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BACHELOR THESIS

The monetary policy and financial stress: the empirical analysis

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Declaration of Authorship

The author hereby declares that he compiled this thesis independently, using only the listed resources and literature.

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Abstract

This work is concerned with interrelations between monetary policy instrument – policy rate, key macroeconomic control variables – GDP, inflation, and financial stress. As a proxy for financial stress we consider composed financial stress index for the Czech Republic. We estimate the SVAR model, which allows for more than one variable to be endogenous and also for contemporaneous relations. Resulting from the SVAR analysis we conclude that financial stress is definitely a relevant factor for policy-making decisions. In the long term, rising levels of financial stress is decreasing the policy rate, on the other hand increase in policy rate is significantly stressful event for financial markets. Financial stress is significantly a negative factor in terms of real output.

JEL Classfication	E37, E52
Keywords	Policy Rate, Financial Stress, SVAR, shock responses

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Abstrakt

Tato práce se zabývá vztahy mezi instrumentem měnové politiky – centrální úrokovou mírou, makroekonomickými proměnnými – HDP a inflace, a finančním stresem. Jako proxy pro finanční stres zahrnujeme složenou proměnnou Finančního Indexu Stresu pro Českou republiku. Analyzujeme SVAR model, který nám umožní zahrnutí endogenních proměnných, a také nabízí možnost odhadu současných vztahů mezi proměnnými. Z výsledků naší analýzy docházíme k poznání, že finanční stres je důležitým faktorem v rozhodovacím procesu centrálních bank. Rostoucí míra stresu snižuje dlouhodobě úrokovou míru, naopak prudký vzrůst úrokových měr s sebou přináší velkou porci stresu. Finanční stres má negativní vliv na reálný výkon ekonomiky.

Klasifikace	E37, E52
Klíčová slova	Úroková míra, finanční stress, SVAR, IRs

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Acronyms

CNB – Czech National Bank

FSI – Financial Stress Index

SVAR – Structural Vector AutoRegressive model

IRs – Impulse Responses (Impulse Response analysis)

GDP – Gross Domestic Product

CDOs – Collateralized Debt Obligations

EU – European Union

IMF – International Monetary Fund

PRIBOR 3M – Prague InterBank Offered Rate with maturity of 3 months

DSEM – Dynamic Simultaneous Equations Model

Bachelor Thesis Proposal

This work is concerned with the Monetary policy influence on financial stress. How different factors influence stress at financial markets is a very interesting topic, especially nowadays – in a time of crisis when markets experience higher levels of stress and become much more sensitive towards factors determining it. As a technical background I use VAR analysis, which is a proper tool to analyze multivariate time series. Data in my vector autoregressive model will be based on fundamental macroeconomic factors (GDP, inflation rate, unemployment rate, trade balance), interest rate, and financial stress index for CR – regressed variable. Resulting from VAR analysis I will conclude whether monetary policy is or is not significant variable when determining financial stress before and during the crisis.
Outline:

1.Introduction
2.Determinants of financial stress
3.Vector autoregressive model
4.Analysis of the results
5.Conclusion

Tato práce se bude zabývat vlivem měnové politiky na stres na finančních trzích. Jak se různé faktory podílejí na finančním stresu je velice zajímavé téma, zvláště pak dnes v období krize, kdy trhy prožívají vyšší úrovně stresu a na faktory, které ho určují se stávají citlivějšími. Používám VAR analýzu, protože je vhodným nástrojem právě pro zkoumání vícerozměrných časových řad. V modelu vektorové autoregrese použiji makroekonomická data (HDP, míra inflace, míra nezaměstnanosti,obchodní bilance), úrokovou sazbu a finanční stres index pro ČR – proměnná kterou podrobíme regresi. Z výsledků VAR analýzy budu zkoumat jak signifikantní je měnová politika pro úroveň finančního stresu – před krizí a v období krize.

Osnova:
1.Úvod
2.Determinantyfinančního stresu
3.Vektorová autoregrese
4.Analýza výsledků
5.Závěr

Introduction

After a relatively long period of an economical boom came a bust again. The bust, which was caused by tendencies of financial subjects to underestimate various fat-tail risks during times of growth. Doing this by over-bundling of financial products and the creation of complicated long chains of intermediaries, where crucial information about the riskiness of investment was forgone. This irresponsible behavior burst into the subprime mortgages crisis in the US, which lead to several banks becoming bankrupt with the consequence of drying liquidity in the financial markets and generally the spreading of financial stress across the global financial markets. These forces caused a new attitude to risk also in Europe, where former investments became to be revaluated and reclassified. This combined with interconnections of European banks and companies with US banks lead to a brand new recession within Europe, where perceptions and expectations of market agents, so well captured by the concept of financial stress, are the decisive driving force of further development.

There is apparent nexus between financial stability and monetary policy decisions. However relation of decision making processes to financial instability is hardly linear (Goodhart et al.,2009), in times when financial markets are stable monetary policy is primarily fixed on targeting inflation and doesn't respond to almost non-existing financial stress pressures. However, when stress rises, central banks tend to react in an extensive way. This non-linear optimal policy setting process can be better explained by non-linear dynamics as suggested by (Mishkin 2009). On the contrary it is proved that another policy setting phenomenon - interest rate smoothing is pursued by monetary authorities. These two factors - nonlinearity and interest rate smoothing eventually, up to some extent, deform possible interference using linear model regressions.

As a small open economy Czech Republic can hardly be imagined to be spared of the global turmoil. Thus examining whereas and how Czech

monetary authority reacted in different periods of stress within the last decade is gaining relevance. Czech National Bank is one of the very top performing National Banks, this supports the idea, that tackling the financial stress shouldn't be ignored by Czech Nation Bank. Related research (Baxa et al., 2013) studied the nexus between financial stress and monetary policy rate, and came to the conclusion that there is a negative correlation between the policy rate and an increase in level of financial stress, however this correlation was found to be significant only during the times of higher levels of financial stress). This give us an intuitive idea that foreign monetary authorities really respond to financial stress shocks, and there is no reason to think that the Czech National Bank would do otherwise.

Despite the Czech financial system being quite globally open, there are some clues, which lead us to being concerned that the Czech Republic monetary authority reactions could differ compared to bigger economies. The first factor of difference is the relatively small size of the Czech economy, its openness and dependence on foreign trade. This should possibly reflect in increased sensitivity towards increased exchange rates volatility since it is a critical factor for Czech exporting companies making their business decisions. On the other hand, the Czech bank sector in its structure differs somehow from its foreign neighbors by elevated risk awareness, higher quality loans and thus by higher stability. These two factors are likely to shape the Czech central bank decisions and alter the actual responses from central banks of those larger economies'

The contribution of this thesis is a focus on the specific financial market of the Czech Republic. We will not explore certain phenomena broadly, but rather investigate whether the Czech Republic is following the global patterns of behavior. In order to do this, this thesis builds up Structural Vector Autoregressive (SVAR). Model is to estimate interrelation of five variables included in model. Analyzing the results and conducting Impulse Responses (IRs) to quantify the impacts of various shocks. The biggest focus is given to shocks in increase in policy rate and financial stress shock (FSI).

The purpose of exploring these two shocks more thoroughly is to gain a better insight on what is the actually reaction of financial market to central banks decisions and vice versa. This thesis does well in verifying the theoretical expectations about relations between our variables in the Czech

Republic. Firstly, we have estimated that financial stress and monetary policy are indeed positively correlated. The increase in policy rate has an immediate effect in form of growth in the level of stress. This extra stress persists for a period longer than one year before eventually abating. The sudden elevation of financial stress makes the monetary authority to gradually lower their policy rate with permanent effect. The relationship between GDP growth and Financial Stress is also well explored. The model confirms the theory and suggests, that increase in growth decreases financial stress level in the short term. The rise of financial stress have negative impact on GDP growth. These conclusions create important implications for monetary policy.

We start by listing and explaining the related theories and recent research, which will provide us with solid theoretical ground. Then we would like to define the concept of financial stress, its symptoms and market indicators which are best-suited for construction of the Financial Stress Index, following that we will discuss the concrete composition of Czech FSI, its rates, ratios, spreads and generally properties it bears with its advantages and drawbacks (chapter 1). Then we will explain the remaining variables used in our model - GDP, inflation rate, and finally interest rate - policy rate. Explain incentives for including each of them, their properties, and possible linkages among them and with certain sort of stress. Next we will explain S-VAR (Structural Vector Autoregressive analysis), build up our model and allow for some contemporary and lagged relations among the variables and estimate the model (chapter 2). Once we estimate the model we will attempt to estimate various different shocks primarily in monetary policy and financial stress. All the results will be thoroughly inspected and the interference will be made, based on the assumptions we made (chapter 3). In (chapter 4) we make conclusions about our research results.

Chapter 1: Financial instability and monetary policy

1.1 Financial stability

Why we should bother and study financial stability? According to the most simplified theories such as the nominal part of the economy as a financial market, should only have a marginal impact on real macroeconomic conditions. However it was not later than 1933 when Fisher came up with an idea, that adverse credit conditions affects the real economy by worsened money channeling and a decrease in investments and business activity. This interrelation promoted the urgency for further studies of financial sector impacts. There are some key features which we have to always keep in mind regarding the financial system. In order to understand the financial stability correctly, it is crucial to take into consideration that like a macro-economy is subject to business cycles also financial markets tend to display their procyclical nature, where growth in assets, credit, leverage, imbalances and bubbles is to be always followed by a sharp correction, when imbalances are discovered (Borio, 2007, Minsky, 1992). Unluckily such a correction has a macro-economical consequence because of the dramatic growth in presence financial stress.

There is still an academic debate, whether and to what extent this financial market cycles influence the real economy. One view perspective claims, that shocks in creditworthiness of borrowers are accentuating the development of real output (Bernanke and Getler,1995, Kiyotaki and Moore, 1997). Another view is focused on lenders' balance sheets, where erosion of bank capital is often followed by deleveraging and being reluctant to lend, which naturally leads to economic slowdown (Bernanke and Lown, 1999, Kashyap and Stain, 1995). Still it is believed that different types of financial system are prone differently to absorb the stress. From this comparison, countries which rely more on Arm's-length financing should be affected less, probably because of the possibility to switch the bank financing to market financing.

The theories don't provide a clear picture about when and where financial stress appears, however it usually appears in cycles and some countries will definitely experience it more than others. Another straightforward implication is that financial stress is undesirable, since it undermines the

economic activity through tighter money channeling. This gives us the practical importance of research regarding monetary policy, because it is one of the major tools for fighting it.

Let us now focus on singling out and defining financial stress. Financial stress is hardly directly measurable, since it is most often associated with certain perceptions and patterns in behavior. Basically it is an interruption to the normal functioning of financial markets. However, it is not easy to agree on the more specific definition, since no two periods of financial stress are the same. However, economists tend to associate certain phenomena with financial stress. Which are:

1. *Increased uncertainty about fundamental value of assets*.

   When financial market agents are becoming less sure about their investments, present discounted value of cash flows for example, dividends or interest payments. Uncertainty about present value of assets mainly arises when the outlook on the whole economy, or specific sectors worsens. Another factor, that may cause uncertainty about underlying value of financial assets are various innovations within the financial industry- for example complex structural products as CDOs which failed to be evaluated properly before the crisis of 2007, or program trading in the Long-Term Capital Management before the crisis in 1998. The investor is then subject to Knightian uncertainty, when he is aware of the unknown and an unmeasurable nature of risk. Riskiness cannot be measured correctly for new products or systems simply because until such a product fails for the first time, there is no evidence for assigning any rate of risk to it. In result rising uncertainty makes the market more volatile, because the investors are more likely to react strongly to any new information. As a good example we can consider the case, when the maximum amount which an investor is willing to pay for the stock depends on his estimation of firms long-term profitability. Such an investor will definitely adjust his estimation whenever he receives any news related to the company and consequently revises his offer. The conclusion is, that when investors become uncertain about the true value, they simply tend to change their value estimates on the news basis, thus increasing volatility.

2. *Increased uncertainty about the behavior of other investors*

   For example, trading assets before maturity is very dependent on the behavior of other investors and increased uncertainty can distort many of such a possible investment strategies. Keynes makes his comparison with a beauty contest, where contestants' task is to pick the face, which they think that most of the other contestants will select. Such a game requires the agent to anticipate the behavior of others, and again in such a process any relevant information can differ the selection. This again generally leads to a higher volatility of prices due to same reason as mentioned earlier.

3. *Increased asymmetry of information*

   Asymmetry of information is said to occur when the subject from the supply side of the market knows more about the quality or profitability of assets supplied. The is most apparent in relation borrowers-lenders, when borrowers know more about their financial situation, or between sellers-buyers, when sellers are more aware of the quality and parameters of the products they provide. Such an information gap is an incentive for adverse selection or moral hazard. Adverse selection is a situation where due to lack of information the group of companies in the same industry are awarded similar ratings, whereas quality could be much more dispersed. When this occurs, companies which are over-rated have an incentive to take the loans, whereas those under-rated are given worse conditions, than they deserve and possibly do not take the debt. A good example of moral hazard is perhaps borrowing, when the collateral was over-valuated. Then borrower is not as afraid of default and may change his behavior and make the default even more probable. These are common phenomena during financial crises for two reasons. First, the variation of quality among the group of companies increases. Secondly, uncertainty about the quality of information can decrease if the confidence about accuracy of the rating agency estimates falls.

4. *Flight to quality*

   In other words it is a decreased willingness to hold risky assets. There is a tendency for such a shift in investors' preferences during the times of increased financial stress. Demand for some assets is to decrease and on the other hand some asset is to experience higher

popularity. This change makes the investors demand higher expected returns on risky assets and lower returns on safe ones. This practically widens the spreads between certain financial assets. Fright often occurs, when during the times of euphoria investors tend to ignore some fat-tail risks possibly resulting in enormous losses, when such a loss happens, riskiness of all related products are immediately revaluated, often even over-estimated, and followed by a shift of preferences towards unrelated, relatively less risky assets. Another, quite different reason why investors become more aware of risky assets is that their risk appetite falls. This could be the consequence of a less optimistic view of the future state of the economy.

5. *Flight to liquidity*

   Another sign is rather similar to the previous one, where investor is becoming more afraid of an immediate need for extra cash. When such a concern becomes widely spread, assets which aren't likely to be sold close to its fundamental value, when the need is (illiquid assets), are less desired by the investors, which shift their focus on more liquid assets. Again, such a flight is followed by widening of spreads. Flight to liquidity can, for example, occur either because of concern about the need for extra cash or due to change of perceived liquidity property of some assets. Fright of liquidity is also very typical for times of financial stress.

1.2 Financial Stress Index

As the financial stress index is the most important variable used in this work, let us focus on this concept a little bit more. After the financial crisis in 2007 started, there has been an immense increase in research related to financial stability. And as a key part of this research many financial stress indices have been composed around the world in order to gain the missing part of data needed for any analysis concerned with financial stability and financial stress. Firstly, it must be mentioned, that there is no ideal measure of financial stress, because from its behavioral nature it cannot be directly quantified. But indices, that have been developed, can be quite rationally accepted as a proxies, which more or less manage to capture the phenomena,

especially during the time of extreme levels of stress.. There have been several attempts in literature to capture financial stress in the best way possible, and so generally financial stress indices differ by their composition. This is due the fact that every author considers different variables differ decisively. Another explanation is, that the various indices are created for different countries, for which a different approach should actually be taken, because of the specifications of that concrete financial system and of that whole economy. But generally speaking authors within the FSI tend to include solid financial data, which have a property of reflecting one of the five symptoms mentioned earlier. The data are usually obtained from at least three of these five financial market segments: money market, bond market, equity market, foreign exchange market, financial intermediaries.

The very first such index was composed in a study by Illing an Liu (2006) for Canada and it proved to be capable of identifying many stressful events emerging from different market segments such as banks, stock market, or currency market. Another and maybe the most influential index was composed for the purposes of IMF by Cardarelli, Elekdag and Lall (2009) and engaged the stress in 17 different countries. Hakkio and Keeton (2009) apply different methodology for building of the Kansas City Financial Stress Index. Also a number of private companies such as Bloomberg conduct their own FSIs for USA and other countries.

Not just by the selection of variables the indices differ, but also by the weighting of included variables. This is also caused by different judgments of authors and also by varying properties of economy and financial system across the countries. The standard approaches are equal-variance weight method, in other words standardizing variables (Cardarelli, Elekdag and Lall, 2009, Yiu, Ho and Jin, 2010), and factor analysis using principal components (Illing and Liu, 2006, Hakkio, Keeton, 2009). The second methodology has the advantage, that it reflects the importance of variable with regard to historical fluctuations of financial system. Other studies use Logit model in order to construct an index which is able to show probabilities of financial stress. Recently, the focus has moved towards construction of indices which capture systemic nature of stress, i.e., when stress occurs in more segments simultaneously. Brave and Butters (2010) developed state-space representation of systemic stress. This approach takes into account cross-

correlations of variables and the past development of the index to assign weights to each of the variables. Hollo et al. (2012) are using standard portfolio theory, again based on cross-correlations of variables. Oet et al. (2011) employed method of dynamic sector weighting in their FSI.

In this work the Financial Stress Index for Czech Republic is the most important variable used in our model. This index was composed by Tomáš Adam and Soňa Benecká (2012). Our index is computed for the years 2002 to 2011 and we will be using monthly data. Our index includes more variables from all five financial market segments: money market, bond market, equity market, foreign exchange market, financial intermediaries. Where for each segment there are always more than two market indicators. These are firstly combined together in each subsection and then all five subsections are aggregated together using portfolio methodology of Hollo et al. (2012). As a result the FSI is not just a mean of all indicators, but correlations play a crucial role and the index is high, when the stress sub-indices in more sub-sections are up. It is worth mentioning which were the weights using the same approach for EU : financial intermediaries (30%), equity market (25%), money market (15%), bond market (15%) foreign exchange market (15%), whereas in FSI for Czech Republic weights are : financial intermediaries (30%), equity market (20%), money market (15%), bond market (15%) foreign exchange market (20%). We are aware, that the weighting of components into is one single index is done to certain extent ad hoc. In other words, index is composed in a way to correctly map the past crisis and turmoil. We follow the research of Tomáš Adam and Soňa Benecká, since we identify ourselves with their chosen composition.

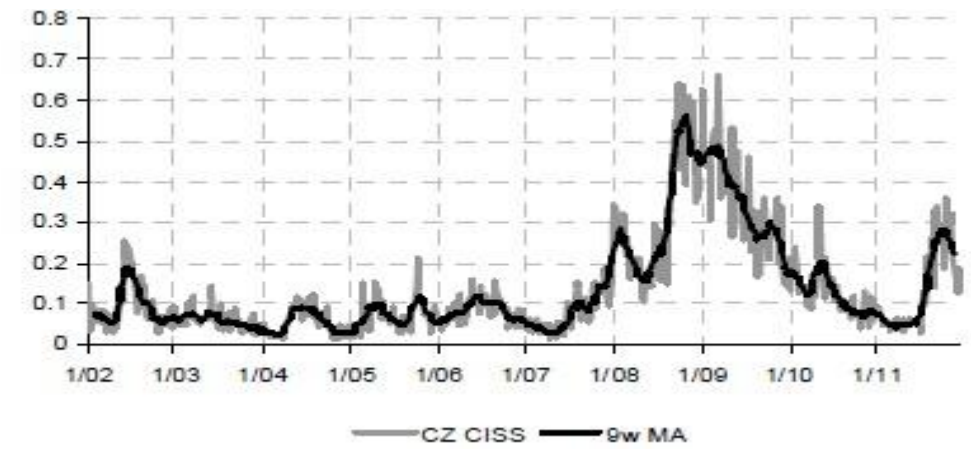
Table 1: Cross-correlations of five market segments by Tomáš Adam and Soňa Benecká

CZ	Bond market	Equity market	Financial intermediaries	Foreign exchange market
Money market	0.38	0.39	0.28	0.16
Bond market		0.29	0.31	0.40
Equity market			0.34	0.28
Financial intermediaries				0.27

We can see, that this is reflecting the fact that stock market is not such an important financial segment as in western EU and that Czech Republic is

really open to foreign trade. The FSI is taking values between 0 and 1. Where 1 is indicating the highest value of possible stress, whereas 0 indicates an absence of any stress.

Graph 1: The FSI for CZ from 2002 to 2011by Tomáš Adam and Soňa Benecká



Note: 9w MA denotes nine weeks moving average

1.3 Linkage between monetary policy and financial stress

There have been only a few empirical studies dealing with the nexus between certain financial stability indicators and policy rates pursued by monetary authorities. These researches differ in methodology and data used as well. Let's list some of the most related studies. Some studies explored the relations between asset prices, most often the stock prices and monetary policy (Rigobon and Sack, 2003, Chadha et al., 2004, Siklos and Bohl, 2008). These researches found some evidence, that indeed asset prices entered the information set by central banks, mainly because they contain information about future inflation rates, and that some banks were directly trying to offset emerging disequilibria. The pitfall of these researches is that, they estimate time-invariant response of policy rate. However, it is rational to suggest, that central banks respond to changes in asset prices only if misalignments become substantial. In other words the central bank reactions are asymmetric. There are also two controversies about the impact of asset prices on monetary policy. Firstly, there is a concern, that asset prices are not representative enough and we should estimate other factors as well. The

second issue is related to identification of asset prices misalignment. It is more than rational to suppose, that identification is affected by perceptions, which evolves over time, and possible response is subject to change as well.

Detken and Smets (2004) developed further the asymmetric response theory and they found, that monetary policy was much looser during the high-cost booms than during the post-boom period.

A few studies employ broader measures of financial imbalances. For example Borio and Lowe (2004) use as a proxy for imbalances the ratio of private credit to GDP, inflation adjusted equity prices, and their composite. However, this particular empirical study came to ambiguous results except for the USA, where the central bank indeed reacted by disproportionately lowering federal funds rate. The empirical research, which is mostly related to my thesis was done by Baxa et al. (2013) where as a measure of financial market imbalances the financial stress index was finally used. The study reaches the conclusion, that central banks indeed react to higher financial stress and their response is non linear. Also the magnitude of response varies across the countries, since this research is dealing with data for all 17 countries, which Cardarelli et al. have composed FSI for. However none of these studies deal with the opposite causality, where increased monetary policy rate can cause financial stress. This topic is addressed by the empirical study of Mallick and Sousa (2011), they examine real impact of monetary shock in the Euro zone and they find, that monetary policy contraction strongly deteriorates financial stress and their paper generally confirms, that when financial stress level increases central banks abandon inflation targeting and tend to stabilize output by adopting vigilant posture towards financial stress, and thereby lowering policy rate.

Chapter 2: Data and empirical methodology

2.1 Data

This model estimates the relationships between four different variables. Three of our variables are macroeconomic variables – GDP, Inflation. The remaining two variables are Financial stress index for the Czech Republic (FSI), and Pribor 3M. All variables are included in real terms. In the model we include data in the normal level, because our dataset generally consists of various rates with no tendency or financial stress, which ranges from 0 to 1. The level-level data makes our model more easily interpretable. The data frequency is one month, and our time series cover just ten years: from January 2002 to December 2012. This is because we were limited by the variable of Financial Stress Index, which has been computed just for this period. Now we will discuss each of the variables at once, and provide some reasoning for including it in our model.

Financial stress index for Czech Republic

As the most crucial concept of this paper is financial stress, the variable which allows us to measure it had to be included in our model. As mentioned before, we use monthly data. FSI takes values from the range (0,1) FSI is successful variable in identifying periods of real financial stress, and thus only controversy could arise about the efficiency of its composition. However, we consider this index to be conducted in a very sophisticated and reality reflecting way.

Pribor 3M

Monetary authority can through its open-market operations affects both the monetary base, and financial market interest rates. However, the central bank

is not able to set independent targets for both of them, because the open-market tools always alter both of the indicators.

One of the open-market operations is setting of discount rate- policy rate, which tends to strongly affect the financial market interest rates. In our model we include variable “Pribor 3M”, this is the Prague interbank lending rate – the rate at which banks have to lend to each other funds with the maturity of 3months . The Pribor 3M, was chosen because of the following reasons:

1. It follows the policy rate in significantly positive way.
2. Unlike the policy rate, the Pribor 3M varies over time. (Policy rates is often set for extended period constant).
3. To some extent also captures the growth in money, which is another monetary policy impact.

Inflation

Monthly inflation rate presented by the Czech National Bank is the first of three macroeconomic variables. Current inflation rate is mostly determined by monetary authority, as inflation targeting is the prevailing policy, during the times of only little turmoil on the financial market. On the other hand, when there are growing tensions in the market, central bank is more likely to loosen the focus on inflation and possibly switch to a policy of low interest rate setting. Also current inflation rate is likely to affect the economy outlook of market agents and therefore contribute to the perceived stress.

GDP growth

Growth in Gross Domestic Product is a key variable for completion of our model. This is the most crucial macroeconomic indicator, and its values have the power to influence our Financial Stress Indicator and vice versa. In our analysis we would like to observe the impacts of various shocks, and impact on GDP is the one of the biggest practical importance.

2.2 Methodology

Structural Vector Autoregressive model – properties

VAR models were popularized in economics by Sims (1980) as a natural generalization of the univariate autoregressive models. VAR has many advantages for analyzing dynamics, but we also must not overlook a few problems which arise when specifying and estimating such a models.

Advantages:

1. The analyst doesn't have to raise any assumptions about exogeneity and endogeneity of included variables, simply all variables are treated as endogenous. This is the huge advantage against simultaneous equations models, where in the name of identification of the model, some variables have to be treated as exogenous and even have to have certain desired correlation properties. However, such a strict assumption of exogenity is often unrealistic, and thus making our model biased.
2. The VAR is complex in a structure. The variables of vector autoregressive models are allowed to be affected not only by their own lags, but also by the lags of other variables. Moreover, in the case of unreduced forms of VAR – structural vector autoregressive models, are even allowed to be affected by contemporaneous terms of other variables.
3. Predicative interference on reduced form of VAR usually outperforms the prediction ability of large-scale structural models, where the identification problem becomes bigger and bigger source of bias.
4. SVAR is more theoretical. When identifying SVAR model, it is necessary to raise theoretical assumptions about included variables. Identification consist of allowing no more than one of two variables in each couple to impact the other one contemporaneously.
5. SVAR model provides us with background for analysis of various shocks to the variables included in estimation. Such a impulse response analysis is capable of estimating the impact of such a shock to the other variable over the predefined period of time.

Disadvantages:

1. When identifying a model, it is sometimes hard to determine the most realistic setting of relations. Many times, the various ideas exist to support the very opposite setting of contemporaneous relations among the variables. This issue could be, to some extent, solved by certain causality tests.
2. Another concern is how should be the length of lag determined. There are various possibilities how to set the number of lags. It could be decided either by the common sense combined with theoretical background, or by using one or more of the tests developed for determining the lag length, such as Akaike Info Criterion, Final Prediction Error, Hannan-Quinn Criterion, Schwarz Criterion.
3. VAR models from their nature tend to have too many parameters. The number of parameters grows as the number of lags increases. This is unfortunate for relatively small samples, when the number of degrees of freedom will be rapidly used up, resulting in large standard errors and therefore in wide confidence intervals.
4. Should all of the components of the VAR be stationary? In order to be able to use hypothesis tests either singly, or jointly, it is essential that all of the variables are stationary. This problem may be solved by differencing, however even this cure has its opponents, as they point out, that the VAR is a methodology designed to examine relationships between variables themselves and differencing would throw away information on any long-run relationships between the series.
5. The different identification method used in SVAR and in Dynamic Simultaneous Equations models (DSEM) – SVAR is taking focus on the role of shocks for the dynamics of the model. This approach avoids some difficulties inherent in the traditional approach to identification, on the other hand it implies, that SVAR cannot perform the same tasks as Dynamic Simultaneous Equations Models. In the field of monetary economics, for example, SVAR model are not the best suited for policy simulations, which is the strength of Dynamic Simultaneous Equations

models, but have instead an advantage in the analysis of the monetary transmission mechanism.

6. There is a big discussion about the importance and interpretation of shocks. SVAR approach in analyzing the monetary policy transition, is often criticized on the grounds, that it suggests that the central banks operate as a random number generator Bernanke and Mihov (1996). This is quite contrary to the actual central bank's behavior, where any error should be quickly reversed. This raises the question of how the monetary policy shocks are related to the monetary authority decisions and how should modeling of such a shock be interpreted.
7. Reservations about undisciplined use of restrictions. The unqualified and not theoretically backed restrictions to the model is also often the case. SVAR model estimations and results are very sensitive to the assumptions made about contemporaneous relations between the variables. Thus thorough consideration and implementation of the most reliable macroeconomic theories is in place.

Having considered the advantages and limitations of various models, we have decided to estimate SVAR model from following reasons:

- Our variables simply cannot be considered exogenous (VAR).
- The theoretical background suggests, that there exist contemporaneous relations among our variables (SVAR).
- And finally, we would like to explore impacts of various different shocks by impulse response analysis, primarily: monetary policy shock and financial stress shock.

AB-SVAR model

Since the early eighties VAR models have become a standard tool for empirical analysis by macroeconomists. They are easy to use, moreover they are often more successful in predictions than complex simultaneous models and they are a priori non-restrictive, i.e. they do not require "incredible identification restrictions".

Let us first show reduced form Vector Autoregressive model of order p:

$$\boldsymbol{y_t} = A_1^* \boldsymbol{y_{t-1}} + \ldots + A_p^* \boldsymbol{y_{t-p}} + u_t$$

Where $\boldsymbol{y_t}$ is a k dimensional vector of endogenous variables at time t. $\boldsymbol{y_{t-1}}$ is k dimensional vector at time $t-1$ etc.

However, this reduced form model is not the proper tool for estimating our reality, where we with the belief the instantaneous effects to exist. That is why we have decided to use AB-SVAR model. It allows us to identify contemporaneous structural innovations on the theory based approach – using A matrix, and also allows us to think of the forecast errors ($\boldsymbol{u_t}$) as linear functions of the structural errors ($\boldsymbol{\epsilon_t}$).

According to Gottschalk (2001) there is an infinite set of different values of matrix A and A_p^* for given data, parameters that are impossible to obtain without additional restrictions because different structural forms give the same reduced-form VAR model. Therefore, without identifying restrictions it is impossible to draw conclusions about the true state (structural model) from the reduced form VAR. The methodology applied in this thesis necessarily entails economic theory-based identifying restrictions.

The SVAR (structural vector autoregressive) model can be used to identify the shocks to be traced in an impulse response analysis by imposing restrictions on the matrices **A** and **B**. Let us rewrite our model:

$$Ay_t = A_1^* y_{t-1} + \ldots + A_p^* y_{t-p} + C * D_t + B\varepsilon_t$$

Where the structural errors ε_t are assumed to be white noise with $(0;\ I_k)$ and $C * D_t$ is coefficient.

The point of departure for a structural analysis is a reduced form model, however. Therefore a reduced form model has to be specified before the *SVAR* analysis can be entered. In the SVAR analysis only restrictions for *A* and *B* can be added. The reduced form residual u_t is recovered from the structural model as $\boldsymbol{u_t} = A^{-1}B\epsilon_t$ so that $\sum u = A^{-1}BB'A^{-1'}$.

Estimation is done by maximum likelihood using a scoring algorithm. Amisano and Giannini (1997).

Impulse Response analysis

Impulse response analysis can be used to analyze the dynamic interactions between the endogenous variables of a VAR(*p*) process. In this analysis the exogenous and deterministic variables are treated as fixed and may therefore be dropped from the system. In other words, the part of the conditional mean of the endogenous variables attributable to these variables is eliminated. The adjusted endogenous variables are now denoted by $\boldsymbol{y_t}$. If the $\boldsymbol{y_t}$ process :

$$A\boldsymbol{y_t} = A_1^* \boldsymbol{y_{t-1}} + \ldots + A_p^* \boldsymbol{y_{t-p}} + C * D_t + B\varepsilon_t$$

is stationary, it has MA(1) representation :

$$\boldsymbol{y_t} = \Phi_1 u_t + \Phi_2 u_{t-1} \ldots$$

Where :

$$\Phi_s = \sum_{j=1}^{s} \Phi_{s-j} A_j \quad s = 1,2 \ldots \text{with } \Phi_0 = I_k$$

The coefficients of this representation may be interpreted as reflecting the responses to impulses hitting the system. The (i, j)th elements of the matrices $\boldsymbol{\Phi_s}$ regarded as a function of **S**, trace out the expected response of $y_{i;t+s}$ to a unit change iny_{jt} holding constant all past values of $\boldsymbol{y_t}$**.** The elements $\boldsymbol{\Phi_s}$ of represent the impulse responses of the components $\boldsymbol{y_t}$ of with respect to the $\boldsymbol{u_t}$ innovations. The $\boldsymbol{\Phi_s}$ impulse response matrices can be computed in the same way for nonstationary processes. In contrast to the stationary case, impulses hitting a nonstationary system may have permanent effects, however.

Because the underlying shocks are not likely to occur in isolation if the components of $\boldsymbol{u_t}$ are not instantaneously uncorrelated, the innovations of the VAR are orthogonalized using a Cholesky decomposition of the covariance matrix $\sum u$. Denoting by P a lower triangular matrix such that $\sum u = PP'$, the orthogonalized shocks are given by $\varepsilon_t = P^{-1}u_t$. Hence, in the stationary case we get,

$$\boldsymbol{y_t} = \Psi_0 \boldsymbol{\varepsilon_t} + \Psi_1 \boldsymbol{\varepsilon_{t-1}} \ldots$$

Where

$$\Psi_{\mathrm{i}} = \Phi_i P \ (i = 0,1,2..)$$

Here $\Psi_0 = \mathrm{P}$ is lower triangular so that an ε shock in the first variable may have an instantaneous effect on all the variables, whereas a shock in the second variable cannot have an instantaneous impact on y_{1t} but only on the other variables and so on. This is the very crucial point of our analysis – different ordering of variables in our $\boldsymbol{y_t}$ vector would give us different results and impulse responses as well. In next chapter, we will specify our model, make the SVAR estimation, and explore what the impulse responses are.

Chapter 3: Estimation

3.1 Descriptive statistics

As an econometrical software we are using JMulti. Firstly, we have to compute reduced VAR model as a starting point for our S-VAR analysis. But even before we enter VAR estimation, let us do an initial analysis of our data.

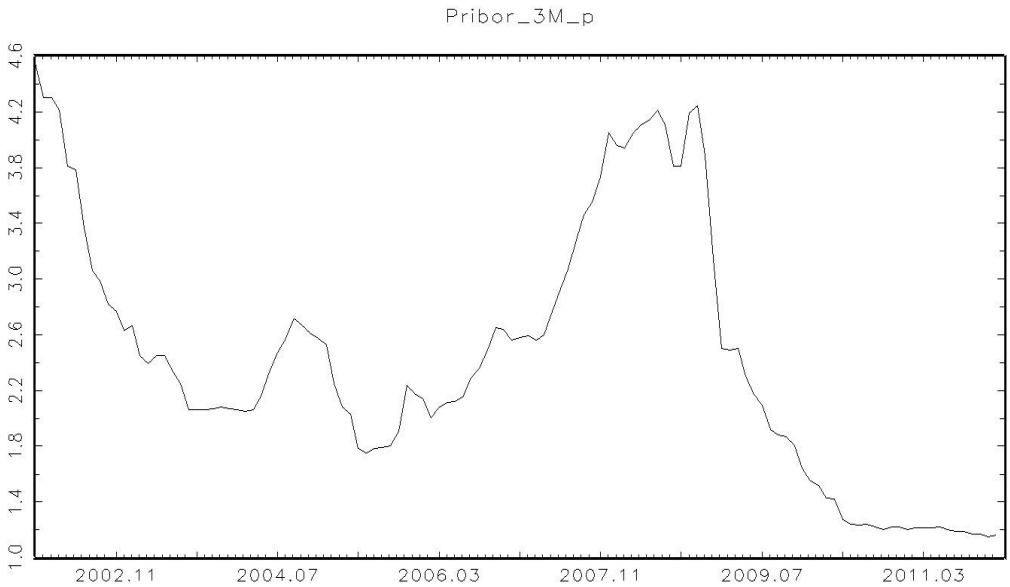
sample range: [2002 M1, 2011 M12], T = 120

DESCRIPTIVE STATISTICS:

variable	*Mean*	*min*	*max*	*std.dev*
Pribor 3M %	2.43258e+00	1.15000e+00	4.55000e+00	9.18365e-01
Inflation %	2.78833e+00	1.80000e+00	4.50000e+00	5.18199e-01
GDP growth %	7.99175e-01	3.40000e+00	2.40000e+00	9.74333e-01
FSI (0-1)	1.36310e-01	2.14545e-02	5.56732e-01	1.22439e-01

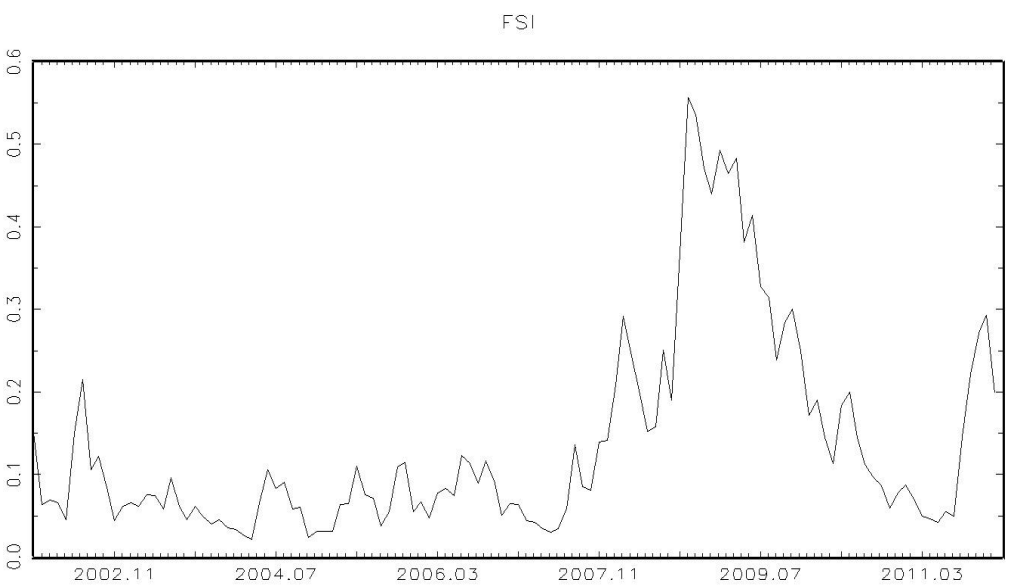
The GDP growth is computed as an extension of quarterly growths, since there are no data available on the monthly base. It means, that the monthly figures represent rate, at which the GDP would grow over 3 consecutive months, if the rate would not change. It does no harm to our model, however we must keep in mind what such a numbers represent.

Graph 2: PRIBOR 3M interbank lending rate



We can see, that from the beginning of the new milenia interest rates were falling with interuption on 2004. However, just before financial crisis lending rates began to grow, until they reached their peak in the December 2008. Untill then rates dramatically plummeted, closing to 1% interest rate. The soar of interest rates could be explained by the beginning of the crisis bringing increased riskiness of investments, whereas the plunge of rates is well explained by significant stimulus of decreasing policy rate accompanied by little upturn in financial markets.

Graph 3: FSI

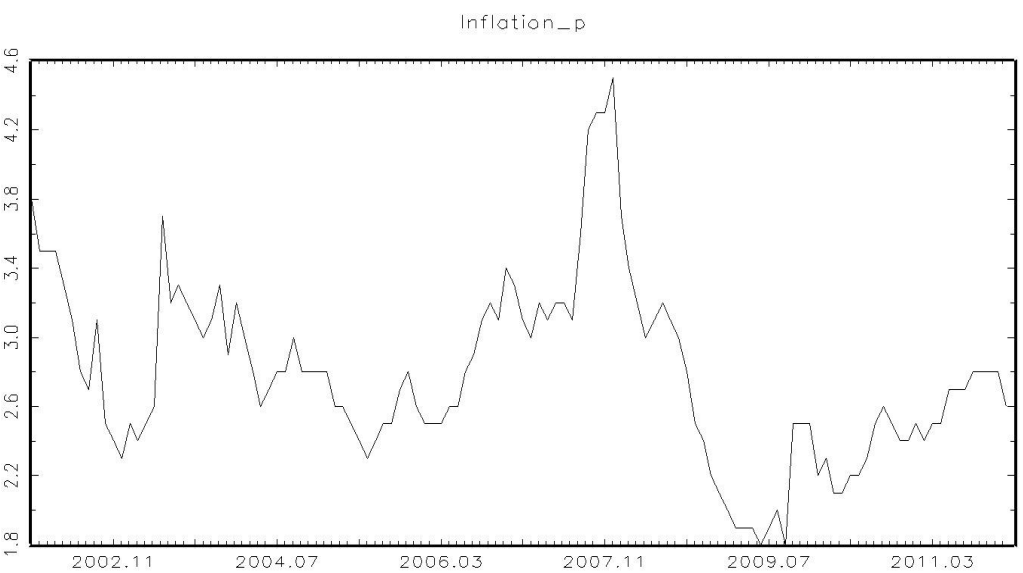


It is apparent from the graph, that during the last decade there have been only minor increases in financial stress except the global financial crisis, when stress reached its peak in late 2008. Then the consolidation on financial markets led to a graduate decrease over the next two and half years. However, at the end of our plot, we can see another increase of financial stress, most probably caused by debt crisis in Europe.

Graph 4: GDP growth

Over past decade, the GDP growth in Czech Republic was moderate until 2008, when the financial crisis took its share and plunged the output by 3,5%. Then a recovery to stagnation followed.

Graph 5: Inflation rate



The inflation rate follows the similar pattern as our other variables. During the last ten years inflation has been possibly a little bit more of a volatile nature, but mostly moderate sized. Exception to this is the global financial crisis, when inflation soared in the very beginning of 2008, reaching 4,5 % in March 2008 followed by graduate decrease, until it found its bottom in May 2009.

3.2 Lagged terms

When estimating VAR model, we first had to decide how many lagged terms of our variables do we want to include in our model, there are several tests we computed to help us decide to include two lags.

OPTIMAL ENDOGENOUS LAGS FROM INFORMATION CRITERIA

endogenous variables: GDP growth, Inflation, Pribor3M, FSI

deterministic variables: CONST

sample range: [2002 M11, 2011 M12], T = 110

optimal number of lags (searched up to 10 lags of levels):

Akaike Info Criterion:	2
Final Prediction Error:	2
Hannan-Quinn Criterion:	2
Schwarz Criterion:	2

Than we estimated a reduced form of Vector Autoregressive model with two lags, since it is the departing point for our structural analysis. We include statistics of reduced VAR in the appendix, because it bears only little relevance.

3.3 SVAR identification

The most crucial point of our estimation is the specification of the model. We need to implement Economical theories to specify our model correctly. We specify our AB SVAR model by imposing restrictions on matrices A and B

Table 2: specification of matrix A

GDP growth	Inflation	PRIBOR	FSI
1	0	0	0
*	1	0	0
*	*	1	0
*	*	*	1

In Table 2 we have defined contemporaneous relations among the variables The table is designed 4x4, where columns $j; j€\{1,2,3,4,\}$ *are assigned in respective way to GDP growth, Inflation, PRIBOR 3M and Financial Stress Index. Rows* $i; i€\{1,2,3,4,\}$ *are designed in the same respective way. Thus, number one on diagonal means, that* $corr(x_{it}; x_{jt}) = 1\ for\ i = j$*, zero (0) represent zero impact of variable* x_{jt} *on* $x_{it}; i > j$ *and asterisk (*) is the observed impact of variable* x_{jt} *on* $x_{it}; i < j$ *.*

We have decided to set the relations in the way represented by the table 01, because we believe that such an ordering is the most realistic. The logic goes as following. GDP growth is hardly to respond instantly to any of the other factors, since it is determined by a number of different factors, and because the whole economy is too big a machine to be steered instantly. Usually heavy path dependence accompanied by seasonality is crucial in determining factor for future GDP growth rates. GDP growth rate is on the other hand likely to determine all the other factors, inflation usually tends to go up, when GDP is growing fast, also interest rates should go up in order to balance growing investments and saving rates and with growing GDP, the financial market is

naturally experiencing only little stress, while the default rates are down and investments are profitable. Interest rates are jointly determined by inflation, as the market lenders will ask for higher interest rates when inflation is high. The financial stress is likely to grow, when inflationary pressures are present, because investors will be less sure about the fundamental value of their assets and investments. And finally we are quite confident about the idea, that financial stress and monetary policy rates are very much affecting each other; however we believe that whereas increase in policy rate can immediately elevate the financial stress, the reaction of monetary policy to growing stress in financial market is hardly instantaneous. This caused us to decide, that monetary policy affects the financial stress contemporary and that the monetary authority responds to financial stress with lag. Although there are various reasoning, resulting in very different ordering, we believe, that this is the most reality resembling.

Table 3: specification of matrix B

GDP growth	Inflation	PRIBOR	FSI
*	0	0	0
0	*	0	0
0	0	*	0
0	0	0	*

Matrix B is a complement to matrix A in identifying the model. Theoretical assumptions are imposed on Matrix A, when matrix B is diagonal it is clear, that we can obtain regular $A^{-1}B$ from reduced form VAR.

Together we have imposed $K^2 + \frac{K(K-1)}{2} = 22$ restrictions (0s and 1s), and because of this our model should be just identified.

We have estimated matrices A and B and discovered some significant and some insignificant relations. Out of our 6 contemporaneous relations only four are significant. These are: GDP and Financial Stress, Inflation and Monetary policy, and finally Monetary policy and financial stress.

ML estimates of the structural parameters enables us to obtain an estimate of the

contemporaneous impact matrix $A^{-1}B$ linking ε_t and u_t. Knowledge of this matrix also allows us to recover the structural shocks from estimated residuals.

3.4 Estimated contemporaneous impacts:

Significant relations:

Monetary policy ⇒ Financial Stress index. Fulfilling our expectations, according to our contemporaneous impact matrix Increase in monetary policy rate have positive effect on financial stress (stress is growing)

GDP ⇒ Financial stress index. Following the theory, the faster the growth of real GDP is, the lower the financial market tensions are, FSI is contemporaneously negatively correlated with GDP growth.

Inflation ⇒ Monetary policy. As theory predicts, when inflation is growing, market interest rates are also growing, since market agents have desired their fixed real interest rates. This is reflected in positive correlation between inflation variables and interest rate variables.

Not significant relations:

GDP ⇒ Inflation. GDP has neutral contemporaneous effect on present inflation. However, expected inflation seems to be positively influenced by higher growths of GDP. This again goes hand in hand with theory.

GDP ⇒ Monetary policy. The negative correlation suggests, that monetary policy is negatively correlated with GDP growth.

Inflation ⇒ Financial Stress. Our estimates suggest possible existence of a slightly positive relation. Where growing inflation should also make the financial stress to grow a little.

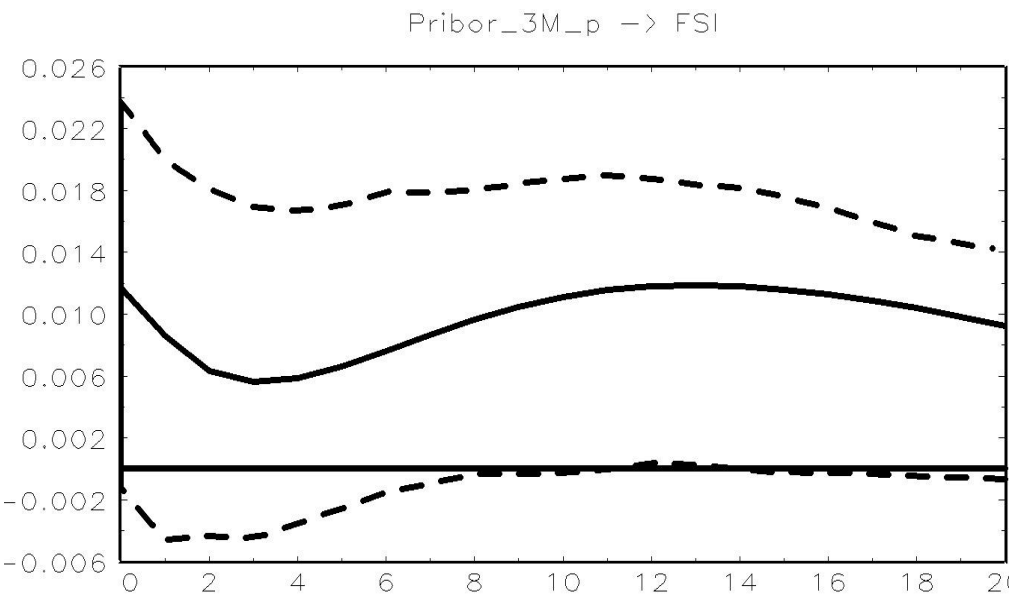
We will take a more thorough look at these relations in impulse response analysis.

3.5 SVAR Impulse Response analysis

A very useful output from the VAR estimation is Impulse Responses. Impulse responses allow us to see how the different variables in the model respond to various identified shocks, i.e., what the dynamic interactions between the endogenous variables are. We have estimated the impact of shock over a 20 months long period. And also computed confidence intervals, concretely: 95% Efron Confidence Interval.

⇧Policy Rate ⇒Financial stress

Graph 6: Impact of Shock to Policy rate on Financial Stress



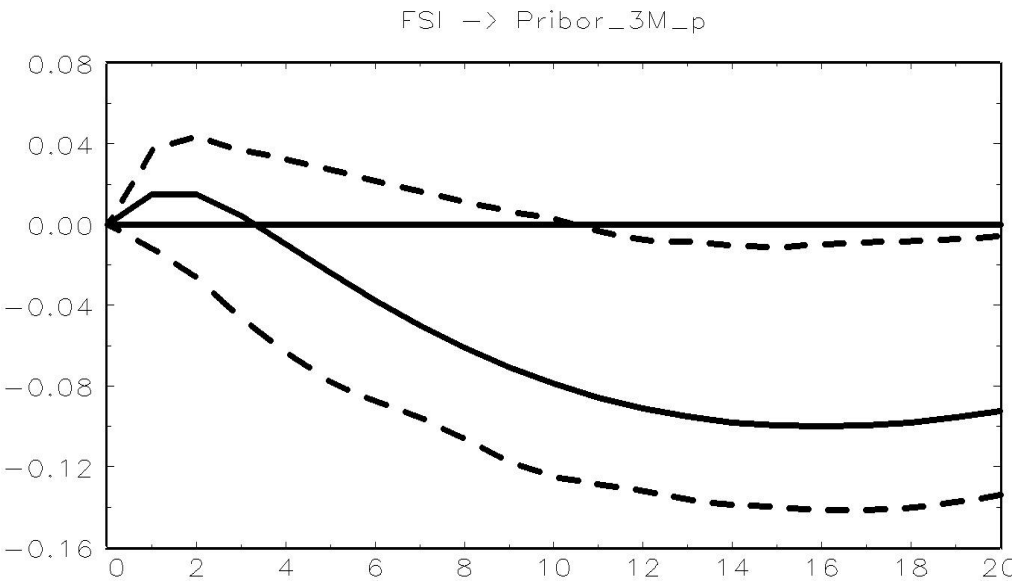
Note: The moving black line represents SVAR impulse responses, dashed lines plot the confidence interval. Constant line is a zero line. The same holds for all other graphs.

As we can see, the Impulse Response analysis suggests, that indeed sudden increase in policy rate by one standard deviation elevates the financial stress immediately. Increase is moderate but rather persistent. Immediately stress rises by 0,013 which is not the amount of stress which could be neglected. Then stress abates a little in the medium-term. This could be explained by information asymmetry, when market agents tend to overreact first, followed by a calming down and decrease in stress in the medium-term. However,

shock analysis suggests rather permanent increase in perceived stress after such a shock takes place. The permanent impact is estimated to be almost as big as the initial increase. This analysis suggests the monetary authority to be careful about increasing its policy rate.

⇧ Financial stress ⇒Policy Rate

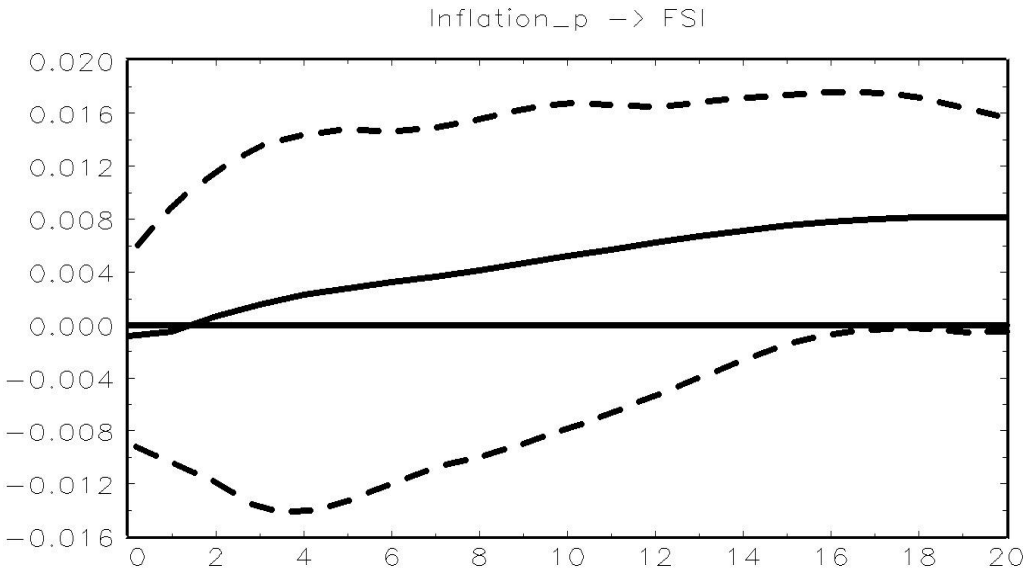
Graph 7: Impact of Financial Stress on the Policy rate



The effect of sudden increase of financial stress on interest rate has a long term nature, where the central bank reacts with a two month long lag, while it takes the bank time to notice the marks indicating growing stress within the market. Once the bank take notice of growing instability it steers the wheel and starts to gradually lower the interest rate. The decrease in policy rate is about to culminate after 17 months from its introduction. Then it is estimated, that policy rate should grow slightly again. However, there is possibly no correction back to the original level. We can notice, that any sudden drifts are absent, this goes hand in hand with interest rate smoothing policy rule.

⇧ Inflation ⇒Financial stress

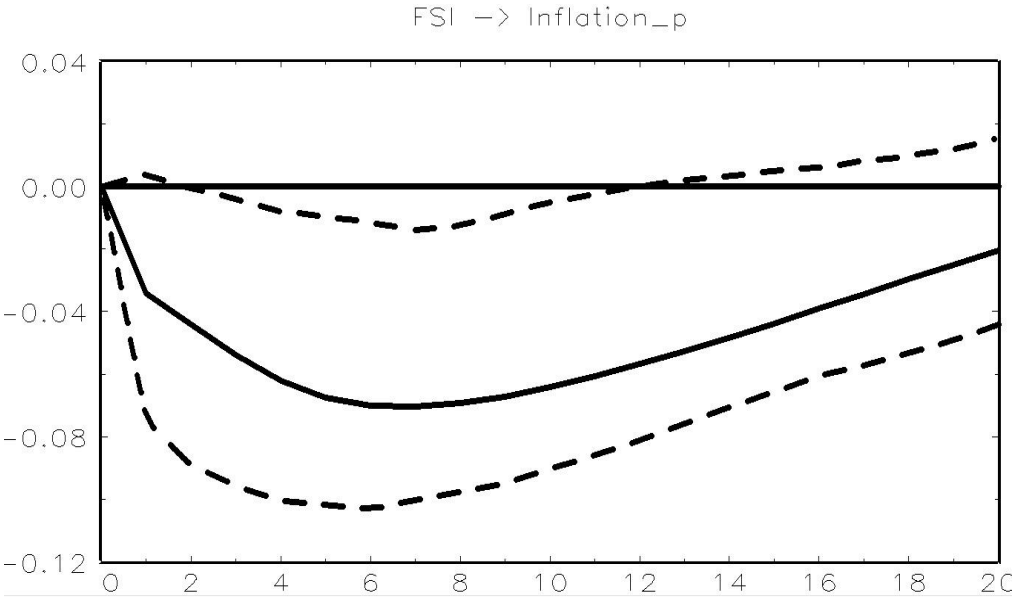
Graph 8: Impact of Inflationary Expectations on the Financial stress



There is no immediate increase in the financial stress across the market. However it is interesting, that current inflation has a medium to long-term impact on financial stress. The positive relationship was hardly unexpected, since higher inflation generally brings uncertainty about the fundamental value of assets and investments. We find this a little bit puzzling, that the effect takes place only with such a lag. One possibility is, that inflation is in fact published with lag and until then, it is hardly observable. This would make the reaction in form of stress indirectly lagged.

⇧ Financial stress ⇒Inflation

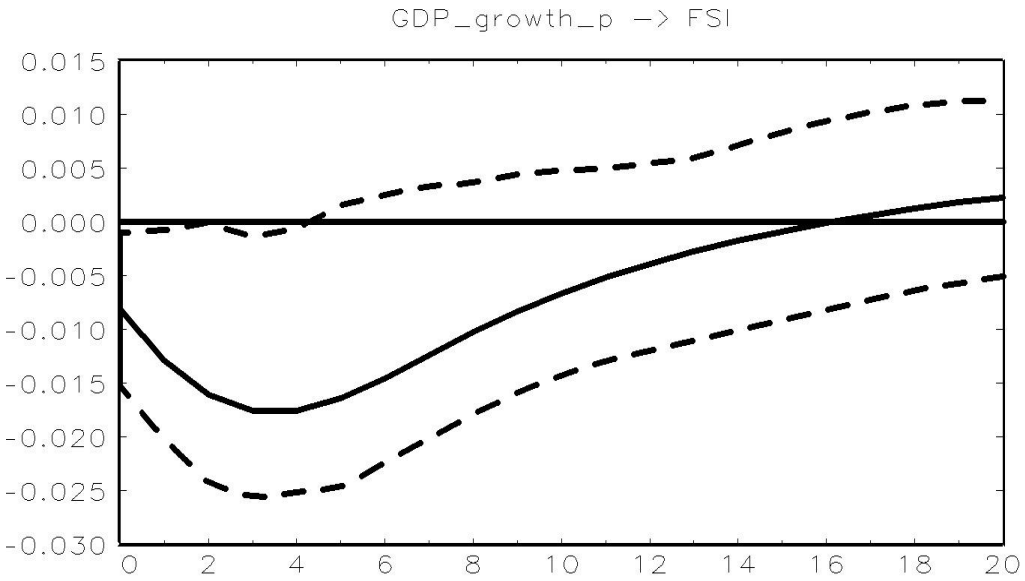
Graph 9: impact of Financial stress on the Inflation



We can see that increase in stress perceived by the market agents brings a sudden drop in inflation. This is possibly due to the linkage of interest rates and inflation. When financial stress is up, interest rates go down, bringing down inflation as well. Or perhaps, we can find another general explanation in inflationary pressures; these are possibly correlated with the performance of the economy, which was significantly falling during the period of financial crisis.

⇧ GDP growth ⇒Financial Stress

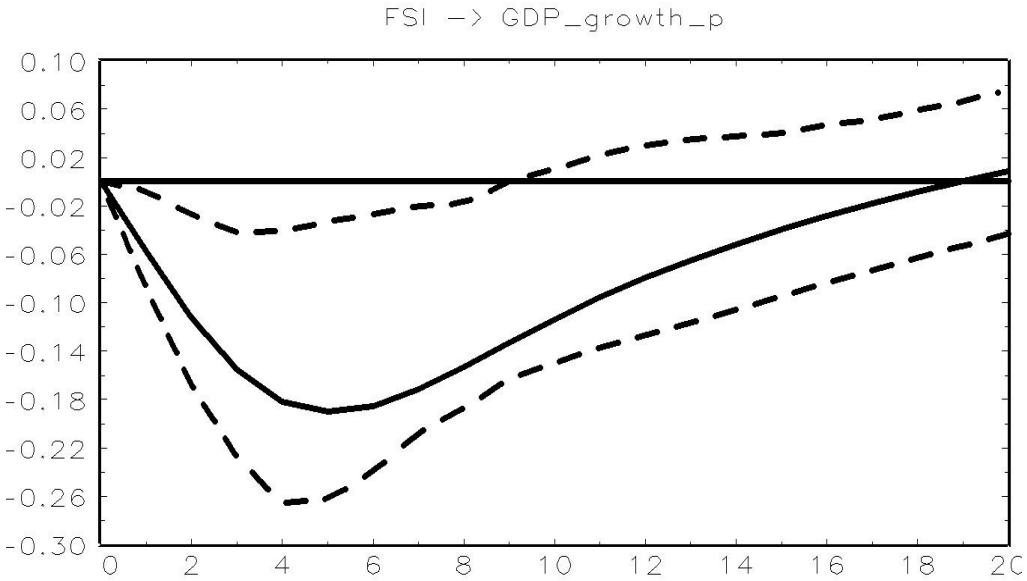
Graph 10: impact of GDP growth on the Financial stress



When an increase in growth rate of real GDP is announced, there is an immediate drop in stress across the financial markets. The impact of such a shock culminates just before the end of the fourth month. Then the level of financial stress begins to rise, until it reaches its original level after 16 months. This relation is well predicted by the theory. Generally high growth across the markets prevents any stress pressures. The effect of GDP shock is bigger in magnitude than the effect of shock in interest rate. This brings us to a conclusion, that in high growth economy, the interest rate shock hardly makes any difference.

⇧ Financial stress ⇒GDP growth

Graph 11: impact of Financial stress on GDP growth



This is very important impulse response analysis between FSI and GDP. In this graph we can see, that FSI has an immediate and let us say drastic impact on GDP growth. After introduction of FSI shock GDP decreases for four consecutive months. After five months GDP growth begins to recover, however recovery will not complete earlier than twenty months after the sudden increase of financial stress. The size of impact of such a shock is really considerable, the accumulated loss of GDP over 20 months could be more, than 1%. This gives us a really good picture about how important the mood on the financial markets of everyday life is.

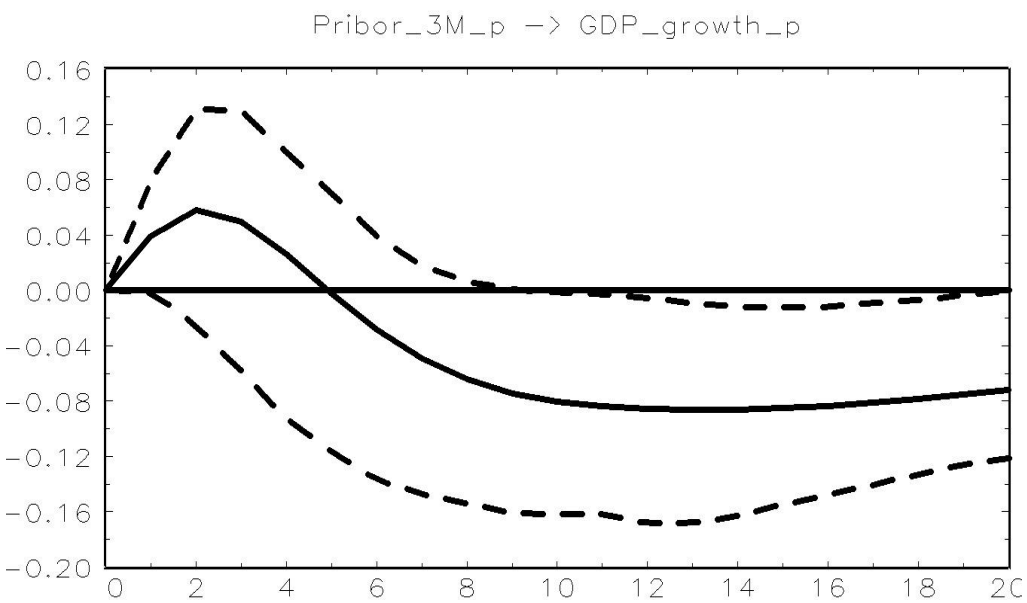
⇧ GDP growth ⇒ Policy rate

Graph 12: impact of GDP growth on the Policy rate

It is estimated, that GDP growth has a positive long-term impact on interest rates. However, there is hardly any immediate impact. This is not in contradiction to theory, since higher GDP growth means primarily higher investments. Higher demand for funds leads to increase in equilibrium market interest rate and policy rate as well.

⇧ Policy rate ⇒ GDP growth

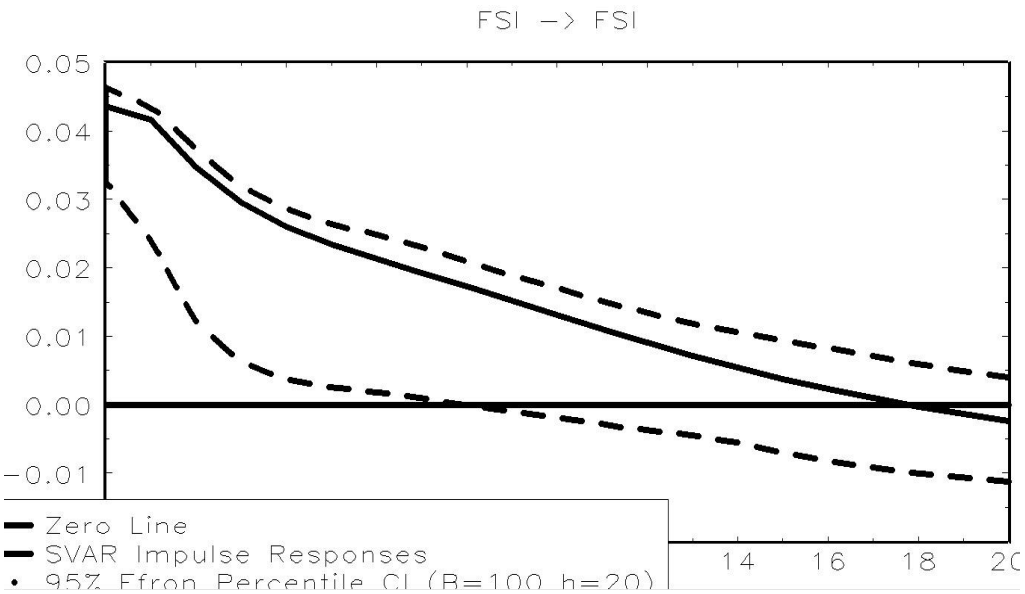
Graph 13: impact of policy rate on GDP growth



In the short term the policy rate is estimated to affect the GDP growth rate positively , however this is definitely offset by a long-term negative impact. We see an explanation in the chain ⇧ Policy rate ⇒⇧ Financial stress ⇒⇩ GDP growth. Due to this chain the two month long lag appears. Theory claims, that higher interest rate prevent investments and through this prevents higher future GDP growth. This is well confirmed by our impulse response curve.

⇧ Financial stress ⇒ Financial stress

Graph 14: impact of Financial stress shock in long-term



We can observe, that shock to financial stress takes a long time to completely abate. (20 months). However, it is important to note, that all processes are stationary, since the effects of own structural shocks do not persist in the long-term.

To summarize the results of estimation we must say, that the reactions to shocks were exactly those we expected. We have commented only on those Impulse Responses, which have been in our primary focus. However, all the impulse response functions can be found in the appendix.

Chapter 4: Concluding remarks

The recent turmoil in financial markets, represented by the financial crisis in 2008-2009 have broadly increased the interest in exploring the relation between financial stability and monetary policy decisions. This thesis focuses mainly on nexus between monetary decisions and financial stress in the Czech Republic over the last decade. In order to be able to study such a relationship, since financial stress is rather an abstract term, which is generally referring to increased instability, we have employed a comprehensive measure called Financial Stress Index. FSI was composed by Tomáš Adam and Soňa Benecká (2012). This index is doing well in capturing the hard times of the Czech financial market because upon its composition it was elaborately decided, tracking five financial market segments: financial intermediaries, equity market, money market, bond market, foreign exchange market, regarding all the special features of the Czech financial market, e.g., lower stock market activity, or a higher exposure to exchange rate volatility. As a proxy for monetary policy we include the interbank lending rate for 3 months. This variable is strongly positively correlated with policy rate and also reflects other factors such as growth in money aggregate.

This thesis employs Structural Vector Autoregressive model to estimate the relations between five endogenous variables: Financial Stress Index, 3 months Interbank Interest Rate, Inflation, Expected inflation, and GDP growth. Such a methodology allows us to estimate even contemporaneous relations and doesn't require us to employ any instrumental variables to identify the model. Another big advantage of this model is ability to estimate impacts of various shocks over time.

Our results of the estimation for the Czech Republic confirmed the theoretical expectations.

We have discovered significantly positive correlation between policy rate and financial stress. Sudden increase in policy rate is estimated to cause immediate response in the form of increased financial stress. Moreover, such a shock could have a permanent impact on perceived market stress. We estimate the financial stress to decrease soon after the introduction of shock, however there is possibly a long-term residuum. On the other hand the policy rate

reacts to the growth in financial stress with lag, and then gradually falls, confirming the interest rate smoothing rule. There is no correction, nor a return to the previous level, thus financial stress shocks are estimated to have rather a permanent effect on interest rate level. We have also discovered negative correlation between GDP and Financial Stress. The shock to the GDP growth is estimated to decrease the financial stress in the short-term, whereas it is neutral in the long-term. Sudden increase in financial stress is likely to plunge the GDP growth. An important finding is that an increase in inflation expectations is immediately followed by rise in the level of financial stress.

Overall, our results point to the importance of financial instability on monetary decision making process and vice versa. This thesis came to the conclusion that decreasing the monetary rate is one of the most useful tools to fight the financial stress. This is vitally important, since financial instability undermines economic activity and thus decreases the real output in the long-term.

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Appendix

Estimated VAR model

```
*** Mon, 29 Apr 2013 18:32:02 ***
VAR ESTIMATION RESULTS
endogenous variables:     GDP_growth_p Inflation_p
Pribor_3M_p FSI
exogenous variables:
deterministic variables:  CONST
endogenous lags:          2
exogenous lags:           0
sample range:             [2002 M3, 2011 M12], T = 118

modulus of the eigenvalues of the reverse characteristic
polynomial :
|z| = ( 1.4655     1.4655     1.0488     1.0488
40.1216    3.6529     3.6529     1.2325     )
Legend:
=======
              Equation 1   Equation 2  ...
-----------------------------------------
Variable 1 | Coefficient          ...
           | (Std. Dev.)
           | {p - Value}
           | [t - Value]
Variable 2 |         ...
...
-----------------------------------------------------
----


Lagged endogenous term:
=======================
GDP_growth_p  Inflation_p  Pribor_3M_p    FSI
-----------------------------------------------------
-------------------------------__
GDP_growth_p(t-1)|    1.349     0.061     0.024    -0.020
                 |   (0.080)   (0.068)   (0.042)   (0.015)
                 |   {0.000}   {0.368}   {0.572}   {0.182}
                 |  [16.862]   [0.901]   [0.565]  [-1.334]
Inflation_p (t-1)|   -0.202     0.730    -0.028     0.005
                 |   (0.117)   (0.100)   (0.061)   (0.021)
                 |   {0.084}   {0.000}   {0.647}   {0.816}
```

```
                    |  [-1.729]   [7.334]  [-0.458]   [0.233]
Pribor_3M_p (t-1)|    0.443     0.369     1.352    -0.020
                    |   (0.183)   (0.156)   (0.095)   (0.033)
                    |   {0.015}   {0.018}   {0.000}   {0.543}
                    |   [2.422]   [2.370]  [14.206]  [-0.609]
FSI          (t-1)|   -1.333    -0.781     0.348     0.956
                    |   (0.539)   (0.458)   (0.280)   (0.099)
                    |   {0.013}   {0.088}   {0.214}   {0.000}
                    |  [-2.473]  [-1.705]   [1.243]   [9.693]
GDP_growth_p(t-2)|   -0.553    -0.073    -0.014     0.008
                    |   (0.078)   (0.066)   (0.040)   (0.014)
                    |   {0.000}   {0.268}   {0.728}   {0.578}
                    |  [-7.131]  [-1.109]  [-0.348]   [0.557]
Inflation_p (t-2)|    0.155     0.084     0.087    -0.002
                    |   (0.115)   (0.098)   (0.060)   (0.021)
                    |   {0.177}   {0.392}   {0.145}   {0.913}
                    |   [1.349]   [0.856]   [1.459]  [-0.110]
Pribor_3M_p (t-2)|   -0.442    -0.345    -0.397     0.030
                    |   (0.175)   (0.148)   (0.091)   (0.032)
                    |   {0.011}   {0.020}   {0.000}   {0.353}
                    |  [-2.534]  [-2.328]  [-4.374]   [0.929]
FSI          (t-2)|    0.173     0.256    -0.446    -0.131
                    |   (0.559)   (0.475)   (0.291)   (0.102)
                    |   {0.758}   {0.590}   {0.125}   {0.201}
                    |   [0.309]   [0.539]  [-1.535]  [-1.278]
------------------------------------------------------------------
--


Deterministic term:
===================
          GDP_growth_p  Inflation_p  Pribor_3M_p       FSI
-----------------------------------------------------------
CONST   |    0.462     0.544    -0.067     0.003
        |   (0.188)   (0.159)   (0.098)   (0.034)
        |   {0.014}   {0.001}   {0.491}   {0.921}
        |   [2.460]   [3.409]  [-0.689]   [0.099]
-----------------------------------------------------------
```

Estimated A and B SVAR matrices

```
*** Mon, 29 Apr 2013 18:32:25 ***
This is an AB-model

Step 1:
Obtaining starting values from decomposition of correlation
matrix...
Iterations needed for correlation matrix decomposition:   9.0000
Vector of rescaled starting values:
  0.0031
 -0.0388
  0.0363
 -0.1816
  0.0210
 -0.0939
  0.2507
```

```
  0.2131
  0.1241
  0.0436

Step 2:
Structural VAR Estimation Results
ML Estimation, Scoring Algorithm (see Amisano & Giannini (1992))
Convergence after 1 iterations
Log Likelihood: 725.5695
Structural VAR is just identified

Estimated A matrix:
  1.0000   0.0000   0.0000   0.0000
  0.0031   1.0000   0.0000   0.0000
 -0.0388  -0.1816   1.0000   0.0000
  0.0363   0.0210  -0.0939   1.0000

Estimated standard errors for A matrix:
  0.0000   0.0000   0.0000   0.0000
  0.0782   0.0000   0.0000   0.0000
  0.0456   0.0536   0.0000   0.0000
  0.0161   0.0197   0.0323   0.0000

Estimated B matrix:
  0.2507   0.0000   0.0000   0.0000
  0.0000   0.2131   0.0000   0.0000
  0.0000   0.0000   0.1241   0.0000
  0.0000   0.0000   0.0000   0.0436

Estimated standard errors for B matrix
  0.0163   0.0000   0.0000   0.0000
  0.0000   0.0139   0.0000   0.0000
  0.0000   0.0000   0.0081   0.0000
  0.0000   0.0000   0.0000   0.0028

A^-1*B
  0.2507   0.0000   0.0000   0.0000
 -0.0008   0.2131   0.0000   0.0000
  0.0096   0.0387   0.1241   0.0000
 -0.0082  -0.0008   0.0117   0.0436
SigmaU~*100
  6.2863  -0.0196   0.2402  -0.2054
 -0.0196   4.5418   0.8238  -0.0171
  0.2402   0.8238   1.6989   0.1336
 -0.2054  -0.0171   0.1336   0.2104
end of ML estimation
```