EFFECTIVENESS OF MONETARY POLICY IN UKRAINE: SHEDDING LIGHT ON THE CREDIT CHANNEL

by

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A thesis submitted in partial fulfillment of
the requirements for the degree of

MA in Economic Analysis

Kyiv School of Economics

2021

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Abstract

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The objective of this paper is to estimate the response of the economy to the monetary policy shock taking into account three monetary transmission channels: the interest rate channel, the exchange rate channel, and the credit channel. Paper attempts to incorporate the credit market disturbances into a BSVAR model with zero and sign restriction by identifying three types of shocks: (i) lending supply shock, (ii) lending demand shock, and (iii) monetary policy shock. Also, two supplement BVAR models with Cholesky decomposition are used to test for the existence of the credit channel. This study shows that monetary policy transmission is effective in Ukraine and accounts for 15% of the GDP and CPI variance in a two-year horizon. The effect of the monetary policy shock on the GDP and CPI is estimated to peak at 11 and 24 months respectively. Also, the credit channel is estimated to be present in Ukraine and, hence, needs to be accounted for in the monetary policy decision making.

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ACKNOWLEDGMENTS

I would like to express the greatest appreciation to my thesis supervisor professor Sergii Kiiashko for his constant support, continuous feedback, and insightful suggestions. I am proud and grateful that I had a chance to work with Sergii, a teacher whose willingness to help and ability to understand astonished me. This work would not be possible without his guidance on all stages of its writing.

I also wish to thank Nicolas Aragon and other research workshop professors, who reviewed this paper and contributed to its development with their comments and suggestions. I am grateful to Anton Grui, head of the Monetary Policy and Economic Analysis Department at NBU, for suggesting an interesting topic for the thesis and for providing the crucial pieces of data. Finally, I am grateful to professor Yuriy Gorodnichenko, who has given me the scholarship and the opportunity to study and thrive within the KSE community.

GLOSSARY

ADF. Augmented Dickey–Fuller test.

AIC. Akaike information criterion.

ARIMA. Autoregressive integrated moving average.

BIC. Bayesian information criterion.

FEVD. Forecast error variance decomposition.

HQ. Hannan Quinn criterion.

IRF. Impulse response function.

NBP. National Bank of Poland.

NBU. National Bank of Ukraine.

NEER. Nominal Effective Exchange Rate.

QPM. Quarterly Projection Model.

SSSU. State Statistics Service of Ukraine.

SVAR. Structural vector autoregression.

TRAMO-SEATS. Time Series Regression with ARIMA Noise, Missing Observations, and Outliers - Signal Extraction in ARIMA Time Series.

UIIR. Ukrainian Index of Interbank Rates.

UONIA. Ukrainian OverNight Index Average.

Chapter 1

INTRODUCTION

The objective of this paper is to estimate the response of the economy to the monetary policy shock taking into account three monetary transmission channels: the interest rate channel, the exchange rate channel, and the credit channel. The latter was omitted in the NBU estimates for the monetary transmission effectiveness because it was considered to have an insignificant effect on the economy (Zholud, Lepushynskyi, and Nikolaychuk 2019). This paper challenges this claim and explicitly include the credit channel along with two other channels in estimating the effectiveness of the monetary policy transmission.

The credit channel theory states that key policy rate affects GDP and inflation through credit market. In particular, a change in the key policy rate has an impact on the external finance premium – the difference between the costs of funds raised externally and the opportunity costs of the internal funds - that is charged by banks when financing their clients. In the case of contractionary monetary policy, banks expect a decrease in the net wealth of their clients, experience the deterioration of their assets, and become less risk-seeking. All that increases the external finance premium charged by banks. Subsequently, the reduction of the bank loan supply takes place that slowers inflation and GDP growth.

To include the impact of credit channel, I follow the methodology by Peersmann (2012) and incorporate the credit channel as defined by Bernanke and Gertler (1995) into a structural VAR model. To isolate the innovations to the credit market caused by monetary policy, three types of shocks are identified in the model: (i) lending supply shock, (ii) lending demand shock, and (iii) monetary policy shock. Subsequently, I compare this baseline model with a conventional model that uses the Cholesky decomposition and only implicitly incorporates the credit channel. In addition, two subchannels of the credit channel are tested for existence. In particular, I run two additional VAR models to test the banks' response to the monetary policy: (i) do banks behave in line with the balance sheet channel theory by reducing the lending to riskier clients first? (ii) do banks act in line with the bank lending channel theory by rather reducing the volume of loans than selling their liquid assets?

This topic is motivated by three reasons. First, starting from 2015, the National Bank of Ukraine has introduced macroprudential policies to the lending market and cleaned the banking system from players exposed to systemic risks. Those developments changed the credit market and may have changed the monetary policy transmission mechanism too. In particular, it might have set the stage for the credit channel to arise in Ukraine.

Second, after the global financial crisis, the relevance of the credit market disruptions in the macroeconomic analysis became acknowledged. It was revealed that credit market developments should be analyzed not only in the context of the financial crisis effects but in the study of business cycles too. There are, however, a lot of uncertainties regarding the magnitude and the exact transmission mechanism to the economy in emerging markets. It is especially the case in countries with weakly established bank lending markets and constantly evolving macroprudential policies, features that are relevant for Ukraine.

Finally, banks play a prominent role in financing the private sector. In particular, European Central Bank pays close attention to the credit channel of the monetary transmission mechanism in the euro area because bank loans accounted for around

45% of total debt financing in non-financial corporations in 2018[1]. Even though the case of Ukraine is different and the ratio of outstanding loans to GDP is more than three times lower in Ukraine than in the Euro Area, it still amounts up to 24% of the GDP[2]. Due to this relative credit market insignificance in Ukraine and a small data sample for the period after the inflation targeting introduction, credit channel transmission to the economy was not comprehensively studied.

The study of lending supply shock that is caused by monetary policy shifts received a lot of attention from researchers. Bernanke and Gertler (1995) started the discussion around the credit channel by defining it as a set of factors that enhance and complement the interest rate channel effects through changes in the external finance premium. According to the conventional transmission mechanism, monetary policy affects firms' external finance premiums by shifting bank loan supply. Considering a case of contractionary monetary policy, firms with a relatively poor financial position and limited access to external financing may be forced to cut their production and employment in response to the decrease in available bank loans. If not completely shut off from the credit line, firms are likely to incur additional costs associated with finding a new lender and building a credit relationship with him. Such costs may be referred to as the increase in the external finance premium that may induce a firms' output to decrease too. Combining these two effects, which are likely to be present in the Ukrainian economy, results in the fact that a rise in the interbank interest rate reduces the firms' expenditures due to fewer loans issued. Therefore, it strengthens the effectiveness of the monetary policy transmission and should be taken into account in the estimation process.

[1] According to ECB Economic Bulletin, Issue 1 / 2020.

[2] According to the data provided by NBU, Ukrstat and Euro Area statistics, ratio of outstanding loans in December 2019 to the GDP in 2019 is 24 and 78% respectively for Ukraine and the Euro Area.

The main result of the paper is that 15% of the GDP and CPI variance in a two-year horizon in Ukraine can be explained by the monetary policy shocks. I incorporate three monetary policy transmission channels in the model: credit channel, interest rate channel, and exchange rate channel. Both GDP and CPI have hump-shaped response functions to the monetary policy shock. The response of GDP to one standard deviation of the contractionary monetary policy shock peaks at one year after the initial shock and amounts up to a 0.3% decrease. As for the CPI, it is slower in response and reaches a 0.2% decrease in a two-year horizon. The results are consistent with Peersman (2012) estimates for the Euro Area, NBP (2016) model for Poland, Grui and Vdovychenko (2019) Quarterly Projection Model for Ukraine.

Also, I show that the balance sheet and the bank lending channels are functioning in Ukraine. Banks reduce the loan supply to riskier clients more actively and to a larger extent compared to less risky ones. It reflects the different changes in the external finance premium for different clients. Those that have less collateral and provide less information are faced with a larger increase in interest rates. Such behavior supports the existence of the balance sheet channel. Moreover, banks tend not to reduce the liquid assets in their portfolio in response to the contractionary monetary policy but to decrease the supply of loans instead. It shows that the bank lending channel is present in Ukraine.

The rest of the paper is organized as follows. Chapter 2 discusses how the credit channel functions and how it relates to the conventional interest rate and exchange rate channels of monetary transmission. Chapter 3 presents the baseline SVAR model with the identification scheme and elaborates on the data preparation process. Also, it discusses two supplement models that aim to test the existence of the balance sheet and bank lending channels. Chapter 4 is dedicated to the preliminary tests of the data sufficiency and estimation results. Chapter 5 provides conclusions.

Chapter 2

LITERATURE REVIEW

The conventional view of how monetary policy works claims that Central Banks use their leverage over short-term interest rates to affect the cost-of-capital and, subsequently, the consumption of durable goods and firm investment. The credit channel theory, however, implies that monetary policy also influences the external finance premium faced by borrowers and enhances the traditional interest rate channel through developments in the credit market (Bernanke and Gertler 1995). As for the exchange rate channel, it plays an important role in the small open economies and is considered to be the most powerful avenue of monetary transmission in Ukraine (Zholud, Lepushynskyi, and Nikolaychuk 2019). This chapter is divided into three subchapters. The first one explains how the credit channel relates to the other two channels described above. The second discusses the theoretical foundations for the credit channel existence and its role in monetary policy transmission. Finally, the third subchapter discusses the empirical evidence for the credit channel existence.

2.1. Role of the credit channel in monetary transmission

Figure 1 is a schematic representation of how the monetary policy affects the economy, namely GDP and prices, through the credit channel, costs of capital channel (interest rate channel), and the exchange rate channel. The credit channel is shown to function in parallel to the interest rate channel. In particular, it enhances the impact of the cost of capital channel on the interest rates by developments in the credit market that are discussed in more detail in Chapter 2.2.

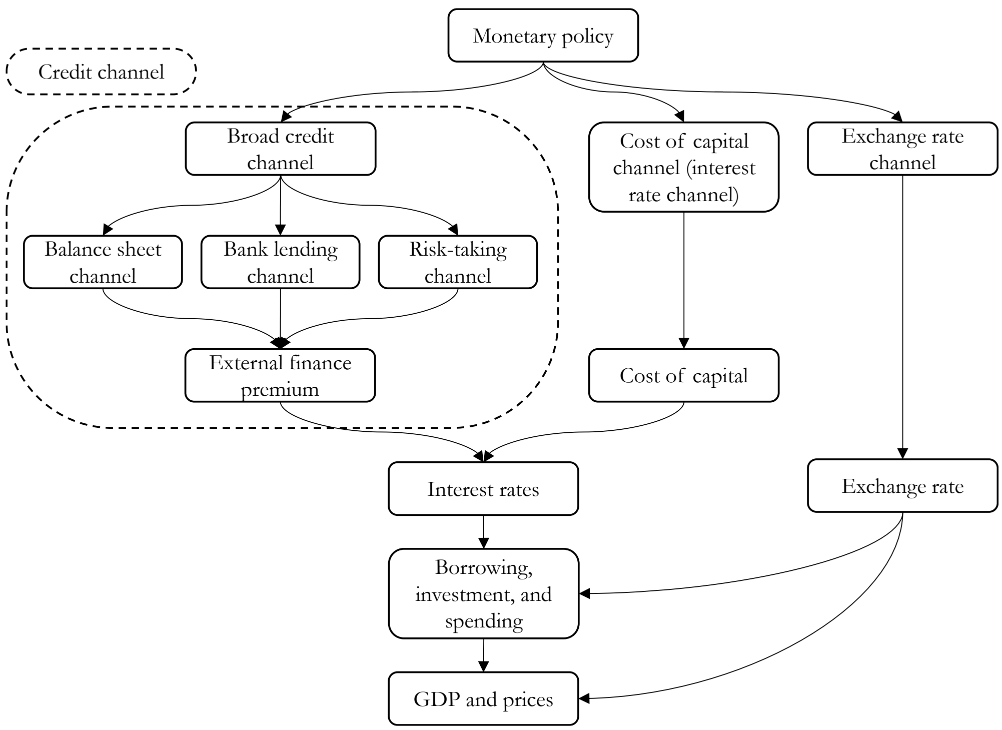

Figure 1. Three channels of monetary policy transmission.
Source: ECB, NBU

In case of the contractionary monetary policy, banks are expected to increase the premium they charge for their services. It is referred to as the external finance premium. It will subsequently increase the interest rates on loans and influence the households' and firms' decisions regarding borrowing, investment, and spending. In particular, they are expected to decrease all of the listed.

2.2. Theoretical overview of the credit channel

The credit channel arises due to the disturbances in the external finance premium in response to monetary policy changes. External finance premium refers to a wedge between the costs of funds raised externally and the opportunity costs of the internal funds (Bernanke and Gertler 1990). Notably, it may be considered as additional pay for raising money compared to using own resources. Debt and equity are considered to represent the external funds because they are not directly available to the firm and require an intermediary to deliver them, while retaining earnings may be referred to as an example of the internal funds. The difference in the attraction costs of those funds takes place because of the adverse selection and moral hazard problems (Prescott and Townsend 1984). Borrowers inevitably have better information about their prospects than the lenders, so the "lemons" premium is charged by the latter. Also, the borrowers' incentive to change their behavior and engage in riskier activities after getting the funds is accounted for by lenders by requiring higher interest payments. Unless the external financing is fully collateralized and guaranteed to be repaid, the external financing premium is believed to proceed.

According to the advocates of the credit channel, contractionary monetary policy may increase the wedge between the external and internal financing costs and, hence, affect investment and consumption in the economy along with the interest rate channel (Bernanke and Gertler 1995). The changes in the external finance premium are primarily driven by the lender's costs for borrower risk evaluation, credit monitoring, and debt collection. Since monetary policy affects the firms' and households' balance sheets and the risk of some borrowers not paying back their loans, lenders tend to adjust their interest rates for clients they deem to be riskier or cut down the amount of loans provided to them. Two mechanisms are outlined to explain the functioning of the credit channel: balance sheet channel and bank lending channel.

Balance sheet channel grounds on the presumption that the external finance premium encountered by a borrower depends on his net wealth. The larger is the sum of the client's liquid assets and marketable collateral the lower is the premium charged by the lender. Intuitively, a stronger financial position reduces the conflict of interest during credit terms negotiations. The client may agree to provide larger collateral or even reduce the credit amount by self-financing a greater share of his planned investment. Otherwise, households or firms may be forced to postpone their consumption or cut off their investment due to larger financing costs set by the lender.

Monetary policy may affect the borrowers' balance sheets, also referred to as net wealth, in two ways. First, rising interest rates on the outstanding short-term debt reduce net cash flows to the firm and weaken its financial position. Since many firms finance their inventories by issuing short-term debt, a shift in the credit market will have a significant impact on their liability payments. Second, the rise in the interest rates may decrease the asset prices and, consequently, diminish the borrower's collateral. Higher interest rates motivate agents to invest relatively more into risk-free assets driving other asset prices down.

These balance sheet reactions to monetary policy induce lenders to increase their interest rates. It widens the wedge between external and internal financing costs denoting a higher external finance premium that directly influences consumption and investment in the economy.

The second mechanism, the bank lending channel, reflects the changes in the external finance premium caused by the bank loan supply shifts in response to the monetary policy disturbances. Since banks remain the primary source of intermediate credit, the bank loan supply disruptions may impose significant financing limitations on borrowers. If not completely shut off from the credit line, they may incur additional costs associated with finding a new lender, arranging credit terms, and adjusting to newfound financial circumstances.

Within the framework of bank lending channel, monetary policy affects not only the interest rates but the banks' balance sheet too. Monetary contraction reduces the amount of banks' free reserves and, in some cases, the reduction may be significant enough for reserves to hit the floor of minimum requirements. It is likely that some banks will not be able to offset such a reduction with the issuance of new equity or deposits in the short-run. Subsequently, they are expected to sell their liquid assets, an activity known as the buffer stock behavior (Carroll, Hall, and Zeldes 1992). However, if banks are unable to deliver a sufficient level of reserves by selling off their assets they will be forced to limit lending. That is to say, banks will shrink their loan supply.

In addition to the traditional credit channel framework, after the global financial crisis, researchers began to recognize the risk-taking channel that enhances the bank lending channel (Altunbas et al. 2009). It arises when the banks' incentive to bear the risk associated with lending is affected by monetary policy. Such a change in risk appetite may be enforced by two mechanisms. First, the rise in asset prices following the decrease in interest rate enlarges the collateral available to borrowers. The belief that such uplift is sustainable leads banks to accept higher risks. Second, low interest rates make banks search for higher yields. It attracts their attention to riskier assets and softens the credit standards, which leads to an increase in loan supply.

From a theoretical point of view, there may be up to three groundings for the credit channel existence. The first one, the balance sheet channel, relates to the lenders' response to the disturbances in the borrowers' net wealth after monetary policy changes. Due to the presence of information asymmetries, banks will adjust the finance premium if they suspect their clients' assets being changed. Second, the bank lending channel elaborates on the loan supply shifts being driven by the changes in banks' available funds. Since the monetary policy affects the amount of liquid assets on the banks' balance sheets, an increase in key policy rate may cause the scenario when the banks will be forced to limit their lending. Lastly, the risk-taking channel recognizes that changes in monetary policy influence the banks' willingness to accept higher risks and their appetite for the higher yields search. All that impacts the external finance premium and, subsequently, are expected to affect the economy.

2.3. Empirical evidence for the credit channel

It is empirically difficult to separate the balance sheet channel and the bank lending channel using aggregate credit data because it does not convey enough information on borrowers' financial position and the banks' liquidity constraints. Moreover, after the risk-taking channel getting its attention in 2008, it became even more ambiguous how to isolate the effects attributed to each of the subchannels. Since all three of them are expected to have similar predictions for aggregate demand, a lot of studies view them jointly and concentrate on measuring the credit channel in general. It is often referred to as a broad credit channel.

Researchers have tried to improve identification using micro data. However, as shown by Kashyap and Stein (2000), they fail to analyze the total effect of monetary policy shock on the economy and need to make restrictive assumptions on credit demand. These limitations entail the usage of macro-level data if one needs to estimate the impact on output and inflation, even though the complete identification is open to question.

Ciccarelli et al. (2015) resolved the individual problems of using solely micro- or macro-level data by combining them. Using the U.S. and the unique Euro Area bank surveys they created variables for balance sheet and bank lending channels and showed that both of them amplify the monetary policy shock. Even though their methodology addresses the identification sufficiently, it is based on unique data and is unavailable in most countries. With Ukraine being one of them.

Peersman (2012) suggested identifying a broad credit channel along with the exogenous loan supply and demand shocks. His model is a compromise between distinguishing each credit subchannel individually and the ability to estimate the aggregate effect of the monetary policy transmission on the GDP and inflation. Since his model does not require low-level bank data, which is in a deficit in Ukraine, it was chosen as a workhorse for this paper. Besides, it allows for comparison with Poland. Its Central Bank estimated the effectiveness of the credit channel using Peersman's methodology too (NBP 2011, NBP 2016).

From the previous studies, it may be concluded that monetary policy transmission is amplified by the credit channel. After the cost of capital is affected by the traditional interest rate channel, external finance premium also is subject to a change. Monetary contraction is expected to deteriorate the borrowers' balance sheets worsening their financial position. It will limit their access to financing or at least increase the costs associated with it. Furthermore, the developments in the money market are expected to drain banks' free reserves and, subsequently, reduce their lending capacity. The banks' risk appetite will be affected too. They will have less incentive to look for risky assets as higher interest rates are now available for risk-free assets.

Chapter 3

DATA AND THE MODEL

The main consequence of the credit channel is that a monetary contraction decreases real GDP and restrains inflation through a reduction of bank loans provided and a tightening of lending standards for non-financial borrowers. The challenge though is to disentangle and identify the innovations to the credit market that are caused by the monetary policy. This chapter explains how the problem is addressed in five steps. First, the VAR model is introduced. Second, the data construction process is stated. Third, the identification scheme for structural shocks is explained. Next, the model estimation procedure is described. Finally, I discuss the model shortfalls and present the additional models for testing the existence of the credit channel.

3.1 Baseline VAR model

The following VAR model is a starting point in the monetary policy identification process:

$$Y_t = C + A(L)Y_{t-1} + WZ_t + B\varepsilon_t \tag{1}$$

where Y_t is a vector of endogenous variables containing the seasonally adjusted natural logarithms[3] (multiplied by 100) of respectively GDP proxied by the industrial production index (y_t), CPI (p_t), the volume of outstanding bank loans to households and firms (l_t), the interest rate on newly issued bank loans (i_t), the monetary base (b_t), the interbank interest rates (s_t), the nominal effective exchange rate ($NEER_t$), and the lending multiplier ($l_t - b_t$); Z_t is an exogenous variable controlling for the Covid-19 crisis; C is a vector of constants, $A(L)$ is a matrix polynomial in the lag operator L, W is a vector of coefficients for the exogenous variable, and B is the contemporaneous impact matrix of the mutually orthogonal disturbances ε_t. The baseline model is estimated on monthly data over the sample period 2015M1-2020M12.

Since VARs in this study are estimated in log-levels, one of two conditions should hold: either there are cointegrating relationships in the data or the data is stationary. It is shown in Chapter 5 that all variables withstand this requirement. Moreover, I assume that time series on interest rates are stationary in the long run (Rose 1988). Even though a rigorous analysis of the long-run behavior of the variables is limited by the short sample available, the ADF tests show evidence that the data is stationary and sufficient to use for inference.

Based on the AIC, BIC, and HQ criteria, the estimations should have included one lag of the endogenous variables. However, studies for European countries (Peersman 2012, NBP 2016) use four lags to better capture the macroeconomic dynamics. To get comparable results, this study adheres to the conventional practice. Moreover, the results are robust for different lag lengths.

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[3] The interest rate on newly issued bank loans and the monetary policy rate are not logarithmed.

In addition to the baseline model, I consider its variations to test for robustness. First, I choose a different proxy for GDP. In particular, instead of industrial output, the number of unemployed people was used. Likewise, CPI was alternated with the core inflation. Next, I altered the lag length. Specifically, SVAR(3) and SVAR(5) were estimated. Also, I estimated the model on different sample periods to account for the time of banking system adjustment in 2015 and the covid-19 pandemic in 2020. Three additional time ranges were used: 2015M1-2019M12, 2016M1-2019M12, and 2016M1-2020M12. All these specifications turned out to deliver very similar results, underlying the robustness of the results.

3.2. Data description

All data are obtained from the NBU database. Monthly data on real GDP is proxied by the industrial production index because direct data is available only quarterly. Figure 2 shows that those series follow the same pattern, especially after applying seasonal adjustment. Other variables include CPI, the volume of outstanding bank loans to firms and households, average interest rates on new bank loans, the monetary base, and average overnight interest rates. The last one is constructed from UIIR, UONIA, and internal NBU data on interbank rates because each of them separately provides data only on a portion of the specified time range. As for the industrial production index and CPI, they were transformed from growth rates into levels with the base in 2015. It was done to allow for the cointegration between output, prices, and the monetary base.

Because the variables used in the model are transformations of the original data provided by NBU, there were no seasonally adjusted series available. To overcome this problem, I used TRAMO-SEATS model (Caporello and Maravall 2004) to seasonally adjust all variables except for the interest rates on bank loans, the overnight interest rates, and the volume of outstanding loans. All three of them failed to show seasonality.

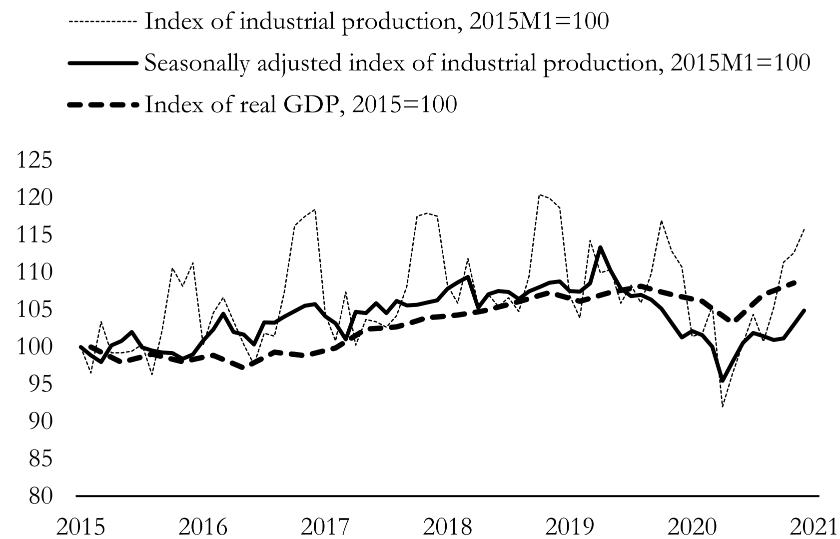

Figure 2. Comparison of the real GDP and the index of industrial production dynamics, 2015-2020

Source: NBU, SSSU

The empirical analysis described above is carried out on macro-level monthly time series over the 2015M1-2020M12 period yielding 72 observations. Seasonally adjusted data are presented in Figure 3. The index of industrial output has been steadily increasing till the middle of 2019. A similar trend is present in the number of unemployed people. It began to increase in the August of 2019 and peaked in July of 2020 during the Covid-19 crisis. As for inflation, CPI surged at the beginning of 2015 and subsequently gradually decreased to an average of 0.4% growth in 2020. This pattern is reflected in a concave shape of the index in the graph. With the decrease in inflation, the interest rate on bank loans and monetary policy rate declined too and were record low at the end of 2020. Regarding the volume of bank loans, it remained almost the same and averaged at UAH 1 trillion during the analyzed period while the monetary base nearly doubled.

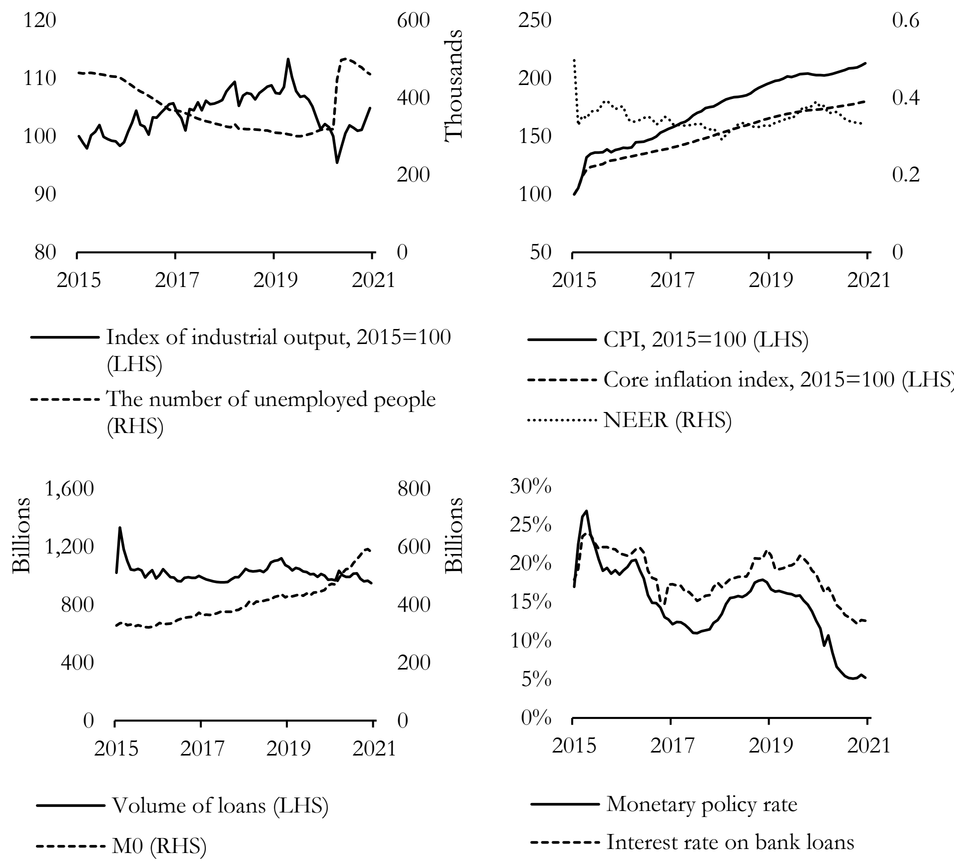

Figure 3. Seasonally adjusted data, 2015-2020

Source: NBU, author calculations

3.3 Identification methodology

The impact of the increase in bank lending is different depending on the underlying source of such an uprise. In particular, monetary policy shock, loan supply shock independent of such policy, and exogenous loan demand shock are expected to have different effects on the economy while all being associated with an increase in the volume of bank loans. Hence, the developments in the lending market could not be directly associated with the credit channel of the monetary transmission.

I address the problem by using the mix of zero and sign restrictions on the contemporaneous matrix B in equation (1) to disentangle three landing market shocks discussed above. The set of restrictions to disentangle monetary policy, lending demand, and lending supply shocks is summarized in Table 1. All sign restrictions are imposed on the contemporaneous effect and the following four months with only one exception. The response of the volume of bank loans restrictions is imposed on the third and fourth lag after the disturbances. Even though it turned out not to affect the model results, I introduced such flexibility to account for the price rigidity in the lending market. It allows for the scenario when firms use their credit lines at prespecified interest rates for some time while the interest rates on new loans have changed.

The restrictions are consistent with the IS-LM model extended to include bank lending (Bernanke and Blinder 1988). Also, it successfully separates shocks that are specific to the lending market from the monetary policy shock by taking into account the interest rate developments and lending multiplier variations. Monetary policy shock is referred to here as the shock propagated through the supply of bank loans.

Table 1. Identification scheme for bank lending shocks

	y_t	p_t	l_t	i_t	b_t	$NEER_t$	s_t	$l_t - b_t$
Monetary policy shock	0	0	↓ lagged	↑			↑	
Loan supply shock	0	0	↑ lagged	↓			↑	↑
Loan demand shock	0	0	↑ lagged	↑				
Shock 1	0	0						
Shock 2	0							
Shock 3								
Shock 4								
Shock 5								

y_t = output, p_t= prices, l_t= volume of bank loans, i_t= lending rate, b_t = monetary base, $NEER_t$ = nominal effective exchange rate, s_t = policy rate, $l_t - b_t$ = lending multiplier

The remaining lending market disturbances incorporate the changes in the loan demand and loan supply. The first one, the exogenous loan demand shock, may arise due to the changes in the access to the alternative sources of financing or borrowers' preferences shifts regarding the credit volume. The second one, the loan supply shock, may account for innovations in banks' operational activity or changes in their risk appetite that allows banks to increase the lending for a given policy stance.

Since the response of the economy is of the key interest in this paper, no sign restrictions were set on the output and prices. Assumptions for these variables are intentionally left loose to avoid bias. Only zero restrictions in the contemporaneous effect on these two variables take place to account for the lag between the real sector response and money market disturbances. For two unidentified shocks, there are no restrictions at all to allow for the presence of the economy shocks in the model.

As for the sign restrictions, a contractionary monetary policy shock is associated with three lending market developments: an immediate increase in the interbank rates, which is a proxy for the key policy rate; an increase in the interest rate on bank loans; and a decline in the volume of bank loans. Such settings allow identifying the monetary policy shock that influences the real sector through the financial intermediaries.

Two other shocks of interest, loan demand and supply shocks, are identified using basic microeconomic reasoning. The shift in the loan demand curve to the right is associated with the simultaneous increase in loan interest rates and the volume of bank loans. As for the positive shock in the lending supply, it is expected to incorporate the decrease in the loan interest rates while the volume of bank loans is expected to rise. Also, I assume that the lending multiplier, defined as the ratio of loans to the monetary base, increases when the supply shifts to the right. It captures the rise in banks' ability to find extra funding to finance additional loans. Lastly, I assume that the Central Bank raises the key policy rate when the lending supply is increasing. It is consistent with a Central Bank's objective to stabilize inflation.

Since the objective of this paper is to include the credit channel effects into the structural VAR model, there is a priori no reason to also identify all the fundamental innovations to the economy beyond those that are of key interest. Bernanke and Mihov (1998a, b) and Christiano et al. (1999) similarly recognize this and concentrate solely on a limited set of shocks that interact with the monetary policy shock. The identification of additional shocks, however, may ensure orthogonality between the shocks of the primary interest. So, two additional shocks are introduced: non-identified bank lending shock (Shock 1) and the economy disturbances without the immediate impact on output (Shock 2). The remaining shocks represent other economy deviations. Since these supplementary shocks are of no interest, they are aggregated and labeled as "others".

3.4 Estimation procedure

I use the Bayesian structural vector autoregression model (BSVAR model) in the estimation. It allows selecting the structural decompositions of the model that satisfy all the imposed sign restrictions regarding the response functions for all variables. This goal is achieved by rotating the mutually orthogonal shocks and selecting only those that match all criteria. Numerically, it is achieved by brute force. The algorithm generates many impulse response functions based on the underlying VAR model and checks whether the sign restrictions are satisfied.

The methodology developed by Arias et al. (2014) allows combining zero and sign restrictions on the impulse response functions of a BVAR model. The combination of the Cholesky decomposition simplicity and the sign restrictions flexibility set the stage for models with more general assumptions. The restrictions that before were sought implicitly now can be achieved by setting explicit assumptions with the desired result in the impulse response functions.

In Bayesian econometrics, parameters are treated as random variables. The information about their prior distribution is combined with the information contained in the data to produce the updated distribution accounting for both sources of the information. In this paper, the Normal-Wishard prior distribution is used.

A total of 2000 draws satisfying all restrictions are extracted to provide the estimation results. Since the average estimates are sensitive to outliers, all figures employ the median estimates together with 84^{th} and 16^{th} percentile error bands.

The range of 68 percentages is motivated by the small sample size. Such error bands were used in Peersman (2012) and NBP (2016), which studies the credit channel of the monetary transmission, and motivated by the same reason while using more observations than in this paper's model.

3.5 Supplement models

The baseline model refers to the broad credit channel that views balance sheet channel, bank lending channel, and risk-taking channel jointly. It concentrates on measuring the credit channel in general and estimates the overall effect on the economy. This approach is convenient for drawing macro-level conclusions but requires some strong assumptions about the banks' behavior. Since the banking sector in Ukraine drastically changed in 2015 and there is a lack of literature on banks' responses to the monetary policy, this paper tests the existence of the subchannels in the credit channel using two supplement models. In particular, this paper concentrates on examining the balance sheet and the bank lending channels.

The first supplement model tests the existence of the balance sheet channel. In response to the contractionary monetary policy, banks are believed to cut their loans to the riskier clients first. The reasoning is that the rise in interest rates decreases the borrowers' net wealth by introducing higher interest payments on their current debt and lowering the prices on their assets. The banks are assumed to know about those changes in the borrowers' net wealth and decrease the loan supply to the clients they have relatively less information about and to those clients that they deem to have a weaker financial position.

Since information availability and a stronger financial position reduce the conflict of interest during credit terms negotiations, financially stronger clients are expected to be rejected less frequently. The reflection of this scenario is a more rapid and radical decrease in riskier loans compared to less risky ones. That is the hypothesis to be tested by the first supplement model.

Because the data for loans segregated by their riskiness is not available, an alternative approach was carried out. I separated loans into mortgages and non-mortgages. The reasoning for this choice is that the larger sum of the client's marketable collateral lowers his riskiness. Intuitively, real estate that is financed by mortgages acts also as collateral and makes the client's financial position stronger.

This approach has a drawback though. The difference between the mortgages and non-mortgages term structures may discredit the results. According to NBU data, in December 2020 49% of mortgages were long-term loans with the expected due dates in five or more years. The same metric for the aggregated bank loans is more than two times lower and equal 18%. It brings the risks of obtaining results that are driven by the term structure differences and not the banks' response towards the differences in riskiness. Hence, the alternative model with differenced logarithms of loans (mortgages and non-mortgages) is run. Such specification overcomes the above-mentioned term structure problem.

The response of different loan types was analyzed with the VAR model with the same form as in Equation 1. It is put here again for the convenience:

$$Y_t = C + A(L)Y_{t-1} + WZ_t + B\varepsilon_t \quad (2)$$

In this model Y_t is a vector of endogenous variables containing the seasonally adjusted natural logarithms[4] (multiplied by 100) of respectively the CPI (p_t), the industrial production index (y_t), the volume of outstanding non-mortgage loans (Δlnm_t), the volume of outstanding mortgages (Δlm_t), the monetary base (b_t), the effective exchange rate ($NEER_t$), and the monetary policy rate (s_t); other inputs and parameters are the same as in the baseline model described in Chapter 3.1.

The model is estimated on monthly data over the sample period 2015M1-2020M12. The lag length is the same as in the baseline model and equal to four. As for the identification scheme, I use the Cholesky decomposition. The order of variables for the decomposition is the same as stated in the previous paragraph when listing all the endogenous variables.

The second supplement model tests the existence of the bank lending channel. According to this channel theory, contractionary monetary policy influences the banks' free reserves to the extent that banks start selling their liquid assets or cutting their loan supply to meet the macroprudential requirements. If the reduction in loan supply is larger in magnitude and more persistent than the reduction in the banks' liquid assets, it allows drawing indirect conclusions about the functioning of the bank lending channel. The evidence of banks being more inclined to reduce the bank loan supply than to decrease their liquid assets outline the effectiveness of the monetary policy. Such behavior reduces access to financing in case of the contractionary monetary policy and affects borrowing, investment, and spending.

I analyze the responses of the liquid assets in banks' portfolios and the volume of bank loans with the VAR model. The same structural form of the model was

[4] The monetary policy rate is not logarithmed. The volume of loans are differenced after taking the logarithms.

utilized as in Equations 1 and 2. The difference is only with the endogenous variables used. In this model Y_t is a vector of endogenous variables containing the seasonally adjusted differences of the natural logarithms[5] (multiplied by 100) of respectively the liquid assets in the banks' portfolios (Δa_t), the volume of outstanding bank loans to households and firms (Δl_t), and the monetary policy rate (Δs_t).

Since the time series fail to show stationarity or cointegration, the model is estimated not in levels but if differences instead. The rest is as in the previous model: monthly data over the sample period 2015M1-2020M12 is used; the lag length is equal to four; the Cholesky decomposition is implemented.

[5] The monetary policy rate is not logarithmed.

Chapter 4

ESTIMATION RESULTS

This chapter presents the estimation results in three subsections. The first one provides information on data sufficiency. In particular, it covers stationarity and cointegration tests. The second discusses the baseline model results. It analyzes the FEVD and IRF. Also, it compares the latter one with the estimates for Poland and the Euro Area. The third subsection analyzes the results of the supplement models and elaborates on the significance of the credit channel of the monetary transmission mechanism in Ukraine.

4.1 Data sufficiency

I test the data for stationarity and cointegration. If at least one of those two conditions is not met the model may produce spurious results. Specifically, the estimates may lead to incorrect conclusions and should not be considered. Data used in this paper is shown to be sufficient for the VAR analysis.

I separated time series into groups: interest rates and nominal data series. The first one includes interest rates on bank loans and the interbank interest rates (a proxy for key policy rate). Those variables are deemed to be stationary because the persisting increase or decrease in them is not sustainable. The second group includes the index of industrial production, CPI, monetary base, and the volume of bank loans. From Figure 2 it is evident that they are not stationary. Later it was proved to be the case using the Augmented Dickey-Fuller test. Hence, the cointegration test was conducted to verify the presence of the long-run linear relationship between four variables.

Interest rates on bank loans and interbank interest rates are estimated to be stationary. Both of them turned out to be stationary according to the ADF test with three lags. Since the baseline model uses four lags, the maximum lag length for the test was increased to five to account for one extra period of data. Even though the time series on the bank loans interest rates fail to reject the non-stationarity for the fourth lag, it does reject H0 for the fifth lag. As for the interbank interest rates, they are stationary for the fourth lag. All tests are summarized in Table 2.

Table 2. Augmented Dickey-Fuller test.

	p-value of the ADF test by lag length				
	1	2	3	4	5
Interest rates on loans	0.41	0.37	0.09*	0.13	0.09*
Interbank interest rates	0.26	0.03**	0.01***	0.02**	0.19

Other variables are not stationary and require additional analysis. Since differencing the data inevitably leads to the loss of important long-run information and changes the interpretation of the estimates, the alternative approach was implemented. The data were tested for the cointegration to allow using it in levels. The goal of the cointegration test is to check for the long-run linear relationship between variables. If the residuals produced out of this relationship are stationary the non-stationarity problem of the individual variables may be overcome.

To test for the cointegration, I employed the Engle-Granger test. It runs the regression of one variable on all others and tests its residuals for stationarity using the ADF test with the critical values adjusted for the number of variables (MacKinnon 1991). Since the dependent variable choice in the regression may influence the results, four different specifications were used to overcome this problem. Each of them used a different time series as a dependent variable.

Since the sample is relatively short, the results of the cointegration test are sensitive to the lag length selection. Three metrics were calculated to determine the number of lags to include in the estimation: AIC, BIC, and HQ. The majority of them suggested using one lag in the test. Table 3 summarizes the cointegration test results.

Table 3. Engle-Granger test for cointegration with one lag.

Dependent variable	EG statistics	p-value
Index of the industrial output	-5.63	0.01***
CPI	-4.28	0.05**
Monetary base	-3.03	0.10
Volume of bank loans	-3.35	0.10
NEER	-5.69	0.01***

Hence, all variables are sufficient to use in levels in the estimation. The interest rates of bank loans and the interbank interest rates are stationary, while the index of industrial production, CPI, the monetary base, and the volume of bank loans are cointegrated.

4.2 Baseline model results

Figure 3 presents the obtained impulse response functions of GDP and CPI to one standard deviation of the contractionary monetary policy shock identified according to the assumptions described in Chapter 3. Results are similar in magnitude as in the Peersman (2012) model for the Euro Area, NBP (2016) for Poland, Grui and Vdovychenko (2019) for Ukraine. IRFs of all variables and all lending market shocks with 68 percent error bands are shown in Appendix A.

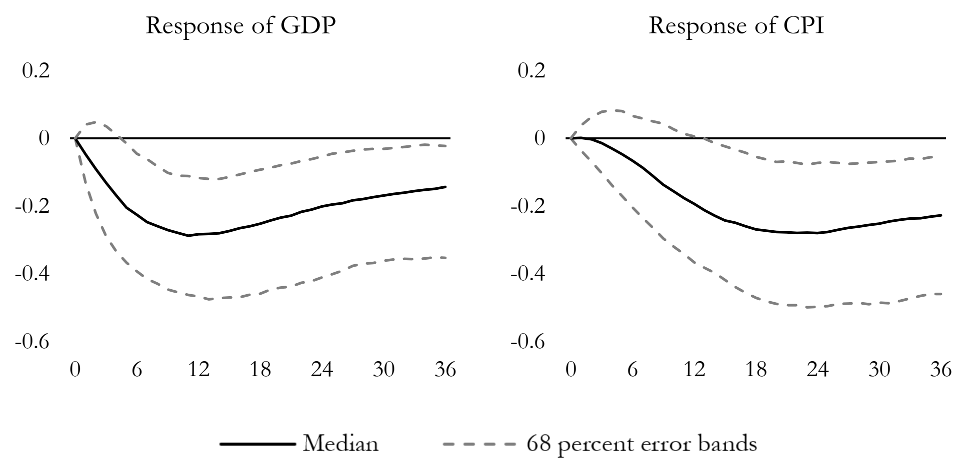

Figure 4. Impulse response functions to one standard deviation of the contractionary monetary policy shock in the baseline model.

Both GDP and CPI have hump-shaped response functions to the monetary policy shock. The effect on the GDP is statistically significant after half a year and grows in magnitude for the following half of the year. It peaks at the 12th month after the initial shock and amounts up to the 0.3% decrease in GDP at that time. During the subsequent periods, it gradually decreases but still remains statistically significant even after 3 years. As for the CPI, its response is slower and becomes statistically significant at the 14th month after the innovation. It peaks at the two-year time horizon by reaching a 0.25% decrease in CPI and gradually declines in magnitude during the subsequent periods.

However, there are differences in the magnitudes, the results are in line with Grui and Vdovychenko's (2019) Quarterly Projection Model for Ukraine. Especially in the CPI response to the monetary policy shock. Their model predicts a 0.2% decrease after one year, while the baseline VAR in this paper predicts a 0.25% decrease. Taking into account the short sample and wide confidence intervals, these results may be considered to be similar. As for the response of the GDP, it is not that alike. It may be due to the fact that QPM uses a different measure for the output in its estimation, namely the GDP gap. Hence the inference is different is should not be directly compared with the GDP response.

Also, the estimates for the monetary transmission that takes into account the credit channel in Poland (NBP 2016) turned to be similar to those in the baseline model. The peak of the GDP response to the contractionary monetary policy shock is at the 12th month too, and the decrease in GDP amounts up to 0.5%, which is within the baseline model confidence interval. The CPI response in Poland becomes statistically significant only 2 months earlier and the magnitude of the response is within the estimated baseline model confidence intervals. The responses scale is comparable with the NBP (2016) results too.

The Peersman (2012) model for the Euro Area, which was estimated using a similar methodology, delivers comparable results to those obtained for Ukraine. The peak of the GDP response is the same as in the baseline model, even though it fades almost two times faster in the Euro Area. As for the CPI, its response becomes statistically significant faster and is two times lower in magnitude. It is explained by the lower inflation level and variance in the Euro Area.

Besides the IRFs, the forecast error variance decompositions (FEVDs) were constructed. They allow estimating how much of the economic deviations are explained by the exogenous monetary policy shocks. Figure 4 shows that 15% of the GDP and CPI variance in a two-year horizon is explained by the monetary policy shocks.

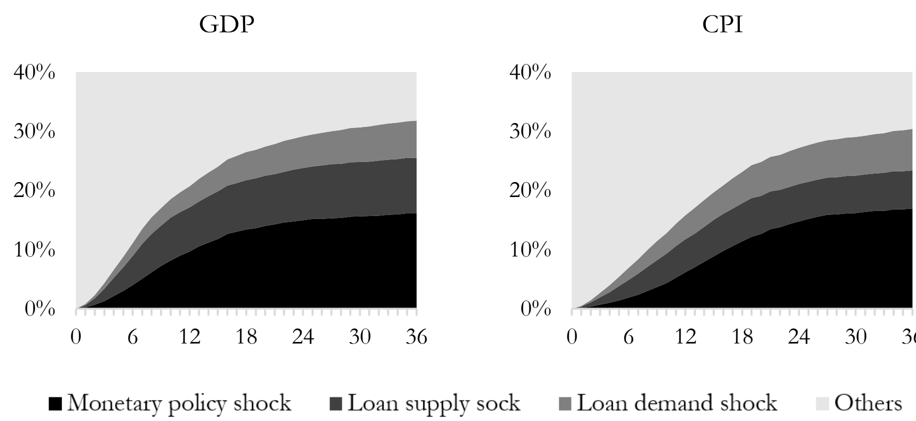

Figure 5. Forecast error variance decompositions in the baseline model.

Variations of the baseline model were considered to test for robustness. A different proxy for GDP was chosen. Instead of industrial output, the number of unemployed people was used. Also, A different measure for inflation was used: CPI was alternated with the core inflation. The alterations in the lag length were implemented. Specifically, SVAR(3) and SVAR(5) were estimated. Moreover, the model was estimated on different sample periods to account for the time of banking system adjustment in 2015 and the covid-19 pandemic in 2020. All these specifications turned out to deliver similar results.

4.3 Supplement models results

Supplement models aim to test the existence of the two subchannels in the credit channel. In particular, they consider the balance sheet and bank lending channels.

Figure 6 provides evidence for the existence of the balance sheet channel. According to the balance sheet channel theory, banks cut the supply of loans to riskier clients more aggressively than to less risky ones. Mortgage and non-mortgage loans were used as a proxy for relatively riskier and less risky loans because real estate that is financed by mortgages may be used as collateral. It provides the client with marketable collateral and, hence, lowers his riskiness.

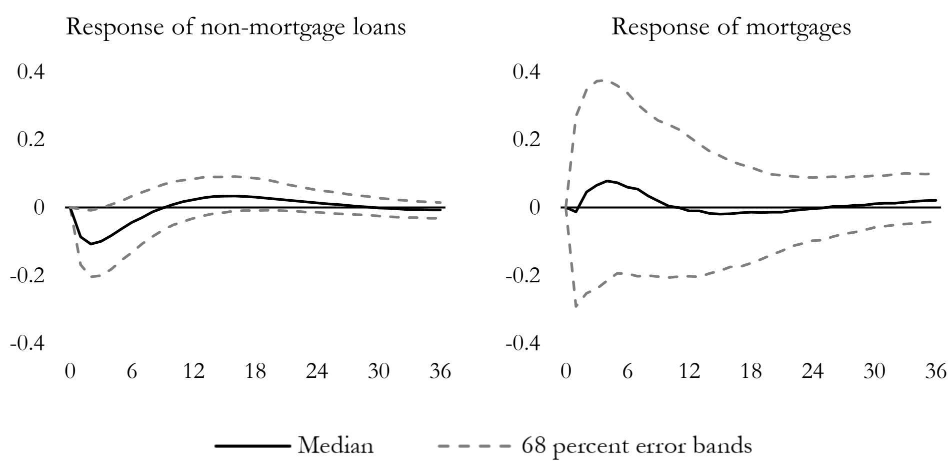

Figure 6. Impulse response functions to one standard deviation of the contractionary monetary policy shock in the first supplement model.

While the supply of mortgages is estimated to be unchanged, the supply of relatively riskier non-mortgage loans is expected to decline in the first three months. Cumulatively it is expected to decrease by 0.3% during that period. For the subsequent months, the change in bank loans is estimated to be statistically insignificant. The outcome is consistent with the baseline model results. IRFs of all other variables in this model are presented in Appendix B.

Figure 7 displays the responses of the liquid assets in the banks' portfolio and the volume of bank loans to the monetary policy shock. It is revealed that banks are more inclined to reduce the supply of loans rather than to sell their liquid assets. Such findings support the existence of the bank lending channel. If NBU carries out the contractionary monetary policy, banks can not fully adjust to the new monetary policy only with liquid assets selling. Hence, they reduce the loan supply that subsequently affects borrowing, investment, and spending in the economy.

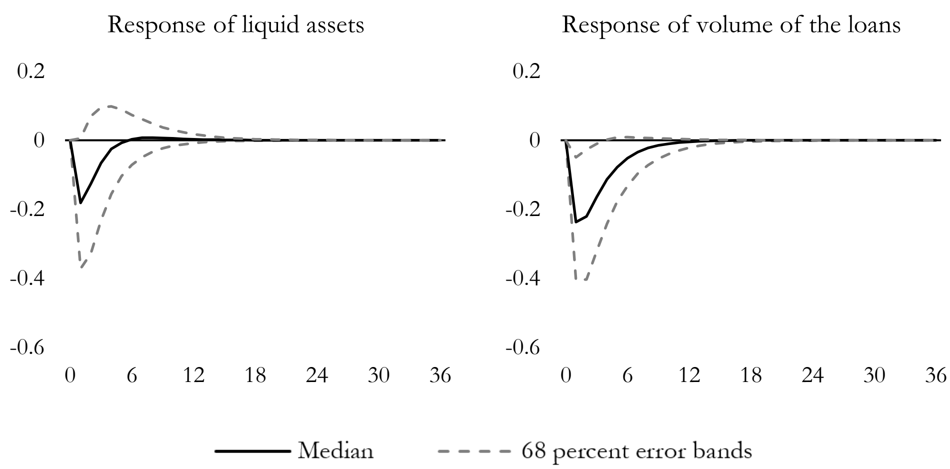

Figure 7. Impulse response functions to one standard deviation of the contractionary monetary policy shock in the second supplement model.

Since the variables used in the second supplement model are not stationary or cointegrated, their first differences were used in calculations. The decrease in the amount of the banks' liquid assets to the contractionary monetary policy is on the border of the statistical significance. However, the null hypothesis of no effect cannot be rejected. As for the response of the volume of bank loans, it is statistically significant and the loan supply is expected to decrease for the first three months. Cumulatively it is expected to decrease by 0.6% during that period. The result is consistent with the baseline model impulse response functions. IRFs of all other variables in the second supplement model are presented in Appendix C.

Two supplement models show evidence that the balance sheet and bank lending channels are functioning in Ukraine. Outlining the need to include the credit channel in estimating the efficiency of the monetary transmission.

Chapter 5

CONCLUSIONS

In this study I show three main results: (i) monetary policy transmission is effective in Ukraine and account for 15% of the GDP and CPI variance in a two-year horizon, (ii) the effect of the monetary policy shock on the GDP and CPI peaks at 11 and 24 months respectively, (iii) the credit channel is present in Ukraine and needs to be accounted for in the monetary policy decision making.

Regarding the first conclusion, the monetary policy shock has a statistically significant effect on both the GDP and CPI. In a two-year horizon, monetary policy shocks account for 15% of the variance in GDP and CPI. The GDP declines by 0.3% in response to one standard deviation of the monetary policy shock and the CPI decreases by 0.25%. The results are consistent with those for the Euro Area and Poland.

Second, the monetary policy shock affects the GDP and CPI with a lag of at least 5 months. Both variables have hump-shaped response functions to the monetary policy shock. The effect becomes statistically significant after half a year for the GDP and after 14 months for the CPI. The responses grow in magnitude till the 11 and 24 months respectively. During the subsequent periods, they gradually fade out but remain statistically significant even after 3 years.

Third, I show evidence for the credit channel existence in Ukraine. Banks reduce the loan supply to riskier clients first, and that reduction in loans is larger in magnitude compared to less risky ones. This finding supports the idea that banks suspect the deterioration in clients' net wealth and reduces the loan supply more to those that have less assets or provide less information about themselves. Such a behavior set a stage for the credit channel.

Also, banks were proved to reduce the supply of loans more aggressively compared to the decrease in their liquid assets in response to the contractionary monetary policy. This finding supports the idea that banks are faced with the macroprudential requirement and cannot sell their liquid assets rapidly. Instead, they constrain bank lending. Such developments ultimately affect the real economy through the credit market.

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APPENDIX A

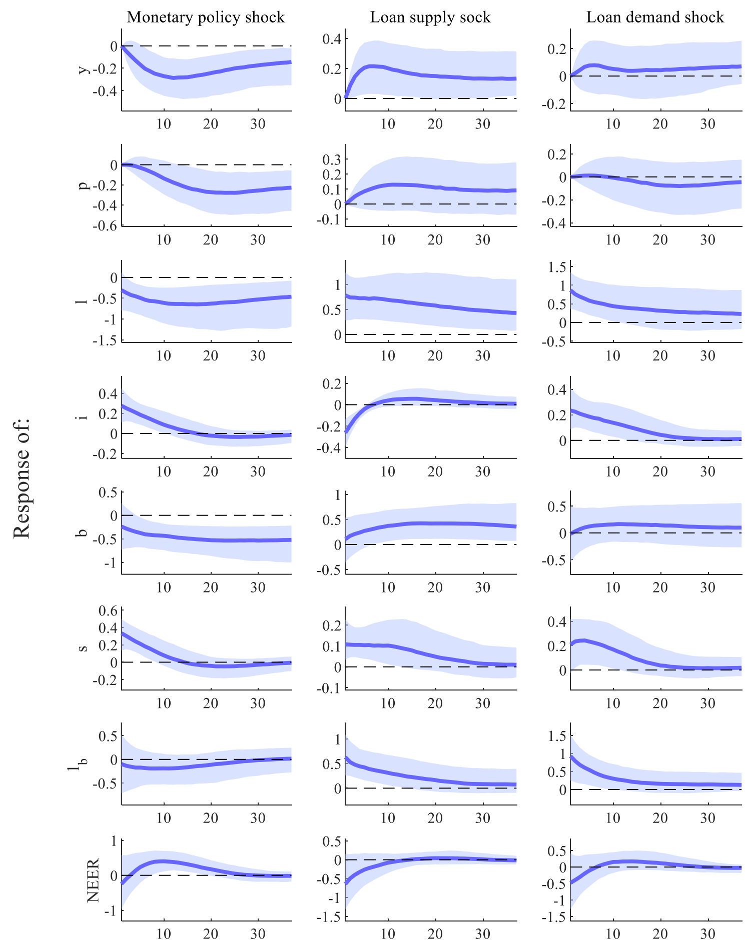

Figure 8. Impulse response functions to one standard deviation shocks in the baseline model, all variables included.

APPENDIX B

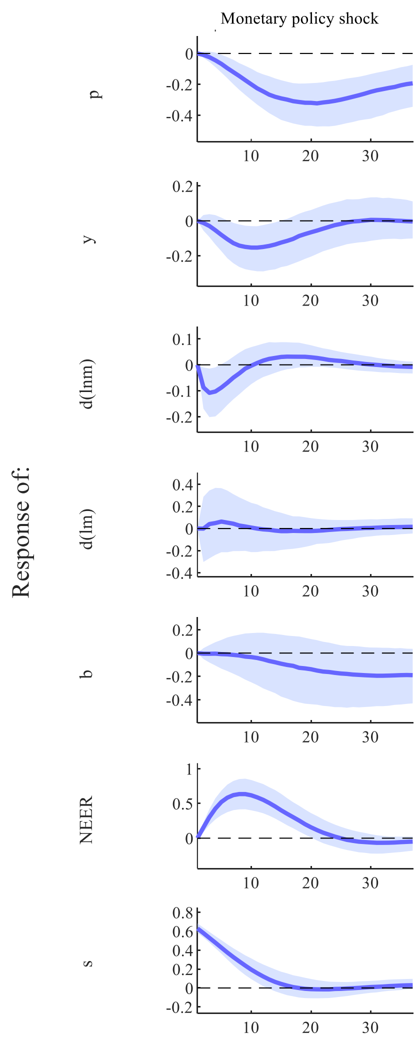

Figure 9. Impulse response functions to one standard deviation of the contractionary monetary policy shock in the first supplement model, all variables included.

APPENDIX C

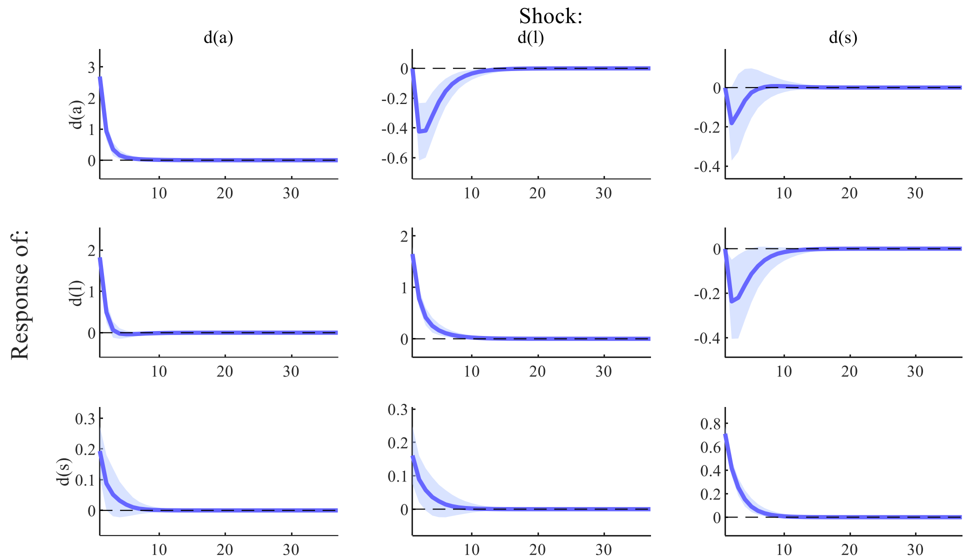

Figure 10. Impulse response functions to one standard deviation shocks in the second supplement model, all variables included.