.644745	6.286169	2.946890	6.554737	3.695101	3.933921	0.933879	5.433941	5.206625
Schwarz SC	4.813817	7.455241	4.115962	7.723808	4.864173	5.102993	2.102951	6.603013	6.375697
Mean dependent	0.309045	1.229783	0.348137	1.504888	-0.134145	0.832438	0.426115	-0.977405	-0.842874
S.D. dependent	1.516489	6.825615	1.068806	8.623026	1.568520	2.034508	0.508985	8.889693	5.283550
Determinant Residual Covariance		66.88166							
Log Likelihood		-1933.348							
Akaike Information Criteria		37.08228							
Schwarz Criteria		47.60393							

Table 10: Residuals of VAR model

	RESID01	RESID02	RESID03	RESID04	RESID05	RESID06	RESID07	RESID08	RESID09
Mean	-1.91E-16	-8.88E-16	1.58E-16	-6.63E-16	-1.41E-16	-4.70E-17	-1.77E-17	3.10E-16	-6.83E-17
Median	0.018464	-0.051022	-0.005769	-5.24E-15	0.100804	-7.67E-17	3.06E-16	-0.071832	1.13E-15
Maximum	2.765088	12.72897	2.358918	12.59377	2.523527	5.580983	0.646177	6.072590	6.161832
Minimum	-3.145930	-11.60898	-1.437581	-14.16719	-3.628340	-3.581388	-0.775633	-7.043853	-8.533738
Std. Dev.	0.999603	3.744600	0.705164	4.282764	1.025090	1.155105	0.257733	2.445381	2.182657
Skewness	-0.320918	0.249078	0.512740	0.161726	-0.592698	0.590013	-0.164025	-0.052438	-0.610649
Kurtosis	3.867394	3.904887	3.960210	3.647943	4.075829	6.806188	3.349128	3.019542	4.774444
Jarque–Bera	6.306767	5.779476	10.69039	2.840781	13.88059	86.01409	1.243164	0.061646	25.13451
Probability	0.042707	0.055591	0.004771	0.241620	0.000968	0.000000	0.537094	0.969647	0.000003
Observations	130	130	130	130	130	130	130	130	130

Figure 3: Residuals

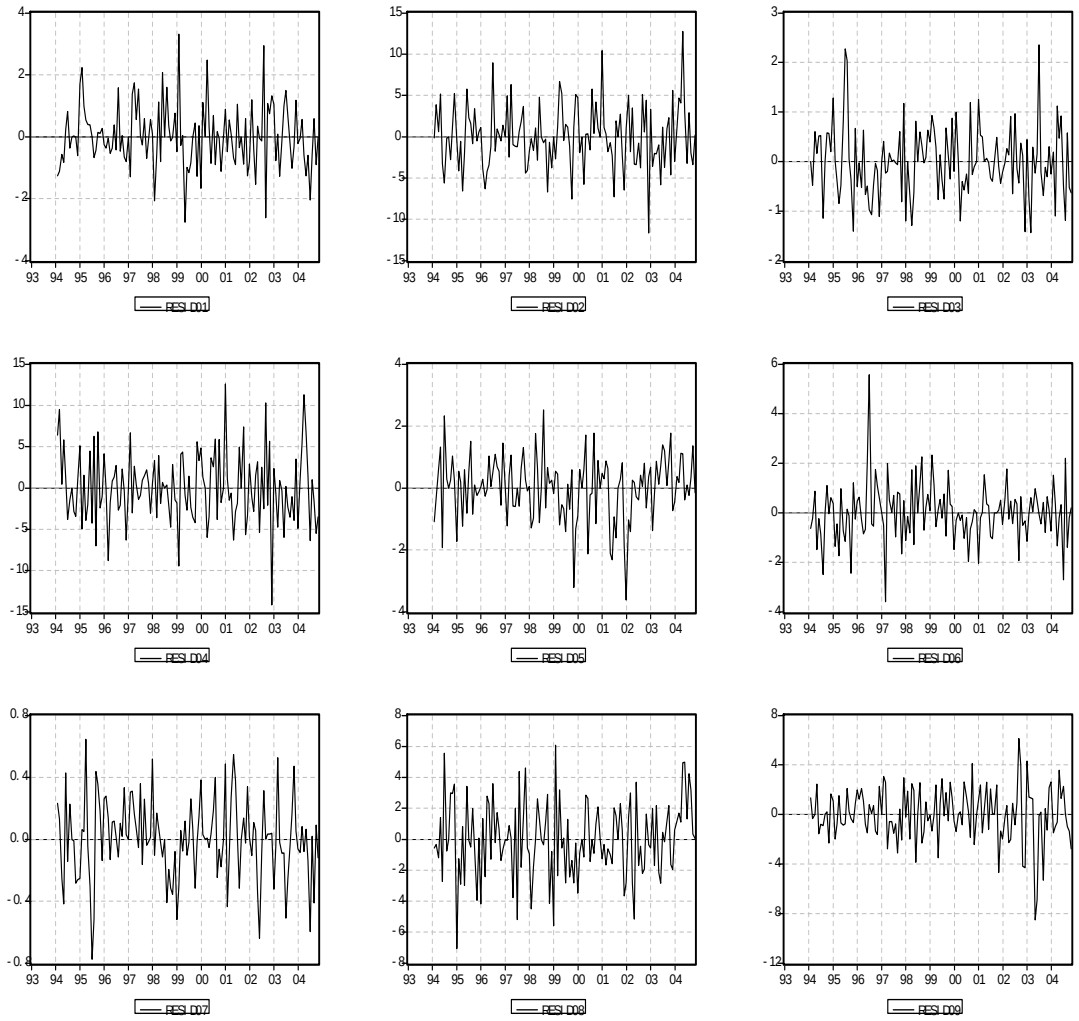


Table 11 shows the presence of some significant correlation between the residuals, which underlines the importance of testing the results of impulse response analysis *vis-à-vis* re-ordering of the variables (see para. 37).

Table 11: Correlations between residuals of VAR model

	RESID01	RESID02	RESID03	RESID04	RESID05	RESID06	RESID07	RESID08	RESID09
RESID01	1.00	0.24	-0.15	0.25	-0.24	-0.16	0.08	-0.02	0.19
RESID02	0.24	1.00	0.19	0.70	-0.04	0.06	-0.01	0.12	0.19
RESID03	-0.15	0.19	1.00	0.21	0.10	0.00	-0.42	0.00	0.05
RESID04	0.25	0.70	0.21	1.00	-0.14	-0.10	0.06	-0.09	0.28
RESID05	-0.24	-0.04	0.10	-0.14	1.00	0.05	-0.25	0.21	-0.09
RESID06	-0.16	0.06	0.00	-0.10	0.05	1.00	-0.02	-0.02	-0.20
RESID07	0.08	-0.01	-0.42	0.06	-0.25	-0.02	1.00	-0.19	0.01
RESID08	-0.02	0.12	0.00	-0.09	0.21	-0.02	-0.19	1.00	0.06
RESID09	0.19	0.19	0.05	0.28	-0.09	-0.20	0.01	0.06	1.00

5. Impulse response analysis

Figure 4: Innovation to DEUR

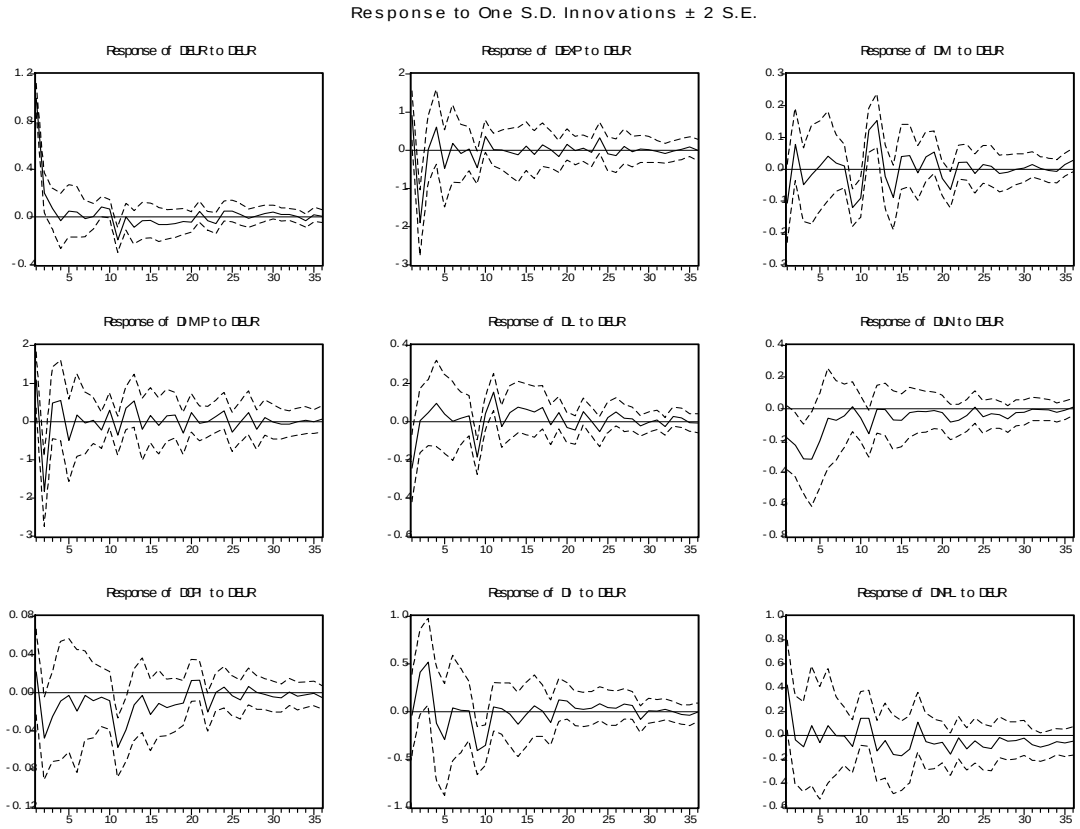


Figure 5: Innovation to DEXP

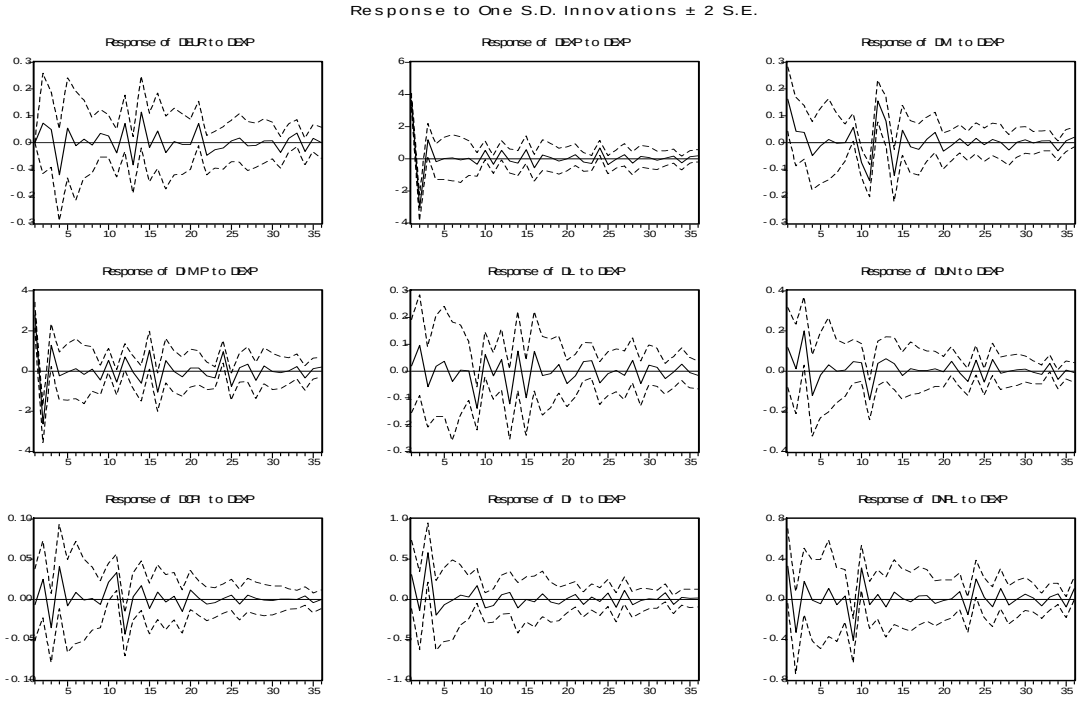


Figure 6: Innovation to DM

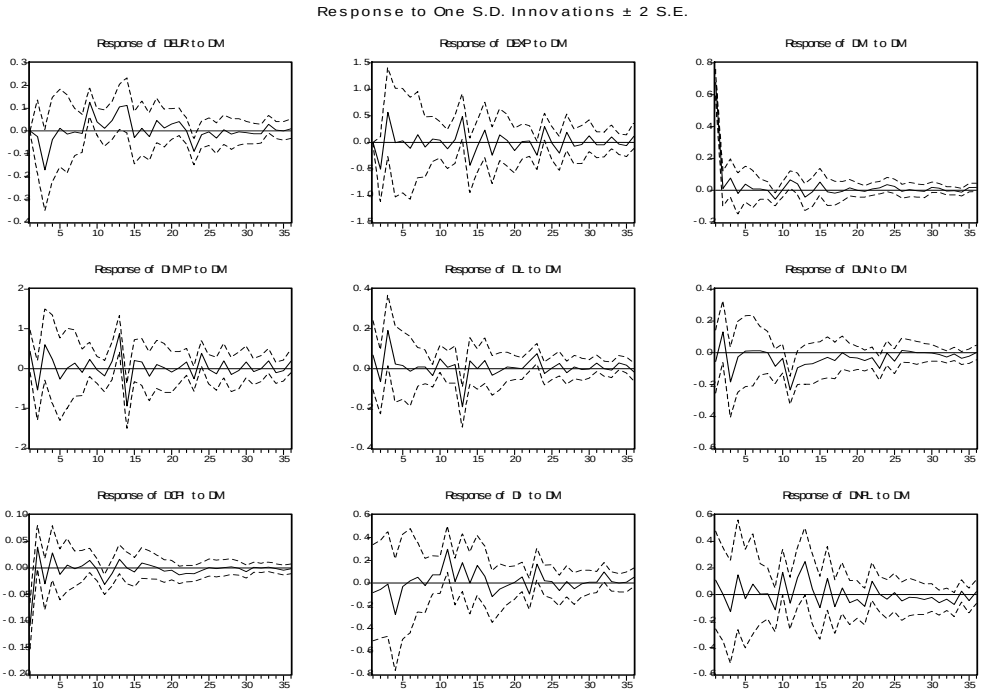


Figure 7: Innovation to DIMP

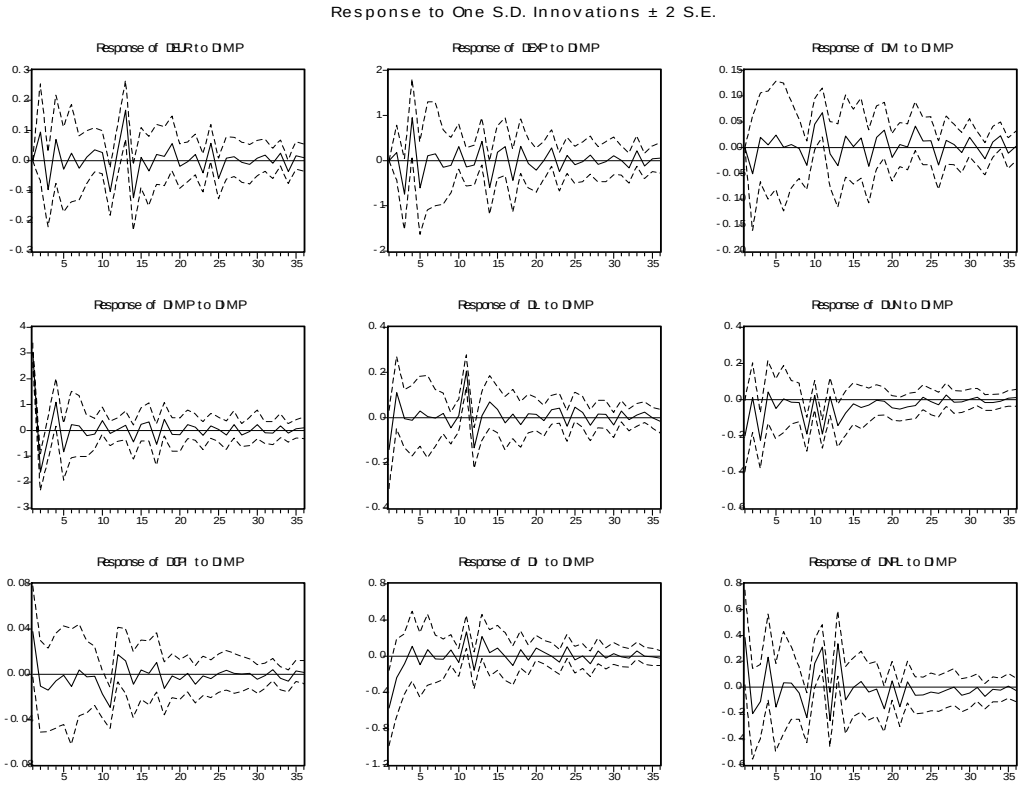


Figure 8: Innovation to DL

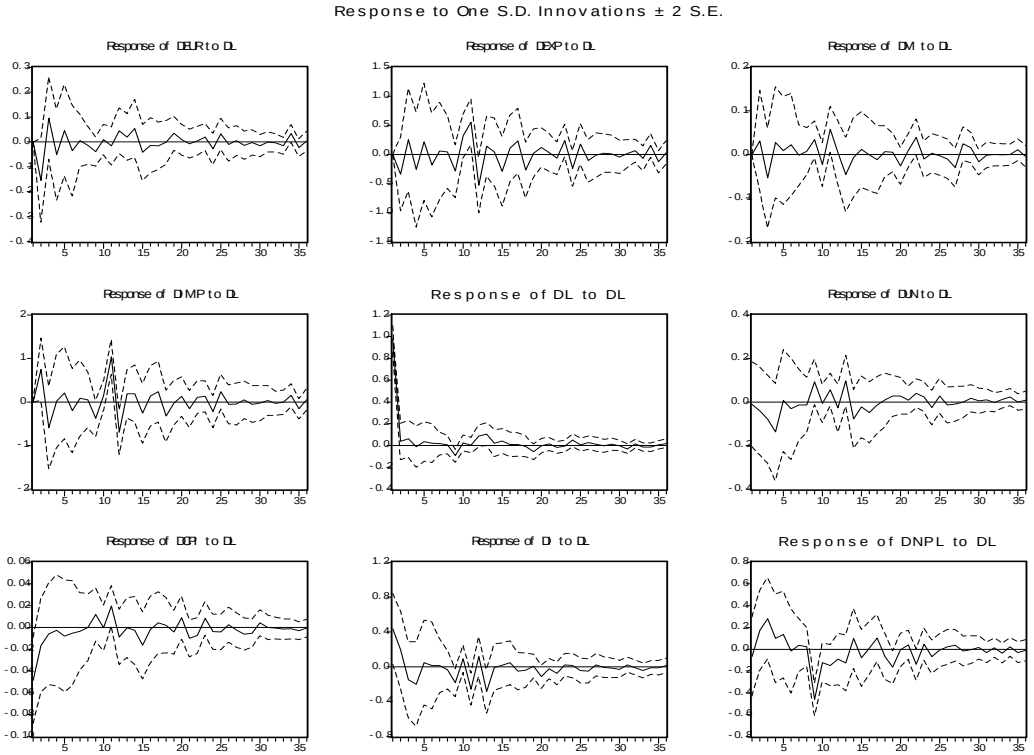


Figure 9: Innovation to DUN

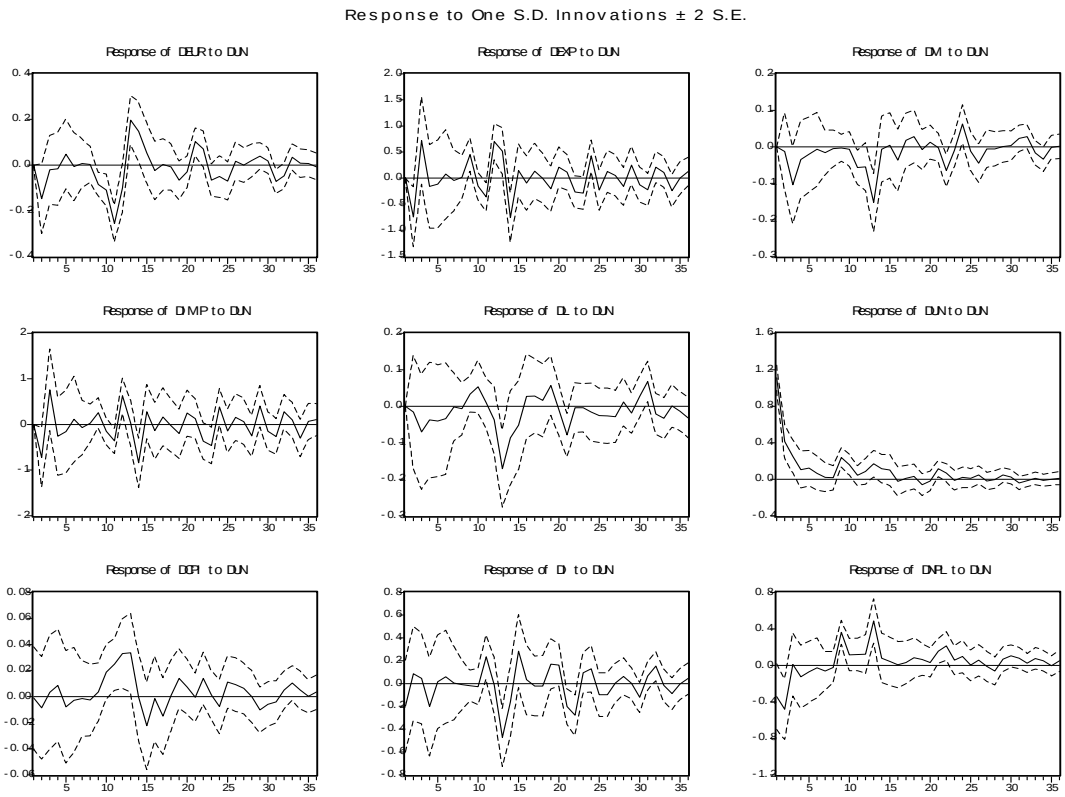


Figure 10: Innovation to DCPI

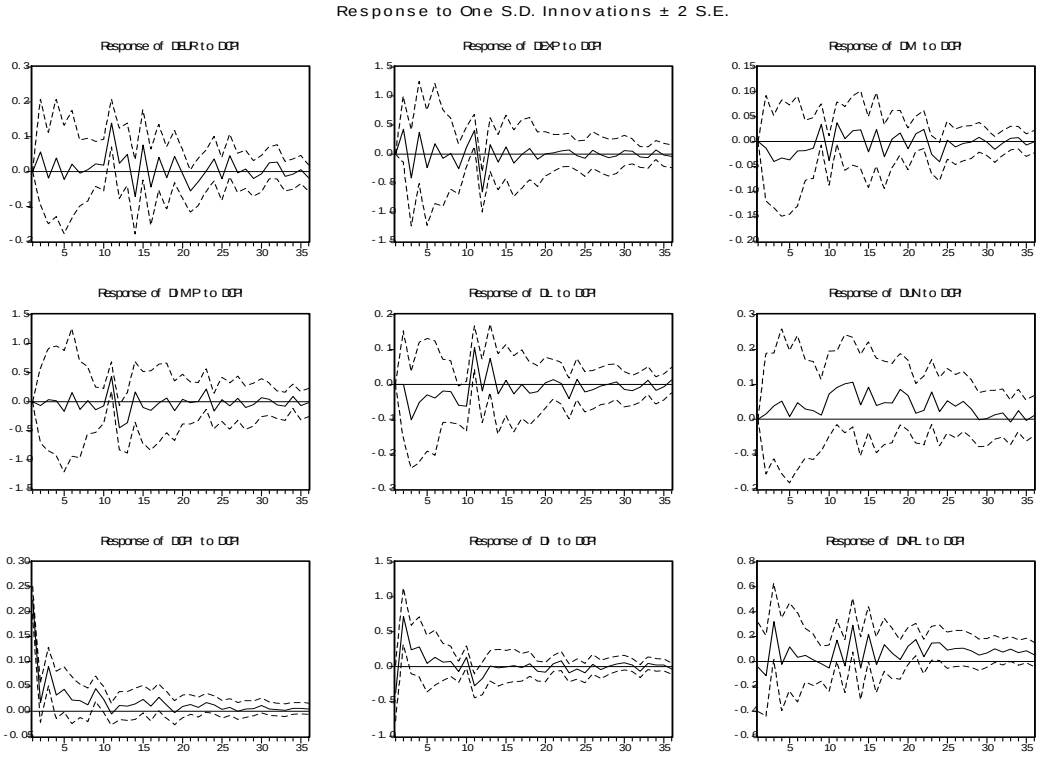


Figure 11: Innovation to DI

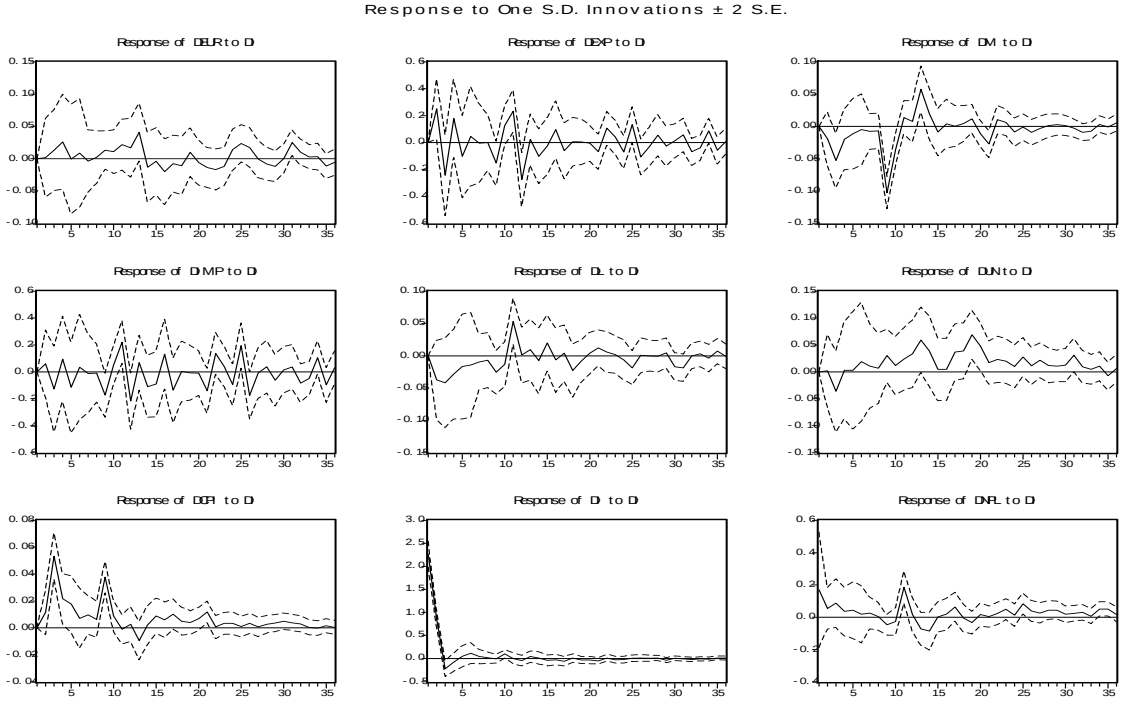
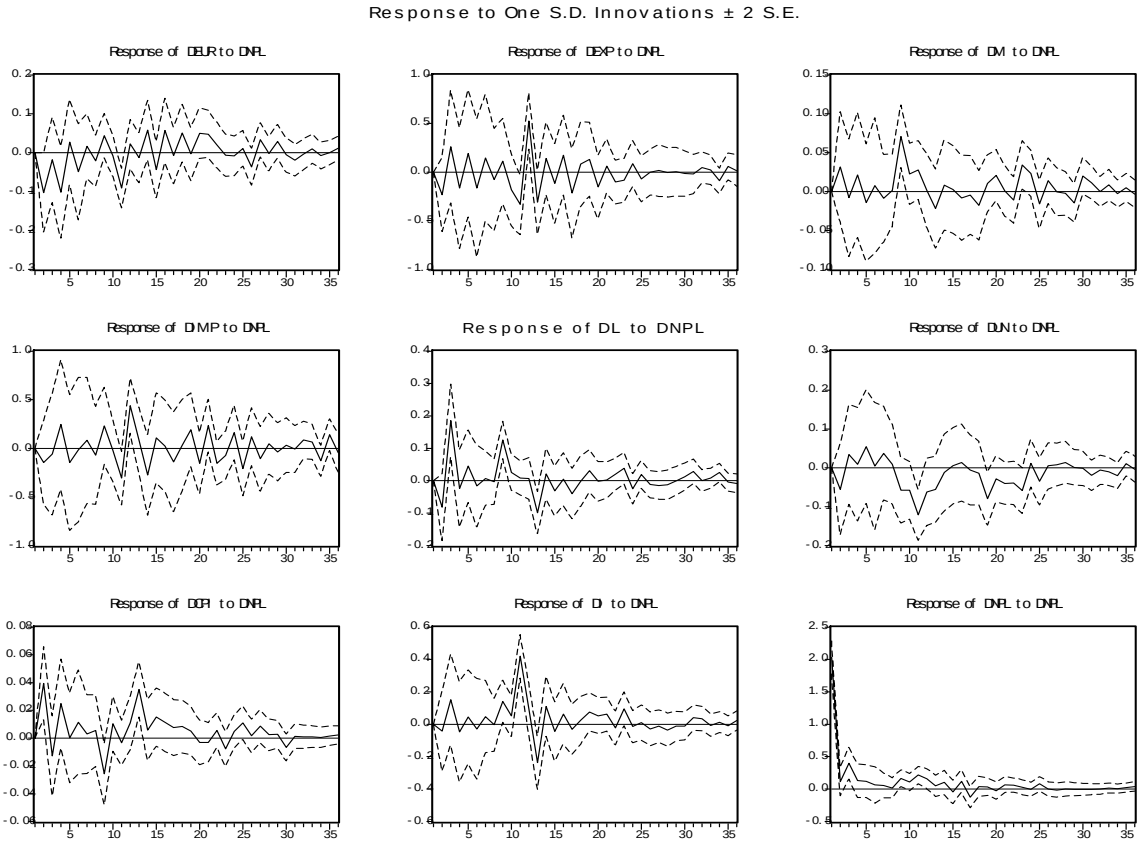


Figure 12: Innovation to DNPL



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