Did monetary transmission mechanism change in Hungary after the crisis? Evidence from different SVAR models before and after 2008

By

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Abstract

This thesis is part of the Hungarian transmission mechanism literature. There is a more comprehensive research material on the transmission mechanism before the crisis than after the crisis. I aim to contribute to the latter part. The hypothesis is that the transmission mechanism changed. I used SVAR approach to create impulse responses for a monetary policy shock. In addition to the existing literature, I use same models in separate samples before (2000M1-2008M7) and after (2008M8-2018M2) the crisis. I used contemporaneous restrictions on the covariance matrix and sign restriction on impulse responses identification approaches as well, to see if the results are robust to identification techniques. Both estimation show that the effects of a monetary contraction are different in the two samples, which lead to the conclusion that there was a change in the transmission mechanism. The results are in line with the theory of decreased slope of the Philips curve (Blanchard, 2014): the output responds more, the inflation responds less to a monetary tightening. If interest rate policy aims to decrease inflation, there is bigger "growth" price to pay than before the crisis. Output, liquidity and exchange rate responded stronger to a policy intervention after the crisis, which means transmission channels of monetary policy improved.

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Acknowledgement

I am very grateful for my supervisor, Balázs Világi, who not only guided me through the research process, but had inspired me to deepen my knowledge in the field of macroeconomics on his amazing lectures.

I owe a gratitude to István Ábel, who was open to my request and looked at my result, giving useful comments to it.

Finally I would like to thank my father who supported me financially, and the family and friends who supported me emotionally to finish my degree.

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Introduction

Knowing how the transmission mechanism works is a key for understanding how monetary policy can affect the real economy. Policy makers must know the effect of changing the interest rate to make appropriate decisions. In Hungary, there was a comprehensive research on quantifying the monetary policy effects which was carried out before the crisis. After the crisis, we have less extensive information about the transmission channels, which opens a space for my thesis research.

It is possible, that after the crisis, through various new issues and opportunities of monetary policy faced has changed the transmission mechanism in Hungary. Just to mention a few, the wide appearance of the zero lower bound, negative interest rates, unconventional policies could change people's previous behavior and the passthrough of interest rates and exchange rate into the economy.

My hypothesis is that there was a change in the monetary transmission mechanisms after the crisis in Hungary. I use impulse response functions to analyze the effect of a monetary policy shock to the liquidity (M0 monetary base), the real activity (industrial production), the inflation (CPI) and the exchange rate (Ft/Euro). The idea is, that the sample from 2000M1-2018M2 was divided into 2 subsamples. I use one subsample before, and one subsample after the crisis (starting from 2008M8). The estimation methods are implemented on both subsamples. If the impulse responses are different, we can conclude that there was a change in the transmission mechanism in Hungary.

By 2018 we have more than 112 monthly observations since the crisis. My contribution to the literature is that I estimate SVAR model on a sample before the crisis and compare the results estimated on a sample after the crisis. I could not find similar approach for Hungarian economic

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analysis. In addition, I use 2 identification method, one is the contemporaneous restriction, other is the sign restriction on impulse responses. This will help to see if the results are robust to the estimation methods.

First, I will introduce the literature on Hungarian monetary transmission channels in chapter 1. I choose the model of SVAR to verify or falsify my hypothesis, so I introduce the identification methodologies I implemented, in chapter 2. Then, I show the data and the transformations I applied for the modelling in chapter 3.

In chapter 4, I analyze the impulse responses from the different subsamples and different identification methods. To make easily comparable results, I used the data and the modelling approach of Ábel-Kóbor (2010) paper for the restrictions on contemporaneous effects. Coming from the economic theory, I also identify the monetary policy shocks by imposing sign restrictions on the impulse responses of the model variables. Both estimation method were applied for the sample before and after the crisis as well. One can find discussion of the results with the literature as well in this chapter.

As any econometric model, SVAR models have their own drawbacks. I will write about what are the limitations of the methodology and what are the further opportunities of the research in chapter 5.

I write about what are the policy relevance of the research output in chapter 6. There are concluding remarks at chapter 7, which is the last one.

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1. Empirical facts and models used for Hungarian monetary transmission

The Central Bank of Hungary distinguishes between 5 different channels for monetary policy transmission in their studies, relying on Mishkin's (1996) classification: interest rate channel, asset price channel, exchange rate channel, credit channel and expectation channel (Vonnák, 2006). The 3 main channels are interest rate channel, exchange rate channel, and expectation channel (mnb.hu).

In 2005-2006 there was a comprehensive research for quantifying different channels of transmission mechanism in Hungary, and later new studies appeared for refreshing the methodology and test for newly available data. In this section, I am going to introduce the methodology, data and main findings of these papers. Literature matrix is available in the Appendix A providing a summary table of this chapter.

1.1. Empirical facts

Vonnák(2010) examined the exchange rate pass-though in the presence of monetary policy and risk premium shocks in 3 developed and 3 Central Eastern European country. In an inflation targeting system, the question arises: how should monetary policy react to exchange rate movements? If the exchange rate channel dominates the interest rate channel, the policy rate should respond to exchange rate shocks. On the other hand if there is higher volatility of exchange rate, that reduced the passthrough to prices, because people and firms learn how to hedge risk themselves. The conclusion was that in case of a risk premium shock, it is almost impossible to smooth the exchange rate with interest rate policy and minimize inflation at the same time. Also, developed countries pass-through rate was lower than the 3 CEE countries,

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because of higher monetary policy credibility. Low and stable inflation, anchored inflation expectations slow down the pass-through.

Horváth et al. (2004) examined the interest rate passthrough in Hungary. The pass-through is bigger and quicker in the corporate sector, the adjustment of the short term corporate loan interest rates are complete. In the corporate loan sector, there is higher competition. The retail lending with high spreads has unperfect adjustments. This can be explained by the lower interest rate sensitivity of retail credit demand. The retail deposits adjust the interest rate increases quicker than the interest rate decreases. Above a certain threshold, the repricing of bank products are quicker, which supports menu cost theory. The conclusion was that the interest rate transmission has improved, but further improvements are forecasted in the corporate deposit and the whole retail sector.

Jakab et al (2006) examined how monetary policy affects the major components of aggregate demand. After a monetary policy tightening, investments decrease, there is no major change in in net exports. In the data from USA, the private consumption drop is a stronger response, while in the EU, the effect on investments is the dominant one. In Hungary, which is a small open economy, the response of the exchange rate is the significant one.

Ábel – Kóbor (2010) built a model to trace the effect of a monetary policy contraction in some aggregated variable of the Hungarian economy. On 1. figure a), the increase of domestic interest rate is seen. The liquidity (1. figure b), thus the monetary base decreases by the contraction, later the effect diminishes but still persistent. The CPI (1. figure c) decreases and the price level is finding equilibrium on a lower level. The industrial production (1. figure d) decreases at the first periods but increases on long term. Results show that the exchange rate responses immediately and sharply, there is an appreciation, but the effect dies out after one year.

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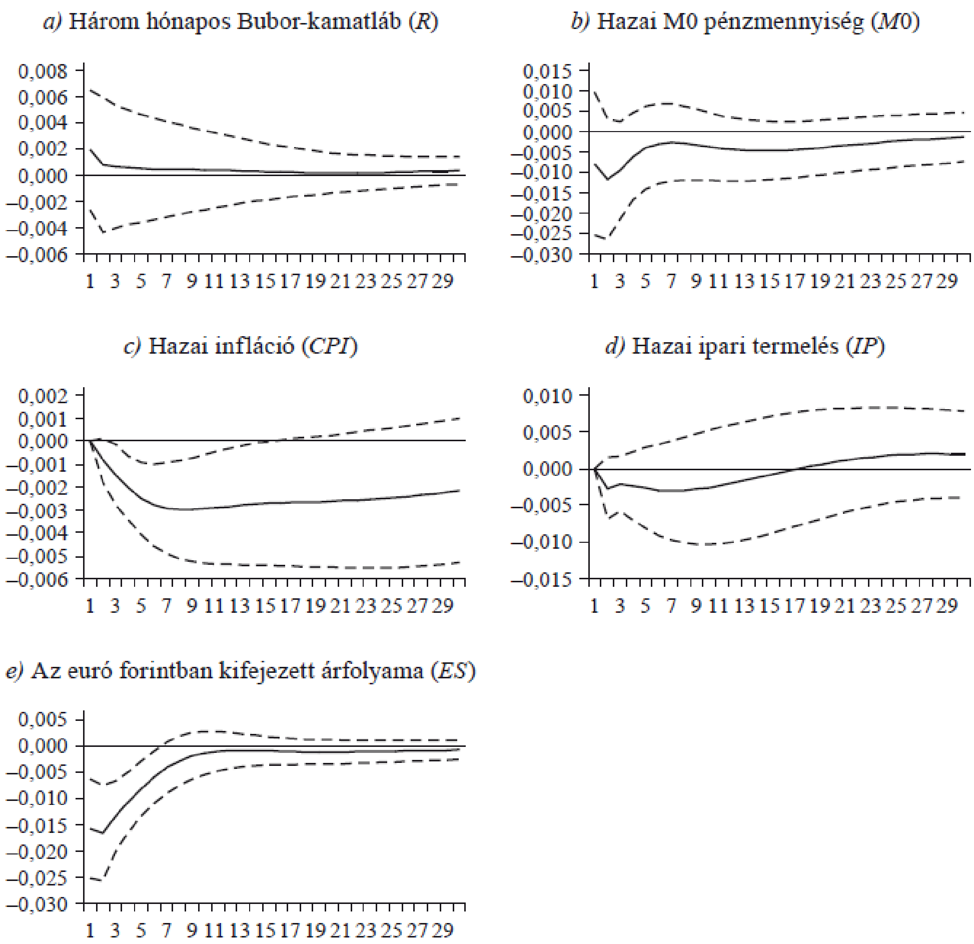

1. Figure: Impulse Responses from 1std monetary policy shock. Source: Ábel-Kóbor (2010, pp. 425.)

Kátay-Wolf (2004) have examined the investment behavior of Hungarian firms. They wanted to know how the change of interest rates affects the investments. The main results imply that the determinant of investment is mainly the user cost of capital. Although the cash flow, thus the financial position of the firm is also crucial, which indicates the credit channel might be at work.

Karádi (2005) examined the exchange rate smoothing in Hungary. As the country is small and open, the hypothesis is that there is exchange rate smoothing even if it is not in the goals of the Central Bank explicitly. There is a stronger exchange rate pass through if the interest rate move is unexpected, and market participants form expectations which influence exchange rate

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accordingly. Results show there is a significant interest rate response for exhchange rate deviating from the target.

Rezessy (2005) estimated the immediate effect of monetary policy shocks on the exchange rate and other asset prices, thus examined the exchange rate and asset price channels. The study found that the increasing interest rates have negative impact on the exchange rate, moreover, the effect increases if they examine with a 2 day window. Quantitatively, 50 basis point surprise increase in the interest rate was followed by 0.3% appreciation of the exchange rate on average, if they used 2 day window, the effect was 4x higher. This implies the inefficiency of the market. The monetary policy shocks were taken as surprise if there was change in the 3 month yield. This approach is usual in monetary policy literature. A monetary contraction has a positive effect on the spot yield but it dies out quickly. Regarding the forward yields, an increased interest rate has positive effects, but on the long run it has negative effects. There was no significant effect on the stock exchange index.

The Horváth et al (2006) paper examines the banking lending channel in Hungary. This channel belongs to the credit channel. They wanted to examine the behavior of the financial intermediaries, how do they affect the quantity of loans, so finally the real economy. Results show that credit channel might be in work.

Pellényi (2012) examined the macroeconomic effects but also the sectoral impulse responses from a monetary policy shock. Though the macroeconomic effects are similar to the literature of SVAR impulse responses, there is significant heterogeneity existing between sectors of the economy. Those sector which rely more on external finance have a higher output response to a monetary policy shock, while others have lower price responses.

1.2. Models, variables used, time horizon

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In Vonnák (2010) paper, SVAR approach was used, with contemporaneous and sign restrictions imposed on impulse responses. Vonnák used Bayesian approach to analyze the variables in level, which are the following: Industrial production, overall consumer prices, 3 month T-bill rate, nominal effective exchange rate, all monthly data. In Hungary, the time horizon was from 1995-2010.

The results of Vonnák (2005) were based on quarterly data from 1995-2003, for log of real GDP, CPI, nominal effective exchange rate, log of 1+3 month T-bill yield. The SVAR approach was based on sign restrictions on impulse responses, and the other approach was based on latter identification scheme, namely restrictions on implied shock theory.

Horváth et al. (2006) used the method of the ARDL (autoregressive distributed lag) model. It captures the asymmetries by the changes in the loans to isolate the supply and demand effects. In the model, the asymmetric effects are captured by interaction terms. They used quarterly bank level balance sheet data from 1995Q1 to 2004 Q3. The data were seasonally adjusted and contained 25 of commercial banks.

The methodology used by Pellényi (2012) was the structural factor model, which says that the behavior of large number of variables can be described by low number of factors. The shocks are identified with sign restriction. 198 macroeconomic and sectoral quarterly data were used from 2000Q2-2010Q4.

Rezessy (2005) used was method of identification through heteroscedasticity. He used OLS regression on the days of the monetary policy decisions as well, but the estimation was biased through strict subsampling, so he used policy dates and non-policy dates as well. The data used was exchange rate, spot yields, forward yields, first differences or logdifferences of observations from august 2001- November 2004, with 160 daily observation of policy, non-policy dates, and preceeding days of monetary decision.

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Karádi's (2005) research was based on a structural empirical model. The assumption was the existence of an unobserved and changing implicit exchange rate target and Kalman filter was used to estimate this target. The CB was assumed to use interest rate policy, an interest rate rule and an exchange rate target consistent with the rule were simultaneously estimated. The data used was weekly from 2001 may to 2004 end which was considered as homogenous period by the author.

Kátay-Wolf (2005) used Neoclassical model of investment to derive elasticities of the determinants of investment. To examine the effect of monetary policy, they used the method of autoregressive distributed lag equations. The data is a large panel data of Hungarian firms from 1993-2002, with unstable macroeconomic environment, like growth rate of sales and cash flow.

The methodology of Ábel-Kóbor (2010) was SVAR modelling approach. They had 7 monthly variables from 1998 to 2010, the 3 month BUBOR interest rate, the Hungarian monetary base, the consumer price index, the industrial production, the dollar price of 1 barrel crude oil, the 3 month euro-libor interest rate and forint/euro exchange rate. The model identification is through imposing contemporaneous restrictions on the covariance matrix. By economic considerations, they used 26 constraints of zero response, though mathematically, only 21 was needed.

The results were observed from 3 different macroeconomic model estimated on quarterly Hungarian data from 1997-2006 in Jakab et al (2006) paper. First, they used the Hungarian Quarterly Projection model, which is a neo-keynesian macroeconometric model. Second, they used the 5 gap model, which decomposes excess demand, output gap into consumption, investment, exogenous government expenditures, export and import gap. Finally, they applied an SVAR approach for interest rate, exchange rate, consumer price index, private consumption, private investment and net export. The identification method was sign restriction on the impulse responses.

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Horváth et al (2004) used error correction model approach and Threshold autoregressive models. They used aggregated interest rate data and individual bank level data from 2001-2004.

Vonnák (2005) examined Hungarian monetary policy within SVAR framework. The results implied that 0.25% monetary policy contraction was followed by 1% quick nominal appreciation of the exchange rate and 0.3% lower output in the next 3 years, prices were lower by 0.15%.

1.3. Summary

Finally, I choose the method of SVAR models to analyze the features of the transmission mechanism. First, in the literature, researcher use this method usually, so there is significant amount of work to be compared to (see literature matrix attached). Second, these models use publicly available data.

Although I think firm level and bank level data can be a tool for analyzing the exchange rate and interest rate channel in a comprehensive manner, there are limitations in accessing these types of data. Aggregated data cannot reveal the heterogeneity in the economy but can give insight about the functioning of the economy as a whole. Furthermore, it is possible to get information about more transmission channel at the same time with an SVAR model. I neglected the expectation channel analysis as I do not explicitly model this channel. I used Ábel-Kóbor (2010) paper as a benchmark for constructing the SVAR model and the identification. I oppose the results from different papers when I compare them in my results.

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2. SVAR methodology

I use Lütkepohl – Krätzig (2004) explanation to show the SVAR model estimation steps. The aim of the SVAR models is to get the impulse response functions. The impulse response functions show the effect of a shock in one variable to the other variables. Reduced form VAR models can summarize the dynamic properties of the data. Although if the parameters estimated from a VAR model does not refer to specific economic features they are hard to interpret.

The structural vector autoregressions which we call identified VARs as well, are composing a new class of econometric models. The main difference from the VAR is that the SVAR identifies errors of the system (linear combinations of exogeneous shocks). This innovation part of the system was orthogonalized first by Cholesky decomposition of the covariance matrix. Shocks are constructed by restricting the contemporaneous relationship between the variables. These restrictions should come from the economic theory. The method can be sensitive to the ordering of the variables, thus one should check if the results are robust to different ordering.

Further shock identification can be applied by using restrictions on their long run effect. These restrictions should come from economic theory as well. For example, change in nominal variables does not affect real variable on long term.

The aim is to get impulse response functions, which are highly non-linear functions of the model parameters. Shocks are related to residuals. Shock has economic meaning, like oil price shock, in our case, a monetary policy shock. They are not directly observable, one should make assumptions about them. Structural shocks should be mutually uncorrelated, because we can observe dynamic impact of an isolated shock by this way.

The recursive representation of a VAR model is the following:

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

Structural shocks(ε_t) are assumed to be related to model residuals (u_t) by linear relations:

$$A * u_t = B * \varepsilon_t$$

where B is KxK matrix. K is the number of endogeneous variables in the model. If A matrix is equal to the identity matrix, for the shock ortogonalization still K*(K-1)/2 restrictions are needed. These two sets of restrictions are combined in this identification scheme, called the AB model representation.

Based on the Ábel-Kóbor (2010) paper, I use their B_0 matrix (2. Figure) to identify the monetary policy shocks. Although their model is overidentified with 7 variables and 26 zero restrictions, it was lead by economic theory rationale. I choose to implement this methodology regardless of the above-mentioned problem, to have results which are easily comparable.

$$B_0 = \begin{bmatrix} 1 & b_{12} & 0 & 0 & b_{15} & 0 & b_{17} \\ b_{21} & 1 & b_{23} & b_{24} & 0 & 0 & 0 \\ 0 & 0 & 1 & b_{34} & b_{35} & 0 & 0 \\ 0 & 0 & 0 & 1 & b_{45} & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & b_{65} & 1 & 0 \\ b_{71} & b_{72} & b_{72} & b_{72} & b_{72} & b_{72} & 1 \end{bmatrix}$$

2. Figure: B0 matrix from Ábel-Kóbor(2010, pp 418.), own edit

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The data used in this covariance matrix, thus the data used in the model are: domestic interest rate, monetary base, consumer price index, industrial production, oil price, foreign interest rate and exchange rate, thus y_t = (Bubor, M0, CPI, IP, OP, Euro-Libor, Ft/Euro). Detailed description of the variables is provided in chapter 3.

2.1. Sign restriction

The sign restriction identifies shocks by imposing restrictions on the long run effect of the shocks on the model variables. In this thesis, monetary policy shock is identified the following way, backed by theory: the effect of a monetary contraction is negative on the economic growth, negative on the inflation, negative on the liquidity, negative on the exchange rate (representing appreciation).

I use Uhlig's (2005) rejection method to implement the sign restrictions. The method is based imposing long run restrictions on the impulse responses. This method is a good complementary for the overidentified model approach of Ábel-Kóbor (2010).

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3. Data

In this section I will introduce the data used in the SVAR model. These data are the following, as I already mentioned in chapter 2: Budapest Interbank Forint Credit Interest Rate, the monetary base, consumer price index, net sales revenues of industrial production, oil price, Euro-Libor interest rate, Ft/Euro exchange rate. The data represent in the model (in the previous order): the domestic interest rate, liquidity, inflation, supply side of the economy, the foreign inflation pressure and the foreign interest rate. The variables are used in log version in the model (except interest rates). The time horizon is from January 2000. to February 2018, although in the model 2 subsample used, one before and one after the crisis, starting from 2008 M8.

Though the key policy rate is not included in the model as it is not a variable with regular frequency, it is important to see when the big changes happened and how much did the Monetary Committee change the interest rate.

3.1. Key policy rate in Hungary – MNB

This graph below (3. Figure) shows the evolve of the key policy rate in Hungary in the examined period, from 2000-2018. Before the crisis, from 2000-2003 there was a loose monetary policy, followed by tight policy until 2004 and again loose monetary policy. The peak of the key policy rate is 12.5% in November 2003., the bottom was 6% in September 2005. After the crisis, the maximum of the key policy rate reached 12% in 2008 November. It was followed by a decreasing period of key policy rate, then a year of tightening again. Since 2012 august there is a monetary regime change with a constantly decreasing policy rate, which is at 0.9% since May 2016, nearly reaching the zero lower bound.

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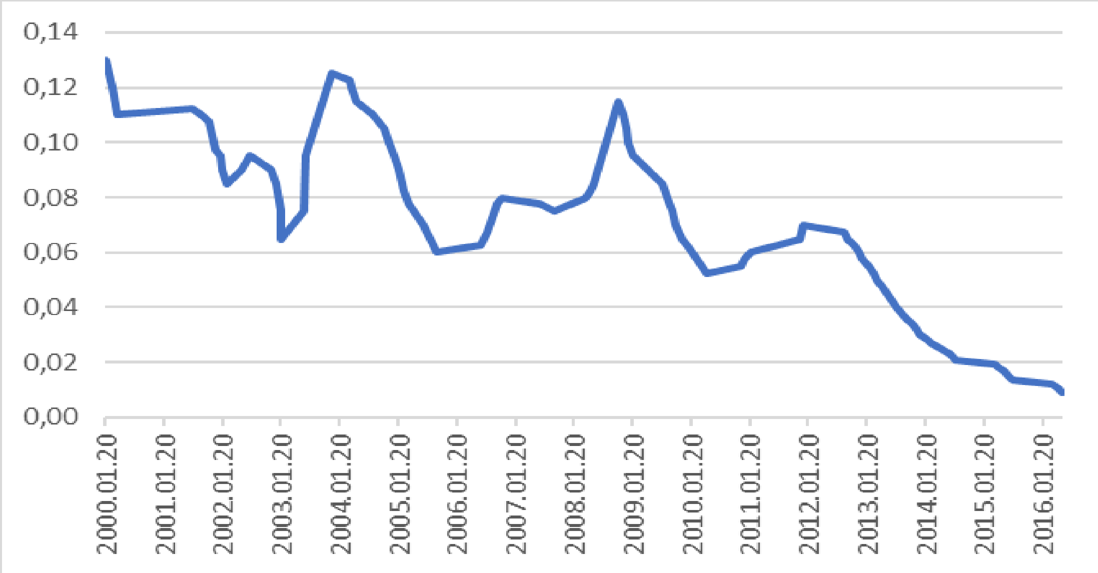
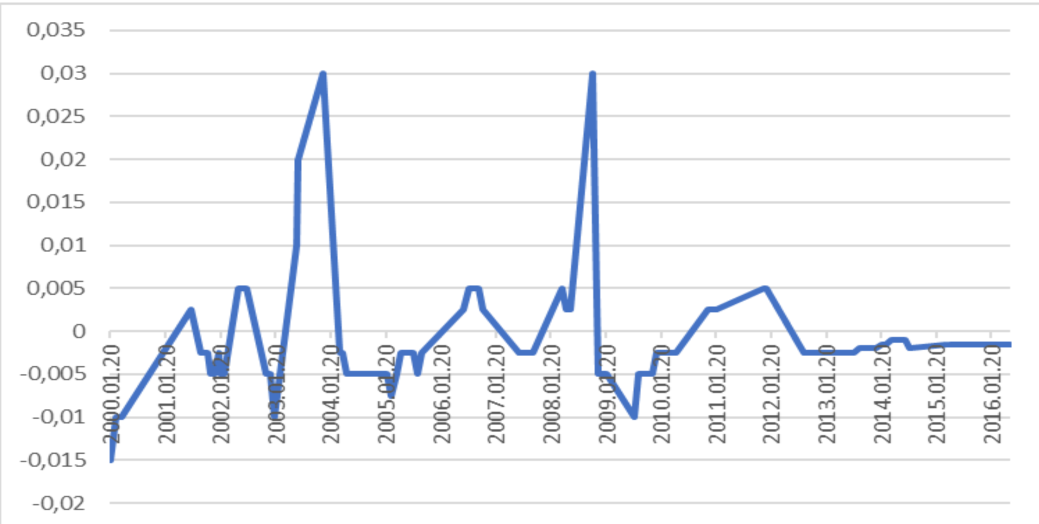


3. Figure: The key policy rate in Hungary 2000-2018. (Source: own edit from mnb.hu, 2018)

On 4. figure below, one can find the difference of the key policy rate, so we can better see the big increases and decreases of the rate. Before the crisis, it clear that the biggest increases happened in 2003. Right after the crisis, the Hungarian economy experienced the biggest increase in the rate which was 3%. There was also a bigger increase in 2012, 0.5% contraction.



4. Figure: The difference in key policy rate in Hungary 2000-2018. (Source: own edit from mnb.hu, 2018)

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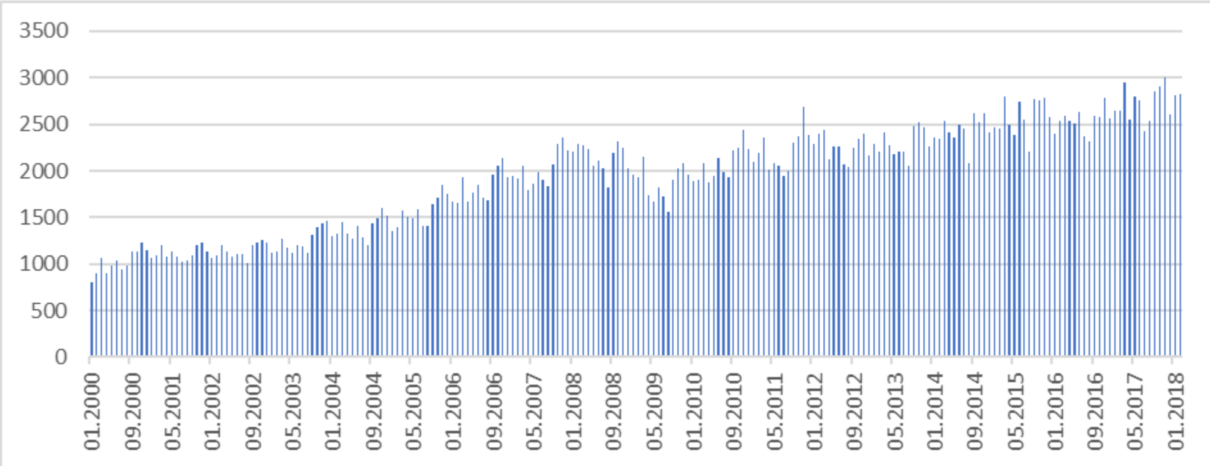
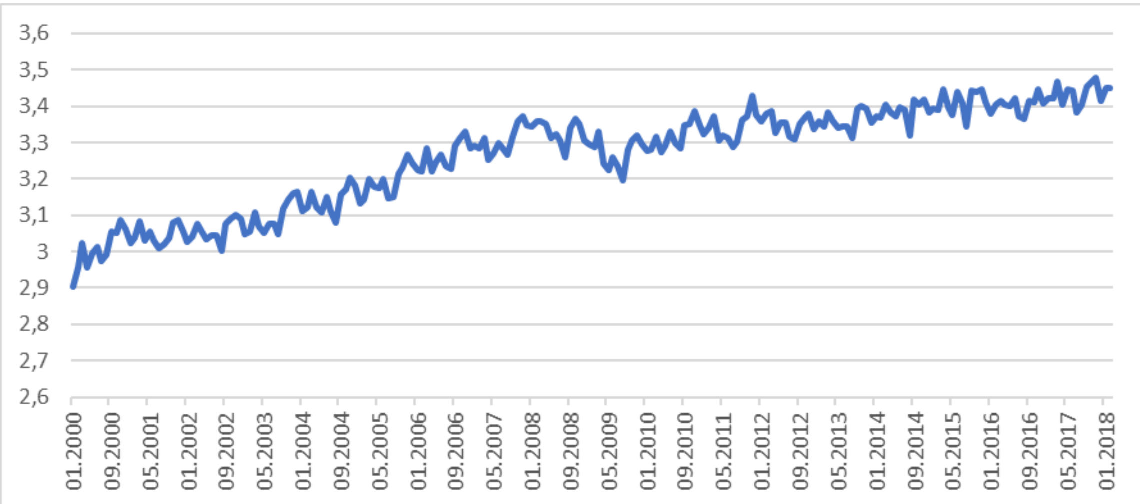
3.2.Industrial Production

The graphs below show the industrial production, monthly data from January 2000 to February 2018. The data is plotted in levels (5. figure) and log (6. figure) as well.



5. Figure: The Net Sales Revenue from Industrial Production in Hungary 2000-2018. (Source: own edit from ksh.hu)



6. Figure: The log of Net Sales Revenue from Industrial Production in Hungary 2000-2018. (Source: own edit from ksh.hu)

3.3. Domestic interest rate

7. figure below represents the domestic interest rate. Though it seems like there is a clear negative trend in the end of the sample, but this is just temporary, the policy normalization of

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countries already started after the crisis, soon the average interest rates are expected to be higher. Thus I choose to estimate the model with BUBOR (Budapest Interbank Forint Credit Interest Rate) in levels. The data was available for daily frequency, so I transformed into monthly frequency by averaging the daily observations.

7. Figure: The Budapest Interbank Forint Credit Interest Rate, 2000-2018. (Source: own edit from mnb.hu)

3.4. Inflation

The 8. figure below shows the Consumer Price Index in Hungary from January 2000 to February 2018. This data is representing the domestic inflation in the model. This is 12 month inflation in monthly frequency. 9. figure represents the log transformed version.

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8. Figure: Consumer Price Index, Hungary 2000-2018. (Source: own edit from ksh.hu)

9. Figure: Log of Consumer Price Index, Hungary 2000-2018. (Source: own edit from ksh.hu)

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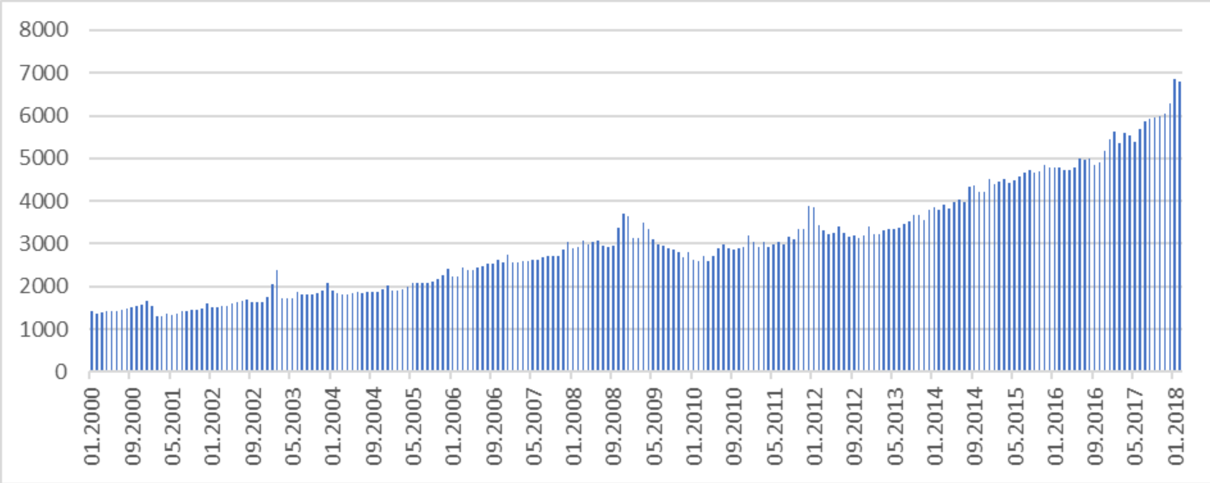
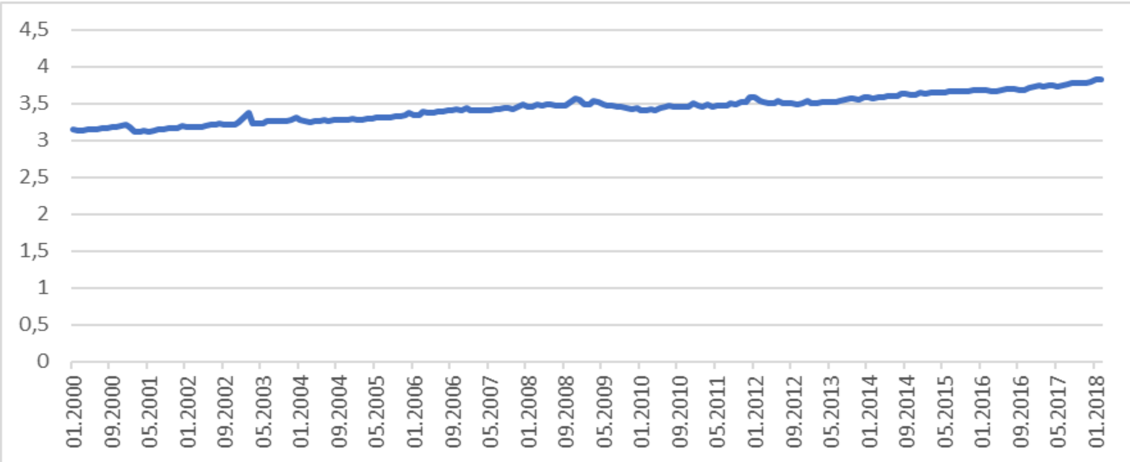
3.5. Liquidity

10. figure shows the monetary base (M0) and its log (11. figure) for Hungary from 2000-2018. This data represents the liquidity in Hungarian economy. The frequency is monthly, the value is in billion forints, monthly averages.



10. Figure: The monetary base (M0) in Hungary 2000-2018. (Source: own edit from mnb.hu)



11. Figure: Log of monetary base (M0) in Hungary 2000-2018. (Source: own edit from mnb.hu)

3.6. Oil Price

This 12. figure below represents oil price and its log version (13. figure). The prices refer to USD per barrel, equally weighted 3 prices (spot price of Brent, Dubai and West Texas Intermediate) averaged.

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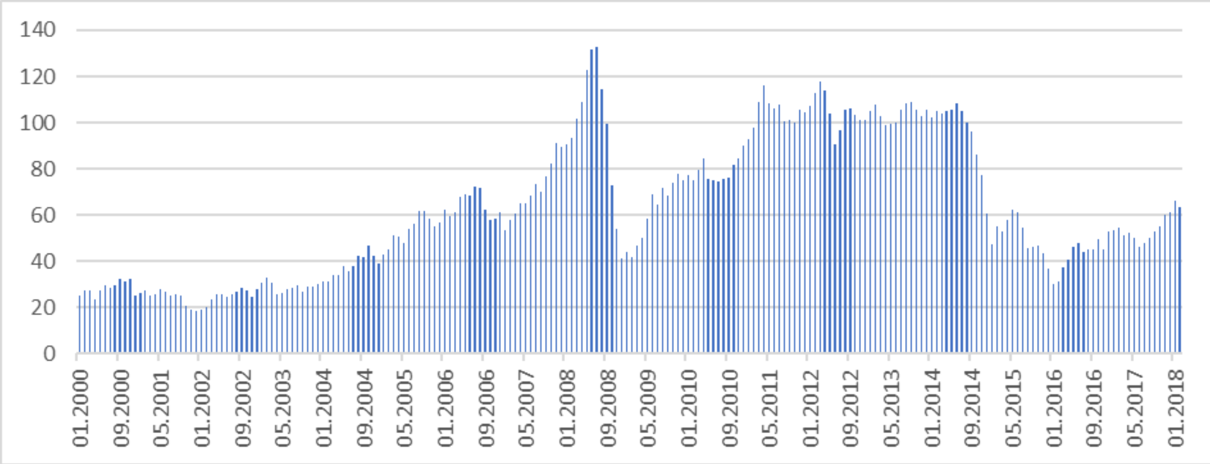
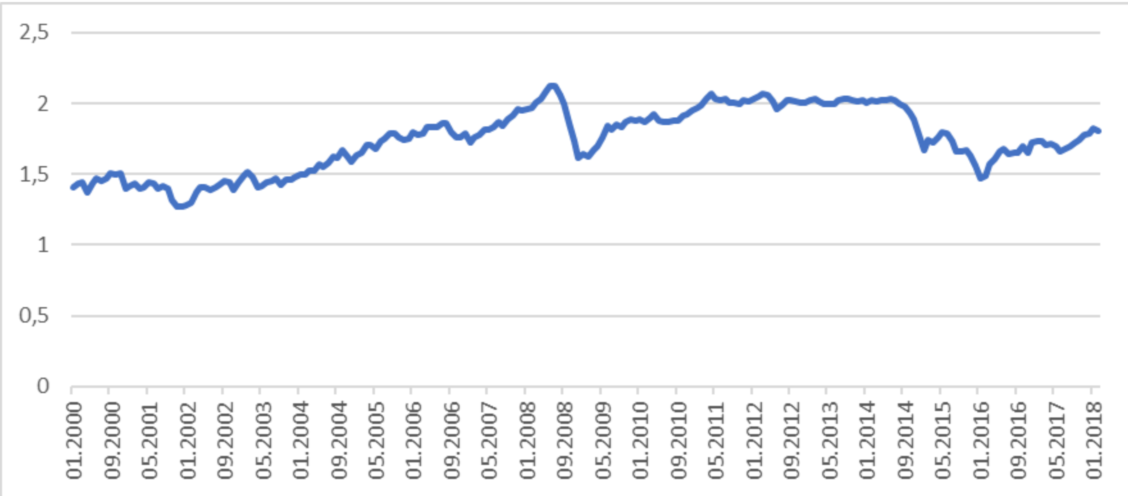


12. Figure: Oil price (USD/barrel) 2000-2018. (Source: own edit from worldbank.org, indexmundi.com)



13. Figure: Log of oil price (USD/barrel) 2000-2018. (Source: own edit from worldbank.org, indexmundi.com)

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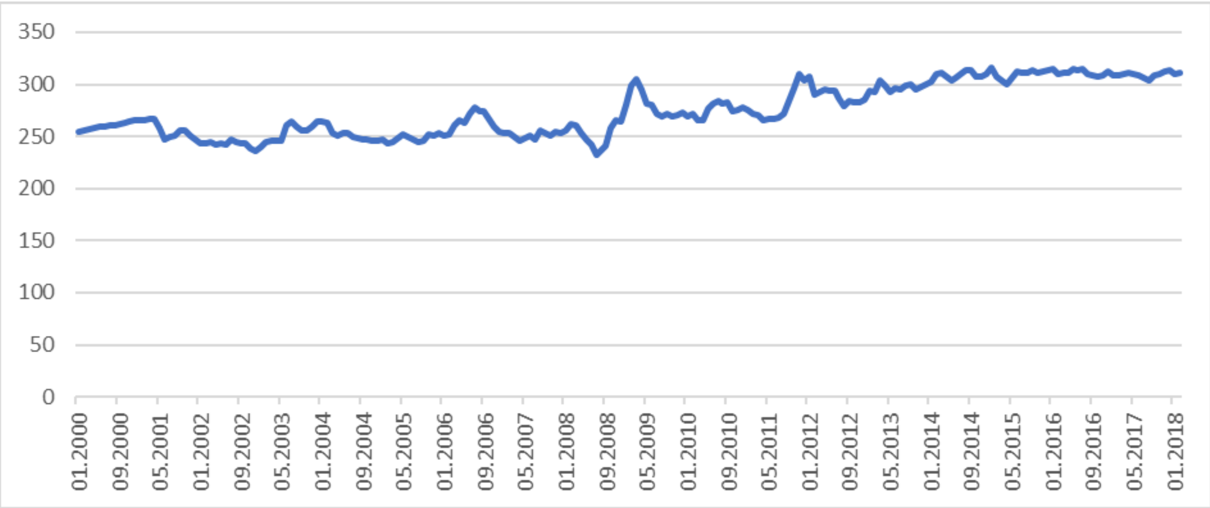
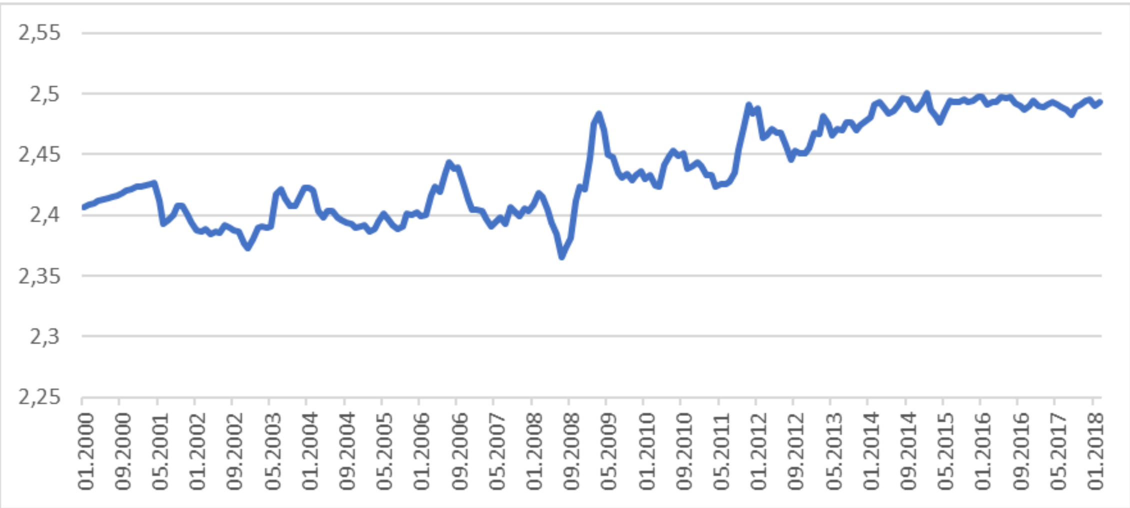
3.7. Exchange rate

The 14. figure below shows the exchange rate of forint/euro. The frequency is daily originally, but it was transformed for monthly observation through averaging. 15. figure shows the data in log transformation.



14. Figure: Ft/Euro exchange rate 2000-2018. (Source: own edit from mnb.hu)



15. Figure: Log of Ft/Euro exchange rate 2000-2018. (Source: own edit from mnb.hu)

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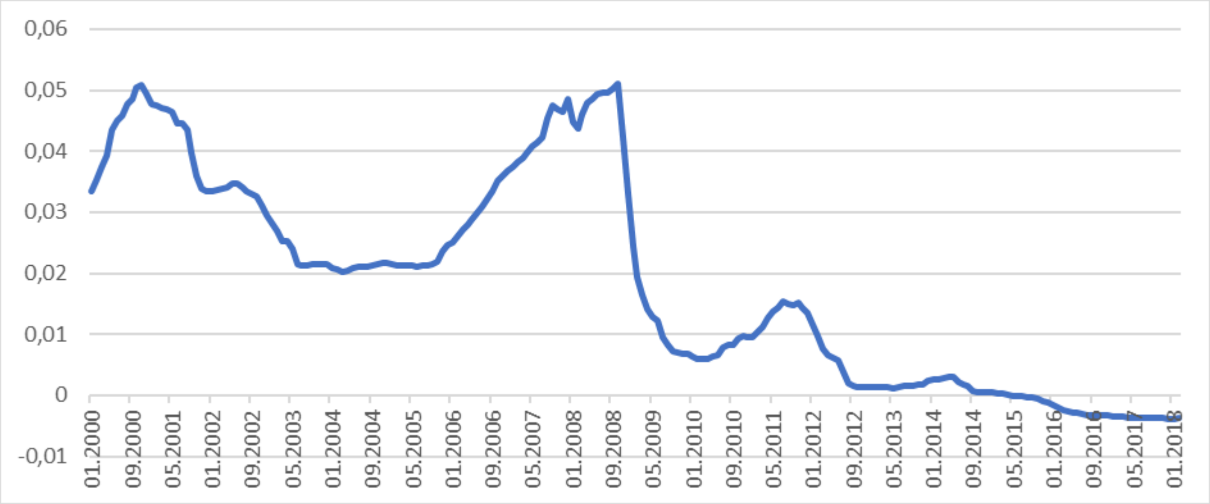
3.8. Foreign Interest rate

16. Figure below shows the 3 month euro libor interest rate. This data represents the foreign interest rate. The data was transformed by averaging the daily observations into monthly frequency. I choose to analyze the variable in levels in the model, for the same reason as I did

with the domestic interest rate. At the end of the sample, we can see the negative interest rates typical for the eurozone countries' loose monetary policy these years.



16. Figure: The 3 month Euro Libor interest rate. (Source: own edit from fred.org)

This chapter showed the path of the key policy rate, biggest policy interventions to get a picture of the monetary policy in the examined period. Then, the variables used in the model were plotted, all the data treatment and sources were introduced. In the next chapter, I will show the impulse responses of the different SVAR models, and analyze the results.

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4. Results, Discussion

So finally, to investigate the effect of the monetary policy to the real economy, different SVAR models were implemented. Usually in the literature, scholars examine the effect of the monetary contraction, so I will do the same, and see what happens after an increase in the interest rate. The identification was carried out through contemporaneous restrictions and sign restrictions as well. It was important to see that different estimation methods do give the same output or not, to check if the results are robust to different methodology.

The first section of the chapter contains the analysis of the impulse response functions for 1 standard deviation monetary policy shock from the contemporaneous identification method, while the second section contains the results from a sign restriction identification method. Each section is divided by the time horizon, because the estimations were carried out on samples before the crisis and after the crisis.

4.1. Contemporaneous restrictions

Two models are shown in this section, one estimated on a sample before the crisis and one estimated after the crisis. Two graphs below show clear difference of the variable's response.

The contemporaneous restrictions on B0 matrix are on 2. figure above in chapter 2. The graphs in this section were created by STATA program. The number of lags are 2 in both models, the selection was based on Schwarz-Bayesian information criterion (see Appendix B). The results are robust for the ordering of the variables in the estimation of the model, the impulse responses do not change significantly, one example is presented in the Appendix C.

4.1.1. Before the crisis

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17. Figure shows that to a monetary policy shock the consumer price index decreases for 2 periods, but then increases. The confidence intervals contain zero for the whole period and are very wide: we can say that it is ambiguous how the monetary contraction affects consumer price index.

In the key paper, there is no such ambiguous behavior observable in the price response (Ábel-Kóbor, 2010), which can be due to a different time horizon. This thesis uses data from 2000-2008, the research paper mentioned uses observation from 1998-2010. Vonnák (2005) showed that 25 basis point increase in interest rate is followed by 0.15% lower price, which supports the findings from Ábel-Kóbor. Vonnák used the time period 1995-2010 which is even further from the period I used in this thesis.

The monetary contraction resulted in an instant exchange rate increase (17. figure) which represent a depreciation. This result is opposite of what the economic theory says. In the estimation, the coefficient of interest rate in the exchange rate equation is positive, but not significant (Appendix D), so we can set aside the immediate jump in the impulse response. Though on the long run there is an appreciation observable, but the confidence intervals contain zero.

This may be explained by the exchange rate puzzle (Kim-Roubini, 2000), interest rate policy is not very strong in affecting the exchange rate in European countries, not like in the US. This puzzle in the response of the exchange rate is not observable in the Ábel-Kóbor (2010) paper, where in the first 6 months, there is a strong appreciation observable. Furthermore, all the literature I reviewed where exchange rate response is examined showed an appreciation response to a contractionary monetary policy shock. Vonnák (2005) showed that an unanticipated 0.25 basis point increase in monetary policy was resulted in an immediate 1% appreciation of the exchange rate. Jakab et al (2006) also supported the hypothesis, in Hungary

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as it is a small open economy, the response of the exchange rate for a monetary policy shock is a significant one. Rezessy (2005) also show that for a 50 basis point surprise increase in interest rate, exchange rate appreciates 1.2%. The immediate appreciation was smaller but the lag was measured in days.

The positive monetary policy shock resulted in the decrease of the industrial production (17. figure). The results also show that in long run (after a year) the effect switches to positive. This is in line with the economic theory. Although the response's confidence intervalis wide and contains zero.

The Ábel-Kóbor (2010) paper has the same findings on the industrial production response, they also have very wide confidence intervals. Vonnák (2005) showed the unanticipated 0.25 basis point increase in monetary policy was resulted in a 0.3% lower output. Jakab et al(2006) examined the aggregate demand decrease for a monetary policy contraction, and found that in Hungary, net exports decrease the most. Pellényi (2012) also showed that monetary contraction is resulted in output decrease, and heterogeneity was found between sector. Those sectors which were more financed externally there was a higher output response from their side.

Liquidity decreases when there is a positive monetary policy shock in 17. figure. As the real activity decreases, and consumers save more, aggregate demand decreases, less money is needed in the economy.

As in The Ábel-Kóbor (2010) paper, the monetary contraction effect is negative on the liquidity, but both results contain zero in the confidence interval.

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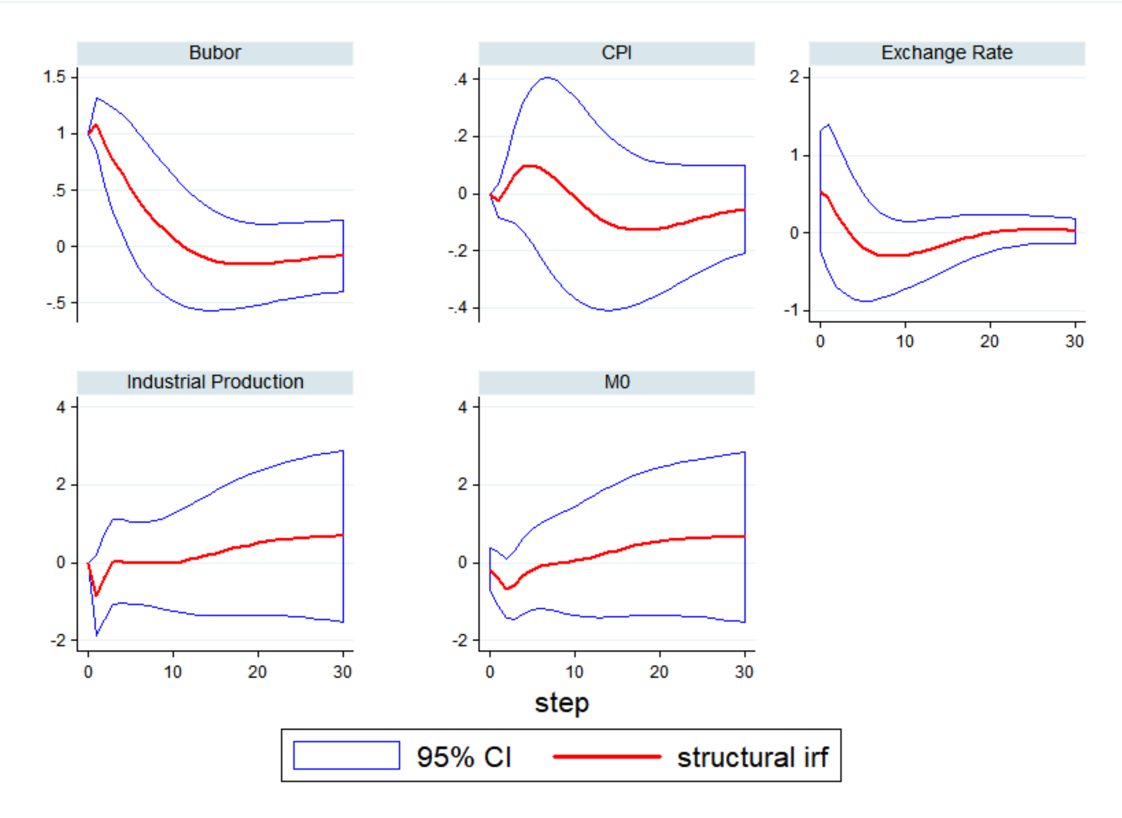

17. Figure: Impulse responses(from contemporaneous restrictions) of 1 percent monetary policy shock before the crisis in Hungary, contemporaneous restriction (2000M1-2008M7). (source: own edit)

Most of the stylized facts are seen on the impulse responses from the contemporaneous restriction model. For a monetary contraction, exchange rate appreciates, industrial production decreases, liquidity decreases. These findings are in line with the literature. But it is important that the confidence interval for these responses are wide, which can make us suspicious about a weak transmission mechanism before the crisis.

Although price index behaves ambiguous, which is contradicting theory, and not seen in the literature findings. For a monetary contraction, there is a little decrease of the CPI for 2 periods but confidence interval is wide and contains zero. Having different time horizon estimates makes harder to compare results with other empirical papers This needs to be broken down into components to see the heterogeneity behind this result.

4.1.2. After The crisis

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The impulse responses on 18. figure show that to a positive monetary policy shock, the CPI does not respond negatively for the whole period. The confidence interval is still wide, though these results are in line with the literature after crisis.

Monetary policy transmission changed, and interest rate policy is not able to handle inflation efficiently. Anchored inflation expectations are more dominant (Blanchard et al., 2014) than interest rate changes, this can be a good explanation.

After the crisis, the exchange rate response is similar (18. figure): for a 1% monetary policy contraction, there is an instant depreciation of the currency, though it is temporary, after 1 period there is an appreciation. In the estimation, the coefficient of interest rate in the exchange rate equation is positive, but not significant (Appendix E), so we can again set aside the immediate jump in the impulse response. Compared to the results before the crisis, the appreciation is quicker, stronger, significant.

The stronger exchange rate respond is indicating a stronger transmission mechanism. This has positive and negative effects as well. A decrease in the interest rate can make exchange rate depreciate which helps the competitiveness of the net exports, but a more volatile exchange rate can easily cause financial instability.

Very clear from the 18. figure that the Industrial production reacts more sensitively to a monetary contraction after a crisis. The fall is sharp and for the whole period, the effect does not turn positive. The confidence interval does not include zero.

Also, 18. figure show liquidity responds the same as before, but confidence interval does not contain zero any more.

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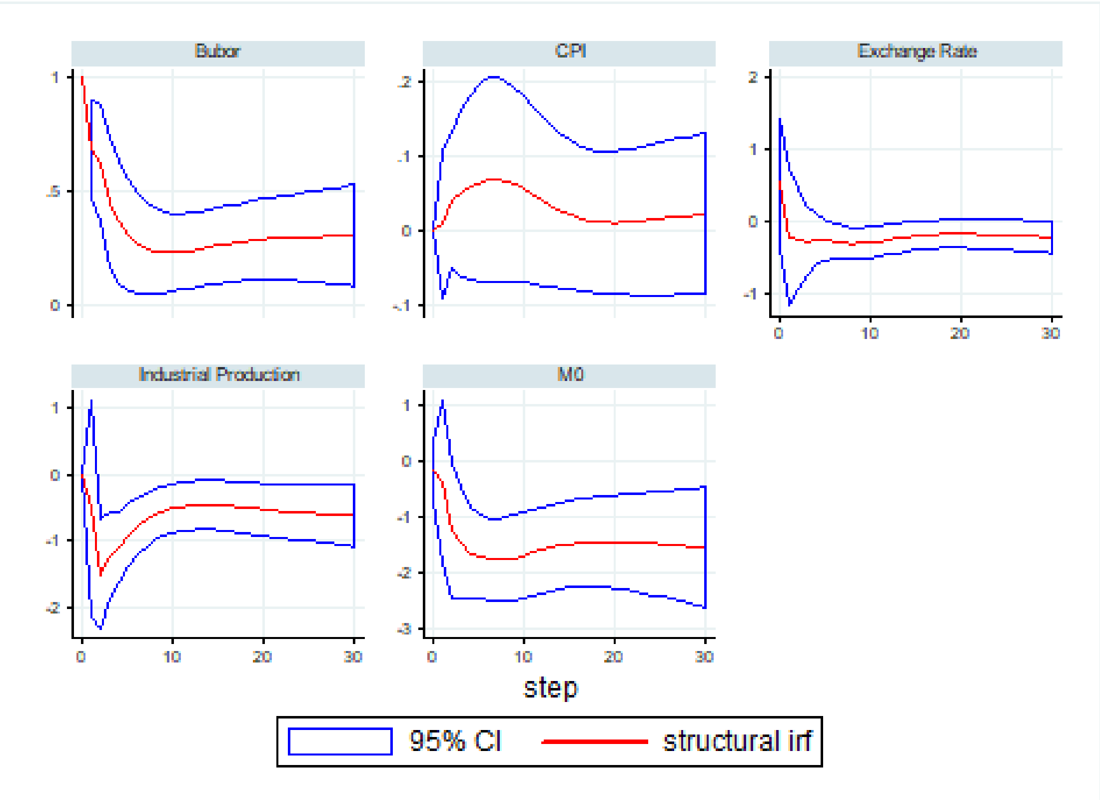

18. Figure: Impulse responses (from contemporaneous restrictions) of 1 percent monetary policy shock before the crisis in Hungary (2000M1-2008M7). (source: own edit)

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2 things at the same time here seems to happen after the crisis. Inflation reaction to a monetary contraction is even more ambiguous than before, showing completely the opposite sign which we expect from theory. Industrial production is decreasing more to a monetary contraction than before the crisis. Why this happens so? These results are supported from Blanchard et al (2014), which paper investigates the Philips curve became less steep. The tradeoff between inflation and growth is changing. If there is a decrease in the interest rate, there is a higher output growth and lower inflationary price to pay. It is true on the other side: if inflation needed to be controlled, there is a bigger growth sacrifice needed

To check if the results are robust to estimation methods, I estimated a model with sign restrictions as well. The output is shown in the next section.

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4.2. Sign Restriction

Again, two models are shown in this section. Invariably, one sample is estimated from the period before the crisis, and one is after. The results of these identification method is not perfectly in line with the results from the contemporaneous restrictions.

The identification is the following: a contractionary monetary policy shock decreases output, liquidity, exchange rate (appreciation) and inflation. The models contain 2 lags, as this specification gave significant amount of impulse responses which satisfy the restrictions. We can see less difference between the two graphs compared to previous section, but magnitude differences can be linked to the previous findings. All the graphs were made by R, with the help of VARSignR package.

4.2.1. Before the Crisis

For a 1 std monetary policy shock, Industrial Production response is different from the model with contemporaneous restrictions before the crisis (19. figure). For the whole period, the response of industrial production remains negative.

Inflation responses (19. figure) in the way as we expect from the theory. For a monetary policy contraction, inflation decreases by 0.1%. The confidence interval does not contain zero. Here we cannot find price puzzle. Still, I think further investigation is needed to capture inflationary/deflationary effects properly.

In the exchange rate response (19. figure), this model specification – a 1 standard deviation positive monetary policy shock is followed by a long run appreciation. The short run magnitude is 0.4%. Although at the very first period, the impulse response confidence interval contains zero, which is similar to what we have seen from previous estimates.

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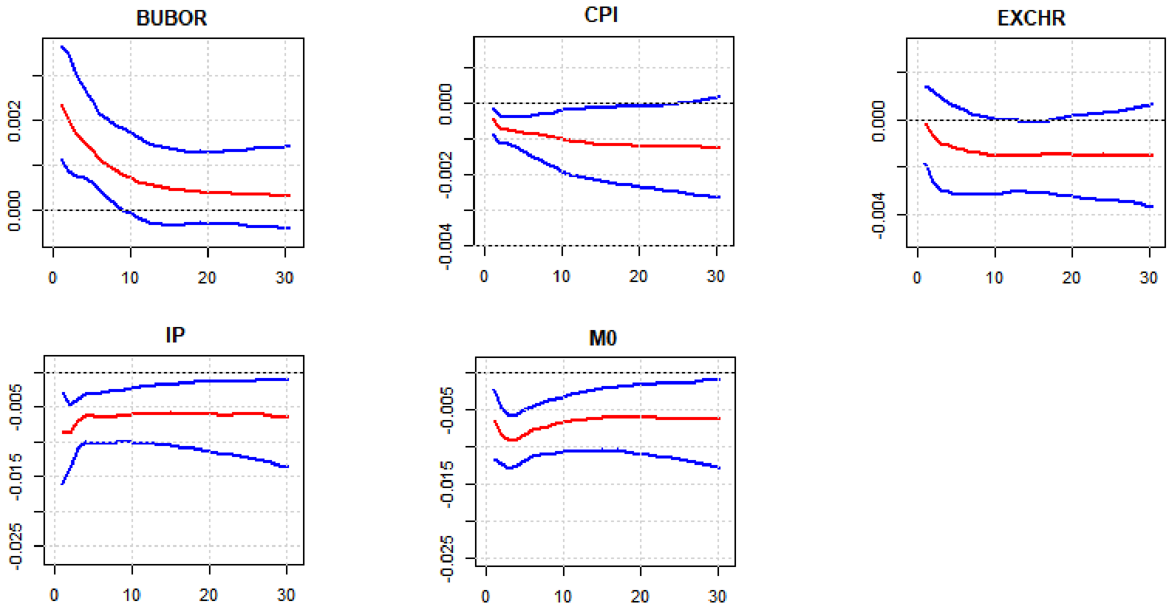
The liquidity decreases (19. figure), as expected, in line with the result from model above and theory. This impulse response function's confidence interval does not contain zero as well.



19. Figure: Impulse responses (from sign restrictions) of 1 standard deviation monetary policy shock before the crisis in Hungary (2008M8-2018M2). (source: own edit)

4.2.3. After the Crisis

There is less difference showed before and after the crisis than with the previous section's model specification.

The Industrial production responses (20. figure) with the same magnitude. The exchange rate responses more sharply, before the crisis, it decreased by 0.2%, after the crisis the response is 0.3%. This is in line with the previous section's findings.

The inflation responses less sharply (20. figure): before the crisis, the effect was 0.1% decrease in inflation, after the crisis it became 0.06%. This is in line with the literature after the crisis,

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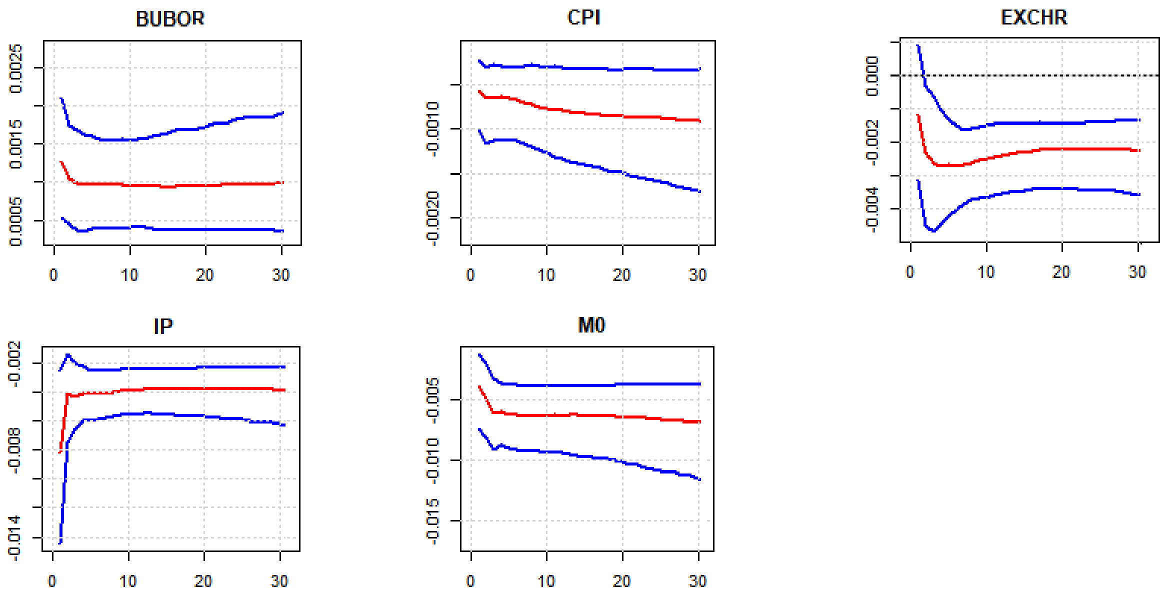
(Blanchard et al, 2014) about the decrease in the slope of the Philips curve, thus again the change in the tradeoff between the output and growth is supported from the results.

The liquidity responds (20. figure) quite the same as before the crisis.



20. Figure: Impulse responses (from sign restriction) of 1 percent monetary policy shock before the crisis in Hungary (2000M1-2018M7). (source: own edit)

4.3. Summary

Both specification show that the effect of a monetary contraction has changed before and after the crisis. The contemporaneous restrictions show that the industrial production response is sharper, while the sign restriction show that the inflation response is smaller after the crisis. Both results lead to a conclusion that the tradeoff between the growth and inflation has changed. Also, we can see higher responses to a monetary policy shocks in general, so we can conclude the overall transmission mechanism improved after the crisis.

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5. Model Limitations, Further Opportunities

As every model, SVAR has its own limitations. The main question in evaluating the model results is does the identification of the shocks represent the reality or not. They may be based on economic theory, but might not reflect the ongoings of the true underlying system. (Lütkepohl – Krätzig, 2004)

Furthermore, the model maker can make the mistake of not choosing the right restrictions, the right variables, so the appropriate assumptions and the right estimation method.

In this paper, the contemporaneous restriction models are overidentified model, so restrictions could be rethought. I used the same B0 matrix as Ábel-Kóbor (2010) just to have comparable results. This specific model and identification is widely used in the literature as well, meaning that having a just identified model or economic theory led restrictions, the latter can be more important.

The sign restriction estimation method could be further sophisticated: the effect of the monetary policy could be differentiated by time period, imposing some 0 restriction in the first period, taking into consideration there is time lag in the transmission mechanism, and not all the data is available at the decision making.

Despite the limitations and space for further sophistications, the obtained impulse responses are in line with the main findings in the literature about the transmission mechanism after the crisis. To conclude why and exactly how these changes evolved is far beyond this thesis. To explore heterogeneity within transmission channels, firm-, bank- and household level analysis is needed, like Horváth et al (2006) did with bank balance sheet data, Kátay-Wolf(2004) did with firm level data, or as Horváth et al (2004) did with bank product level data.

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6. Policy analysis

In a policy point of view, it is essential to know how the tools used in decision making exactly work. If we consider monetary policy, the policy maker cannot make proper decision without knowing the exact effect of changing the interest rate.

The hypothesis was that after the crisis, the monetary transmission mechanism changed in Hungary. This is verified from two different estimation methods of an SVAR model. The tradeoff between output and inflation become smaller, which is in line with empirical finding from Blanchard et al. (2014) that the Philips curve got less steep.

The results implied that after the crisis in the recession, there was a benefit of the change in monetary transmission mechanism. The decrease of the interest rate was followed by a higher growth than before the crisis, and the inflation generation was less sharp.

On the other hand, if there was an inflation shock, there was bigger price to pay after the crisis: the interest rate policy is less effective in controlling the inflation, though it may decrease the growth further than before 2008.

It is also observable that after the crisis, the exchange rate also responds with a greater extent to a monetary policy contraction. If policy decisions make exchange rate more volatile, that can generate financial instability. It was a bigger problem before the conversion of foreign currency-denominated household mortgage loans, but the exchange rate volatility risk still should be considered during the policy making. Vonnák (2010) said if exchange rate channel dominates interest rate channel, it is worth smooth the exchange rate.

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7. Conclusion

This thesis was aimed at proving that there was a change in the monetary transmission in Hungary after the crisis. It is essential to know what is the effect of the monetary policy to the economy, so the policy makers can use the tools appropriately. From the decade before the crisis, more comprehensive research material is at hand, than since 2008. Thus it worth to investigate possible changes of the transmission mechanism and draw relevant policy conclusions.

Before the crisis, transmission mechanism was weaker. Exchange rate channel dominated the interest rate channel, as Hungary is a small and open economy. Economic policy actions, like conversion of foreign currency-denominated household mortgage loans helped to improve the transmission mechanism.

I used SVAR approach to create impulse responses for a monetary policy shock. In addition to the existing literature, I use same models in separate samples before (2000M1-2008M7) and after (2008M8-2018M2) the crisis. I used contemporaneous restrictions on the covariance matrix and sign restriction on impulse responses identification approaches as well, to see if the results are robust to identification techniques. Both estimation show that the effects of a monetary contraction are different in the two samples, which lead to the conclusion that there was a change in the transmission mechanism.

The results are in line with the theory of decreased slope of the Philips curve (Blanchard, 2014): the output responds more, the inflation responds less to a monetary tightening. If interest rate policy aims to decrease inflation, there is bigger “growth” price to pay than before the crisis. Output, liquidity and exchange rate responded stronger to a policy intervention after the crisis, which means transmission channels of monetary policy improved.

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Though my implementation of SVAR is not possible to reveal heterogeneity of the economy, we can conclude there is an overall change in the transmission mechanism after the crisis. Further exploration of the change in transmission channels needed to recommend sophisticated polices.

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References

Ábel, - Kóbor, (2010): Monetáris politikai restrikció egy SVAR modellben. *Közgazdasági Szemle,* 2010., pp. 412-430.

Federal Reserve Economic Data – 3 month Euro Libor interest rate https://fred.stlouisfed.org/series/EUR3MTD156N, Downloaded: 2018.04.16.

Horváth, Csilla -Krekó, Judit – Naszódi, Anna (2004): Kamatgyűrűzés Magyarországon. *MNB füzetek* 2004/8.

Horváth, Csilla -Krekó, Judit – Naszódi, Anna (2006): Is there a bank lending channel in Hungary? Evidence from bank panel data. *MNB Working Papers* 2006/7.

Jakab, Zoltán - Várpalotai, Viktor – Vonnák, Balázs (2006): How does monetary policy affect aggregate demand? A multimodel approach for Hungary. *MNB Working papers. 2006/4*

Karádi, Péter (2005): Exchange Rate Smoothing in Hungary. *MNB Working Papers, 2005/6*.

Kátay, - Wolf, (2004): Investment Behavior, user cost and monetary policy transmission. *MNB Working Paper 2004/12*

KSH – Ipari termelés összes nettó árbevétel, Infláció http://statinfo.ksh.hu, Downloaded: 2018.04.15.

Lütkepohl, H. – Krätzig, M. (2004): Applied time series econometrics. *Cambridge University Press.*

Mishkin, F.S. (1996): The channels of monetary transmission: Lessons for monetary policy. *NBER Working papers,* 5464.

CEU eTD Collection

MNB – A jegybanki alapkamat alakulása. http://www.mnb.hu/Jegybanki_alapkamat_alakulasa Dowloaded 2018.04.15.

MNB – Az inflációs célkövetéses rendszer. https://www.mnb.hu/archivum/Monetaris_politika/monetaris-politika/mnbhu_infcelkituzes_hu Downloaded: 2018.04.20.

MNB – BUBOR https://www.mnb.hu/monetaris-politika/penzpiaci-informaciok/referenciamutato-jegyzesi-bizottsag/bubor, Dowloaded: 2018.04.15.

MNB – Exchange rate https://www.mnb.hu/arfolyam-lekerdezes, Dowloaded: 2018.04.16.

MNB – M0 monetary base https://www.mnb.hu/statisztika/statisztikai-adatok-informaciok/adatok-idosorok/x-monetaris-es-egyeb-merlegstatisztikak, Downloaded 2018.04.15.

Oil Price https://www.indexmundi.com/commodities/?commodity=crude-oil&months=60, Downloaded: 2018.04.15.

Pellényi, Gábor (2012): The Sectoral Effects of Monetary Policy in Hungary: A Structural Factor Analysis. *MNB Working Papers* 2012/1.

Rezessy, András (2005): Estimating the immediate impact of monetary policy shocks on the exchange rate and other asset prices in Hungary. MNB, https://www.mnb.hu/letoltes/rezessy050427.pdf Downloaded: 2010.04.20.

Vonnák, Balázs (2005): Estimating the effect of Hungarian Monetary Policy within SVAR framework, *MNB Working Papers*. 2005/1

CEU eTD Collection

Vonnák, Balázs (2006): A magyarországi monetáris transzmissziós mechanizmus fő jellemzői. *Közgazdasági szemle*, 2006 december. pp: 1155-1177

Vonnák, Balázs (2010): Risk premium shocks, monetary policy and exchange rate pass-through in the Czech Republic, Hungary and Poland. *MNB Working Papers*, 2010/1.

World Bank: Oil Price**,** http://www.worldbank.org/en/research/commodity-markets Downloaded: 2018.04.15.

Uhlig, Harald (2005): What are the effects of monetary policy on output?Results from an agnostic identification procedure. *Journal of Monetary Economics.* 2005. 52. pp 381-419.

Kim-Roubini, (2000) - Exchange rate anomalies in the industrial countries: A solution with a structural VAR approach. *Journal of Monetary Economics*. 2000. June. pp. 561-586

Blanchard, Olivier, et al (2014): INFLATION AND ACTIVITY TWO EXPLORATIONS, AND THEIR MONETARY POLICY IMPLICATIONS. *ECB Forum on Central Banking*. May 2014.

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Appendix A - Literature Matrix

	Horváth et al, 2004	Kátay-Wolf, 2004	Horvath et al, 2006	Karadi, 2005	Rezessy, 2005	Vonnák, 2005	Jakab et al, 2006	Vonnák, 2010	Ábel-Kóbor, 2010	Pellényi, 2012
credit channel	x	x	x							x
exchange rate channel				x	x	x	x	x	x	x
interest rate channel	x	x				x	x		x	x
assetprice channel					x					
methodology	ECM, TAR	Neoclassical model of investment, Autoregressive distributed lag equation	ARDL	structural empirical model, Kalman filter	method of identification through heteroscedasticity	SVAR	Quarterly Projection Model, 5gap, SVAR	SVAR, bayesian	SVAR - Structural vector autoregression	structural factor model
data	aggregated and bank level data	large panel data of Hungarian firms	Bank level balance sheet data	weekly: Interest rate, exchange rate	daily: exchr, spot yields, forward yields, policy+nonpolicy days	quarterly: real GDP, CPI, exchr, 1+3month treasury bill yield	Quarterly key macroeconomic figures	Industrial production, CPI, 3 month tbill rate, nominal effective exchr, monthly	monthly data: bubor, M0, CPI, Industrial production, oilprice, 3month eur-libor	quarterly data: 198 macroeconomic and sectoral data
timeframe	2001-2004	1993-2002	1995Q1-2004Q3	2001-2004	2001-2004	92-2003, shorter: 95-	1997-2006	1995-2010	1998-2009	2000Q2-2010Q4

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Appendix B – Lag selection of contemporaneous restriction models

lags	Before 2008M8 Schwarz-Bayesian Information criterion	From 2008M8 Schwarz-Bayesian Information criterion
1/2	**-44.558**	**-47.119**
1/3	-42.987	-46.5
1/4	-41.697	-45.613
1/5	-40.489	-44.464
1/6	-38.936	-43.433
1/7	-37.779	-42.298
1/8	-36.859	-41.406

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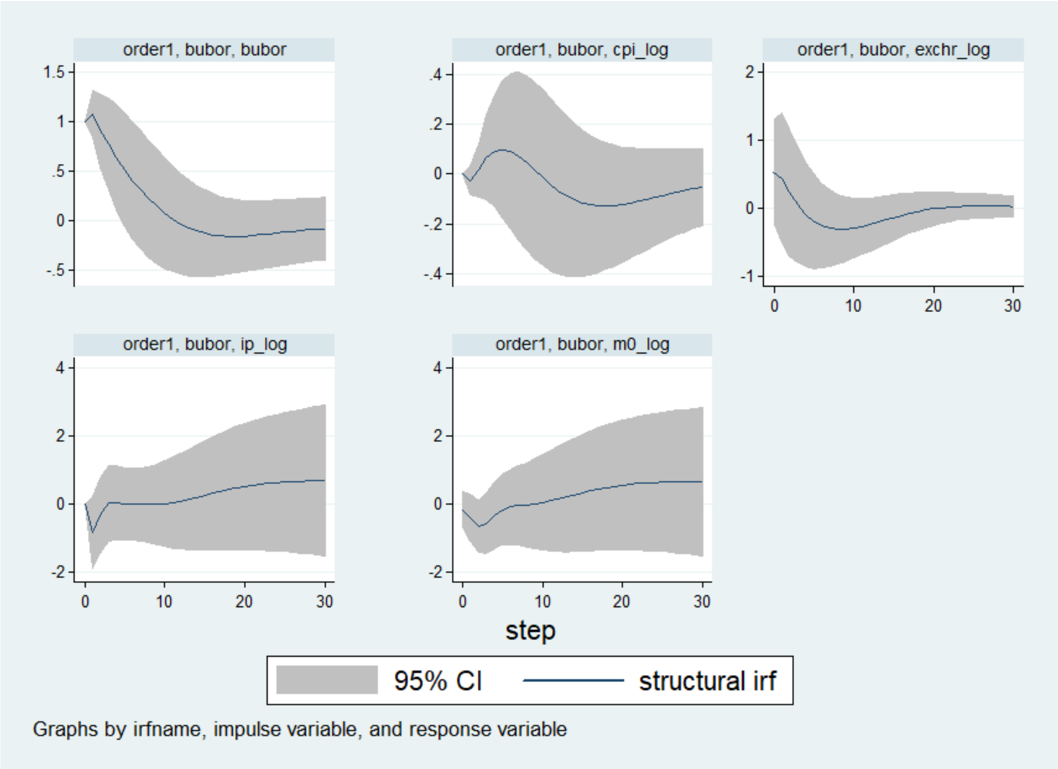
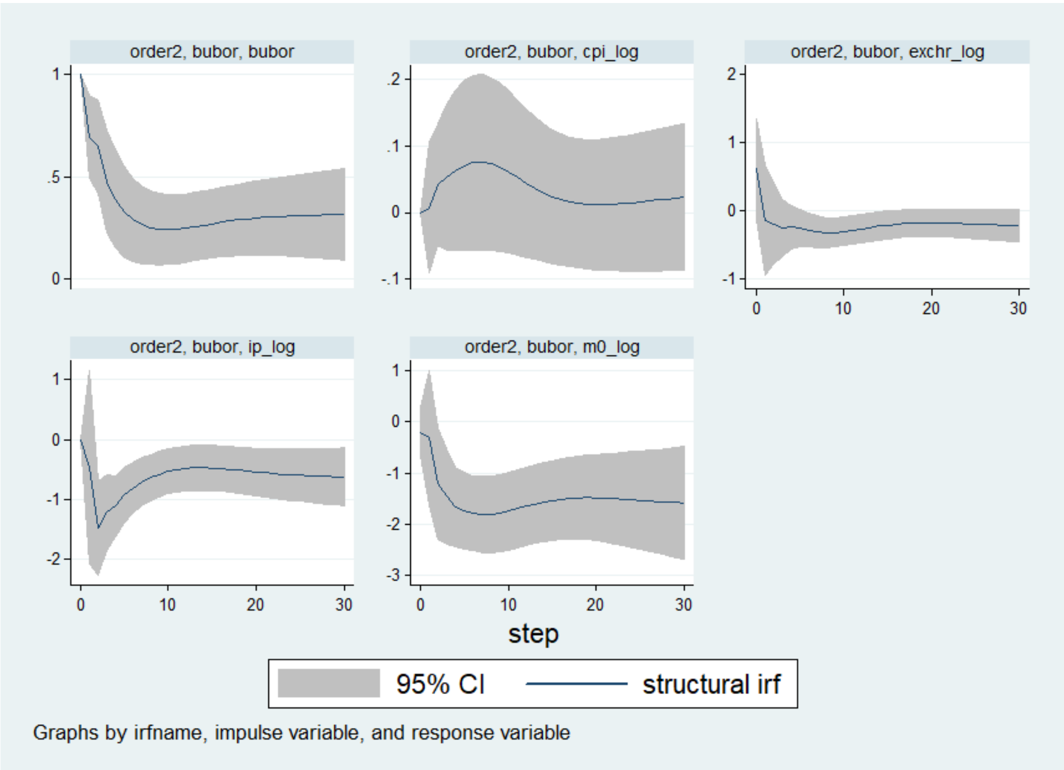
Appendix C – Example of impulse responses for different ordering

Before the crisis



After the crisis



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Appendix D – Parameters estimates from contemp. restrictions

Before the crisis - * represents significance at 1% level

	bubor	m0_log	cpi_log	ip_log	op_log	el	exchr_log
bubor	1	-5.1656987*	0	0	1.1043409*	0	1.2234267*
m0_log	-.17565653	1	1.2665227*	.48518321*	0	0	0
cpi_log	0	0	1	.89089754*	1.0783353*	0	0
ip_log	0	0	0	1	1.0701383*	0	0
op_log	0	0	0	0	1	0	0
el	0	0	0	0	1.1089126*	1	0
exchr_log	.53737229	-2.8039493*	1.3122843*	-.0992167	1.107894*	1.3411864*	1

After the crisis - * represents significance at 1% level

	bubor	m0_log	cpi_log	ip_log	op_log	el	exchr_log
bubor	1	-5.1656089*	0	0	.96054227*	0	1.1537143*
m0_log	-.17838527	1	1.2609186*	.52671281*	0	0	0
cpi_log	0	0	1	.91284645*	1.0283261*	0	0
ip_log	0	0	0	1	1.0317785*	0	0
op_log	0	0	0	0	1	0	0
el	0	0	0	0	1.0241326*	1	0
exchr_log	.53529851	-2.7753647*	1.2489946*	-.06455185	1.0208216*	1.3272103*	1

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