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Identification of credit supply shocks in a Bayesian SVAR model of the Hungarian Economy *

(Hitelkínálati sokkok identifikálása a magyar gazdaság egy Bayes-i SVAR modelljében)

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Abstract

Using Hungarian macroeconomic and financial data, we estimate a Bayesian structural VAR model suitable for macroprudential simulations. We identify standard macroeconomic and credit supply shocks by sign and zero restrictions. In contrast to the previous literature, different types of credit shocks are distinguished in our paper: a risk assessment and a policy shock.

Our main findings are the following. First, we demonstrate that both credit supply and macroeconomic shocks explain the variance of endogenous variables at roughly similar order of magnitude. Second, it is shown that credit supply shocks do not have a dominant role in the decline of the Hungarian economy over the crisis period that started in 2008, although their contribution was non-negligible. Third, the importance of unidentified shocks increased in the crisis period.

JEL: C11, C32, E32, E44.
Keywords: Bayesian SVAR, zero and sign restrictions, credit supply shocks.

Összefoglalás

Makroprudenciális szimulációs célokra a magyar gazdaság Bayes-i SVAR modelljét becsültük makroökonómiai és pénzügyi adatok felhasználásával. A modell segítségével az előjel restrikciók módszerét követve makroökonómia és hitelkínálati sokkokat identifikáltunk. Az eddigi irodalomtól eltérően különböző típusú hitelkínálati sokkokat azonosítottunk: a kockázatérzékelés sokkját és egy gazdaságpolitikai sokkot.

A főbb eredményeink a következők. Először, demonstráltuk, hogy a hitelkínálati és a makroökonómiai sokkok nagyjából ugyanolyan mértékben magyarázzák az endogén változók szórását. Másodszor, megmutattuk, hogy a hitelkínálati sokkok szerepe nem volt domináns a magyar gazdaság 2008-ban kezdődő visszaesésében. Harmadszor, a válságperidódusban nőtt az általunk nem identifikált sokkok szerepe.

1 Introduction

Dynamic macroeconomic models have become the workhorse of empirical macroeconomics in the past two decades. However, the majority of these models neglected financial frictions and the role of financial intermediation. Both the structural VAR and DSGE literatures focused on the transmission of monetary policy and the effects of productivity and other similar macroeconomic shocks. See, e.g., Christiano et al. (1999) and Uhlig (2005) as representatives of the SVAR approach and the seminal DSGE papers of Christiano et al. (2005) and Smets and Wouters (2003).

Nevertheless, the recent financial crisis has made it clear that this strategy cannot be continued anymore: macroeconomic models should consider financial issues. The latest macroeconomic research has reflected this requirement: e.g., Halvorsen and Jacobsen (2009), Meeks (2009), Busch et al. (2010) and Helbling et al. (2010) developed SVAR models to study the impact of credit supply shocks on the macroeconomy, furthermore, Christiano et al. (2008), Gilchrist et al. (2009) and Gelain et al. (2011) estimated DSGE models to analyze the impact of financial imperfections.

The changing focus of macroeconomic research has met an increasing demand for new analytical tools for supporting monetary policy in crisis periods and clarifying the so far neglected issues of macroprudential regulation. For example, as discussed in Borio (2006), one important distinctive feature of the macroprudential perspective is that the ultimate objective of macroprudential regulation is to avoid output (GDP) cost in contrast with the microprudential approach focusing on the solvency of individual financial institutions. As a consequence, responsible macroprudential policy needs appropriate macroeconomic models.

This paper applies the above new developments of macroeconomic research to the Hungarian economy. Our intention is to formulate and estimate a model which describes jointly the dynamics of the Hungarian macroeconomy and the financial intermediary sector. Since recent financial DSGE models have not fit the data adequately yet, as Gelain et al. (2010) demonstrated, we prefer to apply the VAR approach.

The objectives of this paper are the following. First, we would like to clarify the role of the financial intermediary sector in Hungarian business cycle fluctuations. Second, we investigate and describe the effects of credit supply shocks, that is, shocks which are generated by unexpected changes in some fundamental characteristics of the financial intermediary sector. Third, we want to develop a tool for macroprudential simulations which can capture the impact of financial intermediaries on the macroeconomy.

We estimate a Bayesian VAR model for the Hungarian economy and apply the sign restriction approach of Uhlig (2005) to identify macroeconomic and credit supply shocks as in related papers of Halvorsen and Jacobsen (2009), Meeks (2009), Busch et al. (2010) and Helbling et al. (2010).

As one of our main objectives is to develop a tool for macroprudential simulations, we disentangle different types of credit supply shocks in our model since they might call for different policy responses. This is in contrast with existing SVAR literature which treats loan supply shock as a homogeneous phenomenon. However, in principle, credit supply shocks can be generated by unexpected changes of substantially different characteristics of the financial intermediary sector, such as technology, preferences or the regulatory environment. Our paper identifies a shock induced by changing risk assessment of financial intermediaries and a shock related to changing policy or regulatory environment of the financial sector.

Our main results are the following. First, we demonstrate that both credit supply shocks and macroeconomic (the monetary policy and the risk premium) shocks explain the variance of endogenous variables at roughly similar order of magnitude over the entire sample period. This finding justifies the importance of incorporating the financial intermediary sector into macroeconomic models. Second, it is shown that credit supply shocks did not have a dominant role in the decline of the Hungarian economy over the crisis period that started in 2008, although their contribution was non-negligible. Third, the importance of unidentified shocks increased in the crisis period: the identified credit supply and macroeconomic shocks explained the movements of some variables after the end of 2008 much less than previously.

The paper is structured as follows. *Section 2* presents our methodology, describes the data, the model and our strategy for identifying structural shocks. In *Section 3* we present estimation results. Finally, *Section 4* concludes.

2 Data and the model

2.1 DATA

Our quarterly data set ranges over 1995Q1 to 2009Q4. The endogenous variables are represented by four standard macroeconomic time series augmented with three indicators of activity of the financial intermediary sector: (1) Hungarian real GDP; (2) Hungarian CPI, note that the level of the price index is used, not the inflation rate derived from it; (3) BUBOR, that is, the 3-month Hungarian money market rate (4) nominal effective exchange rate; (5) composite of Hungarian forint and foreign currency bank loans to the corporate sector; (6) credit spread calculated as the weighted average of the difference between the average interest rate of forint denominated corporate loans and the 3-month BUBOR and the difference between the average interest foreign currency denominated loans and the 3-month EURIBOR; (7) the corporate default rate. To estimate the model we also utilize two exogenous variables, namely, the 3-month EURIBOR and the GDP based indicator of foreign demand calculated by MNB (the central Bank of Hungary).

Although the majority of the SVAR literature focuses on corporate loans, in our case this restriction limits the applicability of our analysis since widespread foreign currency loans to households resulted in serious financial stability problems in Hungary. However, due to data problems related to household loans[1] we decided to limit our attention to corporate loan markets.

2.2 METHODOLOGY OF BAYESIAN SVAR MODELS WITH SIGN AND ZERO RESTRICTIONS

We use the logarithmic transformation of the levels of the time series expressing quantities (GDP, aggregate credit, foreign demand) and prices (CPI, exchange rate) and the levels expressed in percentage points of the spread, interest rate variables (BUBOR, credit spread, EURIBOR) and the default rate. The above time series are augmented with a deterministic trend[2] and a broken trend to capture structural breaks in the deterministic part of the data generating processes.[3]

We estimate a Bayesian VAR model with diffuse priors following the methodology presented in Kadiyala and Karlsson (1997). The model includes 2 lags of the endogenous variables in each equation based on the Schwarz information criterion.

Structural shocks are identified by the sign restrictions approach of Uhlig (2005) complemented by short-run zero restrictions explained in Reppa (2009).

Since there are seven endogenous variables in our model in principle it is possible to identify seven structural shocks. However, it is a common practice in the SVAR literature that less shocks are identified than the number of endogenous variables, see, e.g., Uhlig (2005) and Busch et al. (2010). This paper identifies four structural shocks: two credit supply shocks, a monetary policy shock and the shock of the required risk premium of foreign investors.

[1] Hungarian household loans display large heterogeneity both in cross-sectional and time-series dimension. This would somewhat invalidate the relevance of our aggregate approach, furthermore, the presence of several structural breaks in the past 15 years diminishes the reliability of time-series techniques.

[2] As Uhlig (1991) argues, adding a deterministic trend to the model is a way to encompass both trend stationarity and difference stationarity as special cases.

[3] Between 1995 and 2001 the Hungarian monetary policy was conducted to support a narrow–band crawling peg exchange rate regime. Since 2001 MNB has been following the policy of inflation targeting.

Identifying credit supply shocks is necessary for deeper understanding of the interaction between financial intermediaries and the macroeconomy. Since we wanted the paper to be comparable with the previous SVAR literature on small open economies, see, e.g., Vonnák (2010), two additional macroeconomic shocks are identified as well: the standard monetary policy shock and the risk premium shock, which is a key determinant of business cycles in small open economies.

Identification of credit supply shocks

Credit supply shocks are induced by unexpected changes in some fundamental characteristics of the financial intermediary sector, such as technology, preferences or the regulatory environment. Hence, in principle, one can define different types of credit supply shocks: all of them influence loan supply, however, their impacts are not necessarily identical.

It is a virtue of structural models derived from microeconomic principles, like DSGE models, that they can clearly describe the differences and similarities of the impacts of the above shocks. However, it is a clear disadvantage of this class of models that they often impose too strong theoretical restrictions which are not supported and verified by the data.

On the other hand, VAR models are designed to describe the data accurately, nevertheless, the exact identification of structural shocks is more difficult in them than in DSGE models.[4] Despite these difficulties we try to disentangle different types of credit supply shocks in our VAR model since shocks induced by different fundamental factors may call for different policy responses.

We distinguish two types of credit supply shocks: a shock which can capture changes in the behavior of the management/staff of financial intermediaries and a shock related to changing policy or regulatory environment of the financial sector.

Let us consider the identification of the first type of credit supply shock. Usually, if macroeconomic risk and the probability of future defaults increases then financial intermediaries are reluctant to extend credit. Hence, it is difficult to imagine a model where banks systematically expand their credit supply if some signals of increasing risk are detected. This observation can be used to identify credit supply shocks. If the joint occurrence of increasing risk and credit expansion cannot be explained by systematic behavior of financial intermediaries then it must be induced by some credit supply shock.

In our particular case we use the empirical default rate as a measure of overall risk and we identify positive credit supply shocks by assuming that they simultaneously lead to an increase of the default rate and the quantity of credit. The observed default rate can be criticized as a backward-looking measure of risk, however, proper forward looking measures of expected future defaults in the Hungarian market, such as corporate bond spreads, are not available. Nevertheless, in our opinion, expectations of market participants for future defaults are largely, although not fully, influenced by past events.

Table 1 displays the exact sign and zero restrictions identifying this shock. The table reveals that beyond the sign restrictions discussed above we impose zero restrictions on the money market interest rate (BUBOR) at date 0. The latter is applied in order to separate this shock clearly from the international risk premium shock, discussed in the next subsection. We want to ensure that the increase in lending is induced by changing behavior of banks and not by a change of liability costs. Note that we do not impose any restrictions on banks' credit spread. The presence of decreasing spreads is not a necessary condition of a positive credit supply shock. For example, in an environment with credit rationing it is possible to expand credit without reducing credit rates.

Of course, the above identification scheme is insufficient to detect exactly which factor causes the unexpected change of banks' behavior. However, it is a plausible interpretation that in most cases the above credit supply shock is induced by the changing risk assessment of banks.[5] The recent financial crisis has also revealed the importance of financial intermediaries' risk assessments, as it demonstrated how radical changes in financial agents' risk perception could result in a drastic collapse

[4] In theoretical DSGE models there is not any limit to the number of exogenous shocks. However, there are certain constraints in their empirical identification. First, the number of the empirical time series limits the number of reliably identifiable shocks. Second, theoretically different shocks can have observationally equivalent outcomes.

[5] One may argue that if agents form their expectations rationally then forward-looking risk assessment is based on endogenous responses to the economic environment, hence it cannot be considered as a source of credit supply shocks. However, we think that increasing complexity of the financial system and

of credit supply. Furthermore, our backward-looking measure of risk (the observed default rate) is completely in line with this interpretation: increasing default rates are usually accompanied by an upward revision of expected default probability. However, if banks' risk assessment changes positively for some reasons then they expand their credit supply despite the elevated risk observed in the past. All in all, in what follows we refer to this shock as the risk assessment shock, although we are fully aware of the limitations of this interpretation.

One disadvantage of the above identification scheme is that it identifies shocks too conservatively: it provides sufficient but not necessary conditions to capture changes in banks' risk perception. If banks' risk assessment improve unexpectedly in an environment of decreasing default rates, which is a possible event, then our method does not identify it as a risk assessment shock. That is, our approach misses some realizations of the shock. However, it is highly probable that it never identifies other events falsely as credit supply shocks.

As mentioned above, we also identify another type of credit supply shock related to changes in policy. We capture this shock by its impact on the credit spread. E.g., if policy makers decrease (increase) a certain tax levied on financial intermediaries then it is highly probable that the credit spread will decrease (increase) to some extent. Of course, in general it is hard to specify the exact numerical magnitude of such a change since it depends on the slope of credit demand curve and the degree of competition.

The sign and zero restrictions identifying the second type of credit shocks are displayed in Table 1. A positive shock is identified by decreasing credit spread and expanding credit and the real GDP. Recall that we do not impose any restriction on the spread in the case of the risk assessment shock. Furthermore, in order to distinguish unambiguously the policy shock from the risk assessment shock we impose a zero restriction on the default rate at the initial date.

It is important to note that changing tax rates are not the only possible interpretation of the above identification scheme. Varying degree of competition and mark-ups also result in altering spreads. Furthermore, binding capital or liquidity constraints of banks could have an impact on spread since the necessary costly adjustment of capital and increasing tax burdens have similar effects on banks' behavior. Finally, changing regulatory environment can also cause spread adjustment as regulatory requirements influence capital and liquidity constraints of financial intermediaries.

We would like to review and compare the identification methods of credit supply shocks in the related literature. According to our knowledge, it is a common feature of SVAR models that they identify a single credit shock[6], furthermore, it is difficult to find a precise characterization of the economic rationale of these shocks in the literature. For example, Busch et al. (2010) exemplify credit supply shocks simply by the applied sign restriction (positive impact on loans and GDP and negative on loan rates), although, in their *Introduction* they assign the shock to anticipated future developments of credit risk, that is, to risk assessment. Meeks (2009) follows an indirect logic: if increasing corporate bond spreads indicate higher likelihood of future defaults then the underlying shock must be macroeconomic, however, if they indicate lower likelihood of defaults then the observed phenomenon is induced by a credit supply shock. Helbling et al. (2010) do not specify any economic factors behind their credit supply shock: they adopt Meek's method and identify a positive shock by increasing quantity of loans, default rates and declining credit spreads and productivity. It is important to declare that our identification method of the risk assessment shock is inspired by Meek's approach. The identification method used in Halvorsen and Jacobsen (2009) is based on the changes in the ratio of bank and non– bank credits. Since in Hungary loans are distributed nearly exclusively by banks it was impossible to apply this approach in our case.

Identification of monetary policy and credit risk premium shocks

A large part of the SVAR literature is devoted to studying the effects of monetary policy shocks on aggregate variables, see, e.g., Christiano et al. (1999) and Uhlig (2005). Our identification of this shock follows the consensus view. That is, a positive monetary policy shock implies a decrease in the money market interest rate, depreciation of the exchange rate

constraints of human mental capacity imply that bounded rationality is the proper description of the behavior of financial agents, even if a substantial part of business decisions can be explained by rational elements.

[6] One exception is the paper of Del Giovane et al. (2010), however they do not apply a SVAR framework for deriving their results.

Table 1
Sign and zero restrictions for identifying credit supply shocks

	risk assessment shock			credit spread shock		
date	$t = 0$	$t = 1$	$t = 2$	$t = 0$	$t = 1$	$t = 2$
Real GDP		+	+		+	+
CPI						
BUBOR	0			0		
NEER						
Loan	+	+	+	+	+	+
Credit Spread				-	-	-
Default rate	+			0		

Table 2
Sign and zero restrictions for identifying macroeconomic shocks

	monetary policy shock			risk premium shock		
date	$t = 0$	$t = 1$	$t = 2$	$t = 0$	$t = 1$	$t = 2$
Real GDP		+				
CPI		+			-	
BUBOR	-	-	-	-	-	
NEER	+			-	-	
Loan						
Credit Spread	0			0		
Default rate						

Note: A '+' symbol indicates positive, a '-' symbol negative restriction on the impulse response functions at a certain date. A '0' symbol indicates a zero restriction imposed on the contemporaneous response. An empty entry represents the lack of restrictions at that date.

and an increase in the level of output and the CPI, see Table 2. Since the reaction of loans to monetary policy is still an open issue we do not impose any restrictions on the quantity of loans.

To identify the shock of the required risk premium of foreign investors we follow the approach presented in Vonnák (2010). His approach is based on the uncovered interest rate parity augmented with a risk premium term. Combining this condition with rational expectations implies that the risk premium has a contemporaneous effect on both the short term interest rate and the exchange rate. Hence, an unexpected decrease in the risk premium can be identified by a decrease of the short term interest rate and an appreciation of the exchange rate, as indicated in Table 2. Although the risk premium shock is a phenomenon of the financial markets, we classify it as a macroeconomic shock due to its large impact on the business cycles of small open economies.

3 Results

3.1 IMPULSE RESPONSE FUNCTIONS

Risk assessment shock

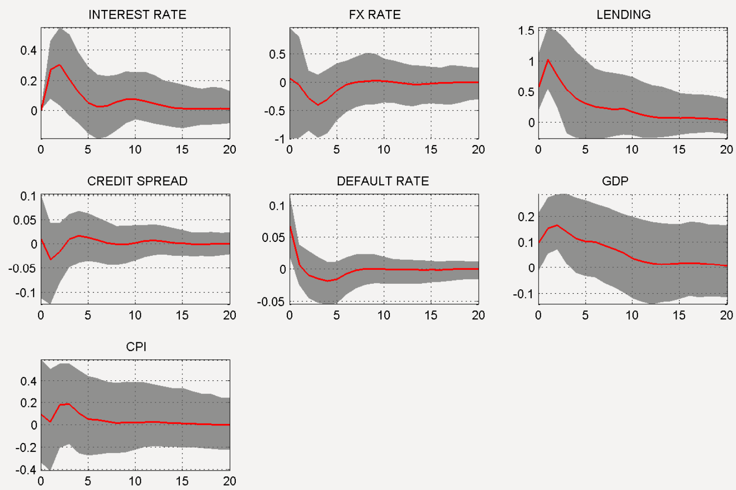
Figure 1 plots the median impulse response to a positive risk assessment shock with the 16% and 84% quantiles. As the imposed restrictions requires, see Table 1, the default rate and the quantity of loans increase on impact, moreover, the latter displays a very significant and persistent reaction.

The above credit expansion is accompanied by a significant increase in the real GDP and the median response is also highly persistent. On the other hand, it has a quite neutral effect on the median response of the CPI.

The initial response of the BUBOR (short term interest rate) was restricted to zero, however, later it increases strongly. Our explanation for this phenomenon is that the expanding loan supply is accompanied by an increasing demand for loanable funds and rising prices of these funds which are represented by the BUBOR variable in our data set.

The impulse responses of the nominal exchange rate and the credit spread have relatively characterless shape. The latter is interesting because it demonstrates that a credit expansion generated by the risk assessment shock does not coincide with a drastic decrease of the price of credit: banks might make their loans appealing in other ways or credit rationing might be present on this market.

Figure 1
Impulse responses to a one standard deviation risk assessment shock



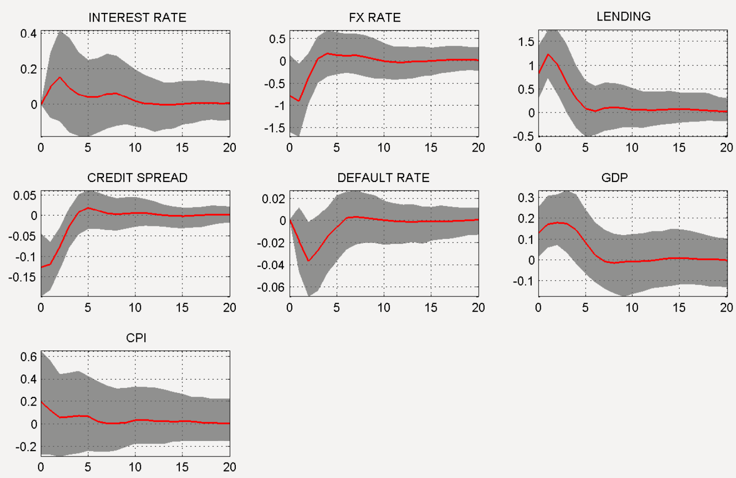
Credit spread shock

Figure 2 displays impulse responses belonging to the credit spread shock. The shock has a positive impact on loans, the real GDP and a negative impact on the credit spread, consistent with the restrictions presented in Table 1.

While the impact of this shock on the BUBOR is weaker than in the previous case, its impact on the GDP is comparable to that of the risk assessment shock, although it is less persistent. The credit spread shock results in stronger and quicker appreciation of the nominal exchange rate than the risk assessment shock. As in the previous case, the shock does not have a significant impact on the CPI.

The most characteristic difference between the two types of credit supply shocks is reflected in the behavior of the credit spread. This might suggest another way of interpreting these shocks: while the first shock captures those credit expansions which are not accompanied by considerable movements of the spread and might be described by rationing, the second one depicts credit expansions with significant and noteworthy price adjustments.

Figure 2
Impulse responses to a one standard deviation credit spread shocks



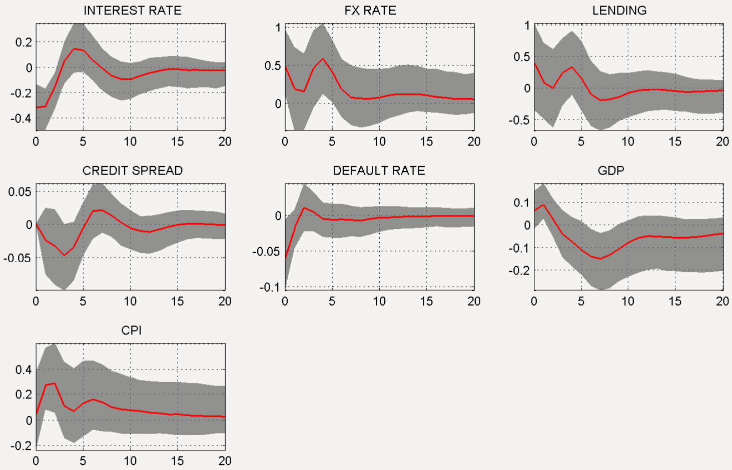
Monetary policy shock

Figure 3 shows impulse responses to the monetary policy shock. As Table 2 indicates, the shock has a negative impact on the interest rate and a positive impact on the real GDP and the CPI, furthermore, the nominal exchange rate depreciates. While the positive deviation of the CPI is highly persistent, the real GDP is shifted below its trend quickly[7] due to the overshooting of the BUBOR rate after 3 quarters. This phenomenon might be explained by monetary policy's reaction to inflationary pressure. An alternative explanation can be derived from the findings of Endrész and Krekó (2010): they show that the gain in competitiveness generated by a depreciation of the nominal exchange rate is mostly neutralized by the deteriorating balance sheets of the production sector due to their relatively large foreign currency debt.

Regarding variables related to financial intermediaries, both the credit spread and the default rate diminish. However, the quantity of loans does not reveal any significant pattern. This might indicate that the interest rate channel is more important in the transmission of monetary policy shocks than the credit channel. Nevertheless, this does not exclude the possibility that the credit channel has an important role in the transmission of the systemic part of monetary policy.

[7] This result is in line with the findings of Jakab et al. (2006).

Figure 3
Impulse responses to a one standard deviation monetary policy shock

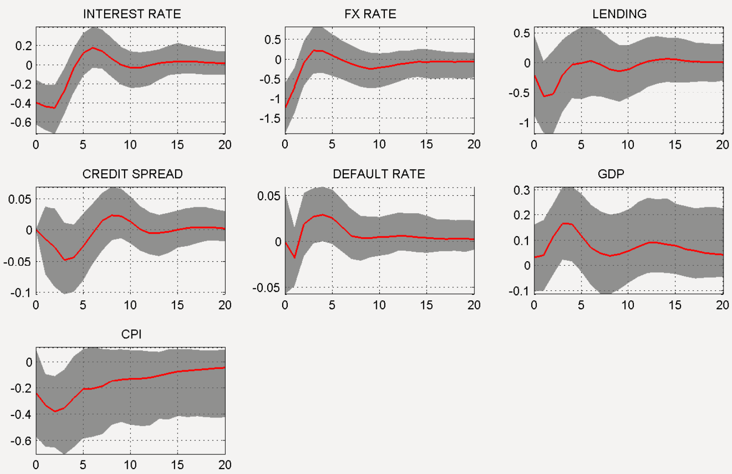


Risk premium shock

The effects of an exogenous drop in the required risk premium of foreign investors are summarized in Figure 4. The applied identification scheme, see Table 2, implies that the nominal interest rate decreases and the nominal exchange rate appreciates.

The median response of the GDP is positive and persistent, although with a very wide confidence interval. The median response of the CPI is significant, persistent and negative due to the depreciation of the nominal exchange rate. The effect of the shock on the credit spread, the default rate and the quantity of loans is ambiguous.

Figure 4
Impulse responses to a one standard deviation risk premium shock



3.2 VARIANCE DECOMPOSITION

Anomalies in the behavior of financial intermediaries could result in a deep economic crisis as the recent one has demonstrated. However, it is not obvious whether they have significant impact on the economy even in normal times. This section uses variance decomposition based on the median model[8] to decide this question. Variance decomposition is a tool for measuring the relative contributions of shocks to the dynamics of endogenous variables. Our calculation for variance decomposition is based on the entire sample. Consequently, it is suitable for ranking the relative importance of shocks in normal periods since the recent crisis influences only the end of the sample.

Table 3 displays the four identified structural shocks' contribution to the forecast errors and the unconditional variance of the endogenous variables. The table reveals that unidentified factors are responsible for at least 40 per cent of the volatility of the endogenous variables. This is in line with the DSGE literature which demonstrates that productivity, preference and markup shocks also have important impact on the business cycle. The quantity of outstanding loans is the variable which is influenced most by our identified shocks: in the short run nearly 60 percent, in the long run half of its volatility is explained by them. On the other hand, they explain less than one third of the 1-quarter forecast error of the CPI and less than 40 per cent of its unconditional variance. Regarding other endogenous variables, while in the short run our structural shocks are responsible for around 30–40 per cent of the forecast errors of the variables, in the long run their contribution increases above 40 percent.

Table 3
Identified shocks' contribution to the forecast errors and the unconditional variance of endogenous variables
(per cent)

	Real GDP	CPI	BUBOR	NEER	Loan	Spread	Default rate
1 quarter	36.4	26.7	40.8	39.9	57.1	36.2	35.4
4 quarters	45.0	36.1	44.2	45.2	50.2	41.1	44.8
8 quarters	45.8	37.6	46.5	47.5	50.4	44.1	45.6
Unconditional	43.5	39.0	46.3	47.0	49.0	44.5	45.7

Table 4 summarizes the contribution of individual shocks to the forecast errors and the unconditional variance of endogenous variables. Note that the table does not refer to the total volatiliy of variables. The entries in the table represent the percentage decomposition of only those parts of the forecast errors and the variance which are explained by the four identified structural shocks.

The table reveals that the credit supply shocks' contribution to the variance of macroeconomic variables is non-negligible, often significant. While they explain a larger part of the volatility of the real GDP than the identified macroeconomic shocks both in the short and the long run, in the case of the CPI and the nominal exchange rate the contributions of the credit supply and the identified macroeconomic shocks are almost equal in all time horizons. Regarding the 3-month money market rate (BUBOR), credit supply shocks are less important than the monetary policy and the risk premium shocks. This phenomenon is especially strong if the 1-quarter forecast error is considered.

Naturally, credit supply shocks play a dominant role in the behavior of the quantity of corporate loans and the accompanying credit spread. However, it is interesting to note that in contrast with our initial expectations the main driving force of the credit spread is not the spread but the risk assessment shock. On the other hand, both the credit supply and the macroeconomic shocks have similar impact on the fluctuation of the corporate default rate.

In summary, the relative contributions of credit supply and macroeconomic shocks to business cycle dynamics are of similar order of magnitude over the entire sample. This finding demonstrates that the behavior of the the financial intermediary sector has significant impact on the economy even in normal times. In other words, the economic significance of the finan-

[8] The median model, introduced in Fry and Pagan (2007), is selected from the accepted models using the criterion of producing closest possible impulse responses to the median impulse response. In our calculation we use the algorithm proposed by Liu (2007) to find the median model.

cial sector is not an exclusive feature of crisis times. Hence, incorporating financial intermediaries into macroeconomic models is necessary for better understanding macroeconomic dynamics.

Table 4
Individual shocks' relative contribution to the forecast errors and the unconditional variance of endogenous variables explained by the identified structural shocks

(per cent)

	Credit supply shocks		Macroeconomic shocks	
	Risk assessment	Spread	Monetary policy	Risk premium
1-quarter forecast error				
Real GDP	40.4	30.5	12.0	17.1
CPI	26.4	27.6	18.6	31.2
BUBOR	02.8	10.4	30.1	56.7
NEER	33.8	17.4	08.4	40.4
Loan	44.2	29.2	11.9	14.7
Spread	70.0	23.7	03.0	03.2
Default rate	04.3	39.5	35.4	20.8
4-quarter forecast error				
Real GDP	34.9	27.5	11.3	26.3
CPI	22.6	27.6	18.6	31.2
BUBOR	10.4	19.9	21.3	48.4
NEER	27.2	22.6	16.9	33.3
Loan	40.5	29.8	13.2	16.5
Spread	50.4	22.8	12.5	14.4
Default rate	16.6	33.6	25.0	24.8
8-quarter forecast error				
Real GDP	28.3	26.6	19.5	25.6
CPI	22.7	27.3	18.9	31.1
BUBOR	14.2	20.3	20.8	44.7
NEER	26.8	23.1	17.9	32.1
Loan	36.0	29.1	15.8	19.2
Spread	43.4	23.7	14.4	18.4
Default rate	18.4	32.5	23.3	25.8
Unconditional variance				
Real GDP	26.2	26.5	19.2	28.0
CPI	22.2	27.7	19.4	30.8
BUBOR	16.9	21.5	20.8	40.8
NEER	25.1	24.1	18.2	32.6
Loan	32.3	28.4	16.4	22.9
Spread	37.4	24.5	15.5	22.5
Default rate	19.9	30.9	22.2	27.0

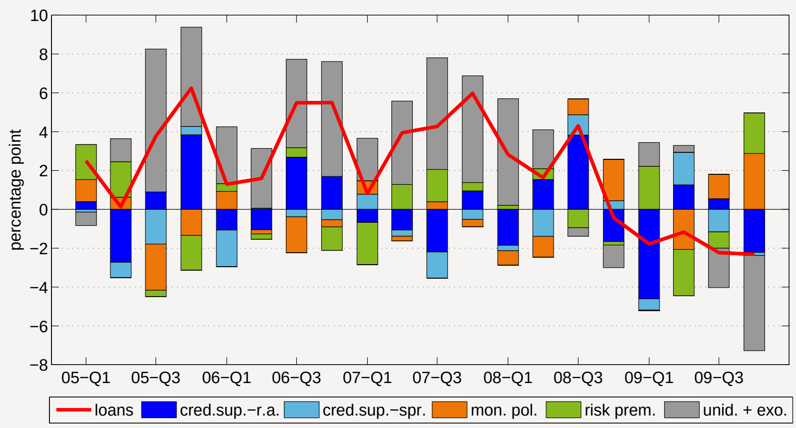
Note: This table does not refer to the total variance of variables. The entries represent the percentage decomposition of only those parts of the forecast errors and the variance which are explained by the four identified structural shocks.

3.3 SHOCK ACCOUNTING: HISTORICAL DECOMPOSITION

In order to understand better the impact of the financial crisis on the Hungarian economy we analyze the dynamics of some important variables by historical shock decomposition based on the median model. The *Appendix* explains how this exercise can be implemented numerically.

Figure 5 displays the contribution of different structural shocks on the quarter-on-quarter growth rate of corporate loans. As the chart reveals, the growth rate of corporate loans became negative in 2008Q4 when the the crisis started in Hungary. The observed drop in the quantity of credit is generated mainly by the risk assessment shock in 2008Q4 - 2009Q1. However, the impact of this shock is ambiguous in subsequent periods: in 2009Q1 the risk assessment shock becomes temporarily expansionary then its effect diminishes and turns into negative again. In 2009Q1 the risk premium shock somewhat neutralizes the large negative effect of the risk assessment shock, however, later it becomes contractionary as well. After 2009Q2 the importance of the monetary policy and the unidentified shocks increase significantly. Strength and sign of the impact of the monetary policy shock is varying: in 2009Q2 it is an important factor behind credit contraction, however in 2009Q3 and Q4 its impact is expansionary. All in all, the risk assessment, the risk premium and the monetary policy shocks together with unidentified shocks are responsible for the credit contraction started in 2009Q4.

Figure 5
Historical decomposition of the growth rate of corporate loans into structural and unidentified shocks



To interpret impartially the large negative contribution of monetary policy in 2009Q2 one should take into account the following considerations. After the collapse of Lehmann Brothers, the MNB (Central Bank of Hungary) to maintain financial stability and to avoid a current account crisis increased its key interest rate by 300 basis points in October 2008. This resolute action and the rescue package of the IMF and the EU calmed down the markets and stabilized the exchange rate of the Hungarian forint. Hence, the MNB had some opportunity to diminish its key interest rate already in 2008. However, due to uncertain international environment in early 2009 the forint started to devaluate heavily again and reached the extreme 315 forint/euro level. Further depreciation would have increased the probability of households' default and resulted in large losses and potential liquidity or even solvency problems in the banking sector. In order to avoid these developments and ensure financial stability, the MNB had to stop easing monetary conditions and postpone rate cutting. That is, it had to keep an interest rate level which was unjustified by inflationary and business cycle considerations. As a consequence, in Q2 monetary policy temporarily became one of the main drivers of credit contraction.

Figure 6 plots how different shocks explain the growth rate of real GDP: unidentified shocks and exogenous factors (including exogenous and trend variables) are the main factors behind the deceleration of GDP growth started in 2008Q2, however, all the identified structural shocks contributed to the observed negative growth rates. This is in contrast with the above findings on corporate loans: while the risk assessment shock contributes heavily to the decline of the quantity of corporate loans, its role is much less prominent in the contraction of the real GDP. On the other hand, the spread shocks is not responsible considerably for the credit contraction, however, it does have a negative impact on the real GDP which is comparable to the effects of the risk assessment and the monetary policy shocks.

Figure 6
Historical decomposition of the growth rate of the real GDP into structural and unidentified shocks

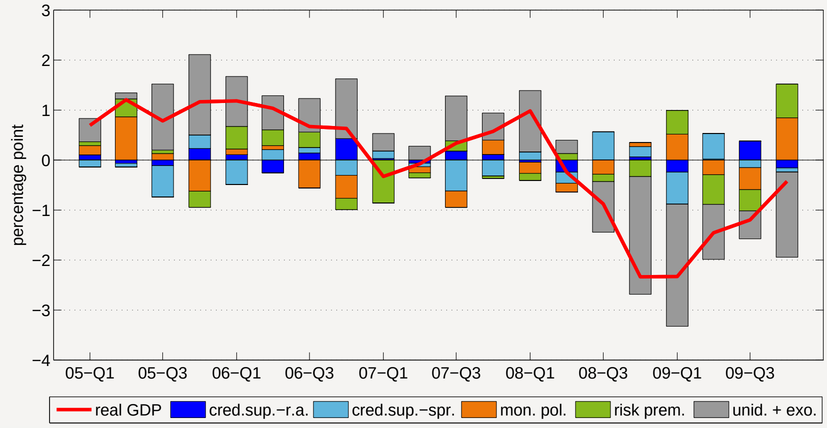
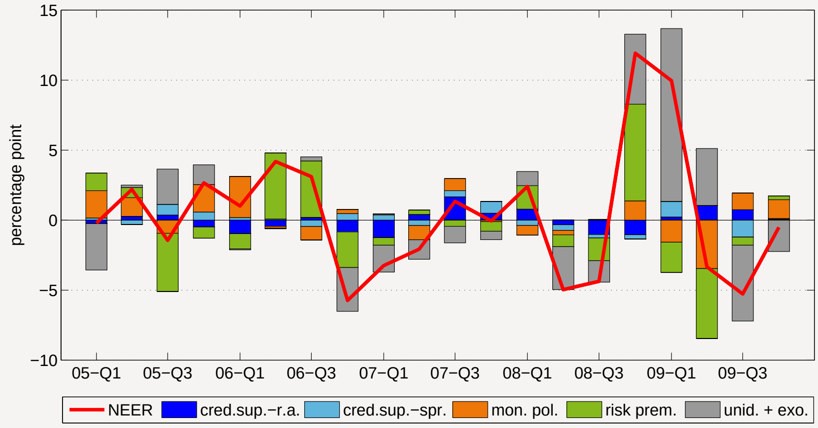


Figure 7 shows the impacts of shocks on the changes in nominal exchange rate. According to the common explanation, in 2008Q4 there was a large attack against the Hungarian forint resulting in a huge depreciation of the currency. In our framework this explanation can be captured by a large positive shock of the required risk premium of foreign investors. As the figure reveals, the result of the simulation exercise supports this view. However, as mentioned above, in 2009Q1 the forint depreciated further due to the turbulence and uncertainty in Central – Eastern – European money markets. Unfortunately, this phenomenon is not captured by our shock accounting: a dominant part of the devaluation is induced mainly by unidentified shocks and the impact of the risk premium shocks is small and has just the "wrong" sign. This outcome might reveal the weakness of the applied identification scheme for this shock and might indicate that some further information, e.g. CDS spreads, should be utilized in the model in order to correctly specify the risk premium shock.

Figure 7
Historical decomposition of the depreciation of the nominal effective real exchange rate into structural and unidentified shocks



In summary, credit supply shocks significantly contributed the observed decline in economic activity started in 2009Q2, however, other structural shocks had also important negative impact on the macroeconomy. It is important to emphasize that the role of unidentified shocks increased in the crisis period. However, as explained in *Section 2.2*, our identification scheme may neglect some part of the risk assessment shock. Hence, the enlarged contribution of unidentified shock might be partly explained by the missing part of the risk assessment shock. E.g., their relative contribution to the dynamics of the real GDP and the nominal exchange rate became highly important. The latter indicates that it is necessary to reconsider the identification strategy of the risk premium shock.

4 Conclusions

This paper presents an estimated structural VAR model for the Hungarian economy. Structural shocks are identified by imposing sign and short-run restrictions.

The estimated model is used to clarify the role of the financial intermediary sector in Hungarian business cycle fluctuations and describe the effects of credit supply shocks. Furthermore, it is developed to be a potential tool for macroprudential simulations. To meet the requirements of policy simulations we identify two types of credit supply shocks: a shock generated by changing risk assessment of financial intermediaries and another one induced by variations in the policy or regulatory environment. Beyond these credit supply shocks, we identify a monetary policy shock and the shock to the required risk premium of foreign investors which has an important impact on business cycles of small open economies.

It is shown that a characteristic difference between the two credit supply shocks is reflected in the behavior of the credit spread. While the risk assessment shock generates substantial movements in bank loans without sizeable credit spread adjustment, the policy shock induces large changes in both the quantity and the price of credit. This finding suggests an alternative way of interpreting these shocks: while the first shock captures loan allocations by rationing, the second one depicts allocations by prices. We also show that in the transmission of monetary policy shocks the interest rate rate channel is more important than the credit channel. Nevertheless, this does not exclude the possibility that the credit channel can play an important role in the transmission of the systemic part of monetary policy.

We demonstrate that the relative contributions of the credit supply shocks and the macroeconomic shocks to business cycle dynamics are of similar order of magnitude over the entire sample. That is, the economic significance of the financial sector is not an exclusive feature of crisis times. This finding suggests that incorporating financial intermediaries into macroeconomic models is necessary for better understanding macroeconomic dynamics.

It is also shown that credit supply shocks significantly contributed to the observed decline in economic activity started in 2009Q2. However, their role was not exclusive: other structural shocks had also important negative impact on the macroeconomy. On the other hand, the importance of unidentified shocks increased in the crisis period: e.g., their relative contribution to the dynamics of the real GDP and the nominal exchange rate became highly important. For further research, it would be be important to explain and understand better the factors behind the above unidentified shocks.

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Appendix A

This section explains how the shock accounting exercise of *Section 3.3* is implemented.

The estimated model can be represented by the following formula,

$$Y_t = B_1 Y_{t-1} + B_2 Y_{t-2} + CX_t + Av_t,$$

where Y_t is the vector of endogenous variables, X_t is the vector of exogenous variables (including trends) and v_t is the vector of structural shocks, furthermore, B_1, B_2, C are matrices of coefficients and A is the matrix provided by the shock identification process.

For $i = 1, \ldots, 7$ define

$$Y_t^i = B_1 Y_{t-1}^i + B_2 Y_{t-2}^i + A^i v_t^i,$$

where v_t^i is the ith shock and A^i is the ith column of matrix A, and define

$$Y_t^8 = B_1 Y_{t-1}^8 + B_8 Y_{t-2}^8 + CX_t.$$

If some initial conditions are fulfilled ($Y_z = \sum_{i=1}^{8} Y_z^i$ for $z = -1, 0$) then it is easy to show that for all t $Y_t = \sum_{i=1}^{8} Y_t^i$.

Hence, one can interpret Y_t^i as the contribution of shock i to Y_t if $i \leq 7$, and Y_t^8 as the contribution of exogenous variables and trends. This decomposition is not unique since it depends on the initial conditions. However, their effects become negligible over the time period we analyzed in the shock accounting exercise.

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