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Monetary policy transmission mechanism in Poland

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The aim of studies making up the hereby submitted PhD thesis was to establish what are the macroeconomic effects of monetary policy in Poland. The dissertation consists of four parts, published as separate, but thematically related journal articles.

In the first part I researched into the impact of current monetary policy and central bank communication concerning monetary policy in the future on equity and bond prices, as well as on the exchange rate. To this end, I constructed measures of both forms of Monetary Policy Council (MPC) actions and carried out a regression analysis using high frequency data. The results of the analysis indicate that both current monetary policy and MPC communication affect financial asset prices in Poland.

In the second part of the dissertation I analysed whether the effects of monetary policy are amplified through their impact on bank balance sheet strength, which affects credit supply. I used bank level panel data, first estimating the parameters of (panel) vector autoregressive models and then, based on them, carrying out counterfactual analysis. According to the results of this study, the above mentioned transmission channel accounts for about one-fourth of a decrease in credit after monetary policy tightening in Poland.

In the third part of the dissertation I researched into the impact of the marginal cost of bank funding and risk on loan rates. First, I constructed a measure of the marginal cost of funding alternative to the usually used WIBOR (Warsaw Interbank Offered Rate) interest rate – a weighted average cost of liabilities. Second, I carried out both model-based and out-of-model analysis of the two measures, in case of model-based analysis controlling for expectations and uncertainty regarding GDP growth, the share of non-performing loans and the capital buffer. I used bank level panel data. The study showed that since the Great Recession (2007-2009), according to most criteria, loan rates had been stronger connected with the weighted average cost of liabilities than with the WIBOR rate. However, it has also been shaped by risk.

In the fourth part I analysed how far does the impact of monetary policy on the Polish economy reach. To this end, I estimated the responses of 132 macroeconomic variables to a monetary impulse within factor-augmented vector autoregressive models. The results show that monetary policy tightening is associated with a decrease in economic activity, inflation, credit and money supply, as well as with an increase in interest rates, a decrease in the prices of some financial assets and a deterioration in expectations regarding economic activity in the future.

Literature and contribution

The first part of the dissertation is related to the literature on the impact of monetary policy on financial asset prices, in which high frequency data are used. It focuses on changes in equity prices, government bond yields or the exchange rate on the days of decisions of monetary policy committees or the comments of their members. According to author's knowledge, the first study from this group is the article of Cook and Hahn (1989), indicating that changes in the federal funds rate target in the United States are associated with the response of longer-term interest rates in days of these changes. Their approach was extended by Kuttner (2001), who showed that government bill and bond rates in the United States respond only to the unexpected component of changes in the federal funds rate target in the days of central bank decisions. Another extension is the study of Gurkaynak et al. (2005), adding to the analysis central bank communication regarding the interest rate in the future as a dimension of monetary policy. At the same time, they shortened the observation window from one day to 30-60 minutes. According to the results of that study, government bond yields in the United States respond to both unexpected component of changes in the federal funds rate target and communication, and equity prices respond to the former form of actions.

As far as studies for Poland are concerned, Serwa and Smolińska-Skarżyńska (2004) showed that in the years 2000-2002 the złoty exchange rate responded to the unexpected component of changes in the reference rate of Narodowy Bank Polski (NBP), however, in the direction inconsistent with the uncovered interest rate parity theory − it turned out that an increase in the NBP reference rate is associated with a depreciation of the exchange rate. According to the results of the analysis of Serwa (2006), in the years 1999-2005 unexpected changes in the NBP reference rate were associated with a response of short-term interest rates, but not of long-term interest rates, equity prices or the exchange rate. Janecki (2012) found a statistically significant relationship between changes in the NBP reference rate and changes in longer-term interest rates in the years 2001-2011. The results of the article of Włodarczyk (2008) for the years 2004-2007 indicate that the comments of MPC members between MPC meetings affect some FRA (forward rate agreement) rates, but not IRS (interest rate swap) rates. Rozkrut (2008) showed that longer-term interest rates and equity prices respond to the comments of MPC members, but the exchange rate does not respond to them. In the above mentioned studies for Poland observation windows of the width between one and seven days were used.

The contribution of the first part of the dissertation to the literature is to research into the impact of both current monetary policy and MPC communication on financial asset prices in Poland within an unified framework, the closest to the one proposed in the study of Gurkaynak et al. (2005). Furthermore, it was possible to use a longer sample (the years 2001-2016), containing: a period in which financial markets were more developed, and the period of NBP using the forward guidance policy (2013-2014). At the same time, researching into the impact of unexpected changes in the NBP reference rate on equity prices and on the exchange rate, 30 and 60-minute observation windows were used as well. They had not been used before in studies for Poland. These improvements had significant impact on the results.

The second part of the dissertation is a continuation of the group of articles indicating that neither commercial banks multiply up central bank money, in order to create deposits, nor do they intermediate loanable funds. Instead, commercial banks create deposits by making loans, and the central bank simply adjusts the supply of reserve money to demand for it (Jakab and Kumhof 2019, McLeay et al. 2014, Werner 2016). Otherwise it would not have achieved the operating target (see Disyatat 2008). But the fulfilment of one of the first two above

mentioned assumptions is necessary for the bank lending channel in the monetary policy transmission mechanism, as formulated by Bernanke and Blinder (1988), to operate.

Taking into account theoretical doubts regarding the originally formulated bank lending channel, Disyatat (2011) proposed an alternative mechanism: an interest rate increase is associated with a deterioration of bank balance sheet strength, measured, for example, by the level of capital, which lowers the supply of credit. The author argues that the results of the previous empirical literature could be partially consistent with the operation of the alternatively formulated bank lending channel, however, he suggests using more adequate methods to identify this mechanism.

This makes a challenge for the empirical literature on this channel, started with the study of Kashyap and Stein (1995). In order to identify the bank lending channel, they proposed comparing the responses of credit to a change in the interest rate between the groups of banks different in terms of characteristics which could insulate from a decrease in the supply of central bank money or deposits. The results of their study indicate that monetary policy tightening causes a smaller decrease in credit in large banks, which, according to their interpretation, can more easily adjust their structure of funding, consistent with the operation of the bank lending channel. Numerous subsequent studies checked for the role of other characteristics (for example, Kashyap and Stein 2000, Kishan and Opiela 2000).

Moving to the literature using Polish data, according to the results of the analysis of Pawłowska and Wróbel (2002), after an interest rate increase credit decreases more in large banks, banks with higher capital and (which is counterintuitive) with lower liquidity. Chmielewski (2005) confirmed the result on liquidity, additionally pointing to a smaller decrease in credit in banks with lower risk and in domestic banks. Havrylchyk and Jurzyk (2005), on the other hand, confirmed the result on the role of ownership (domestic versus foreign), but pointed to the opposite than Pawłowska and Wróbel (2002) result on size. A smaller decrease in credit in small banks is also consistent with the results of the study of Matousek and Sarantis (2009). On the other hand, they confirmed the result of Pawłowska and Wróbel (2002) regarding capital.

The main contribution to the literature of the second part of the dissertation is to propose a way to identify the mechanism formulated by Disyatat (2011). Furthermore, its results were compared with the results of the method of Kashyap and Stein (1995), as well as an empirical method was proposed to establish whether the mechanism formulated by Bernanke and Blinder (1988), or by Disyatat (2011) operates.

The third part of the dissertation is related to the literature on the transmission of the central bank interest rate to loan rates. It is based on a theoretical model, according to which a loan rate depends on a constant margin and a time-varying marginal cost of bank funding (see, for example, De Bondt 2005). The empirical literature for Poland includes the studies of Sznajderska (2012), Bystrova (2014), Kapuściński et al. (2016) using aggregate data, as well as Chmielewski (2003) and Stanisławska (2014) using bank level panel data. As a measure of the marginal cost of bank funding they use the WIBOR interest rate. Kapuściński et al. (2016) and Stanisławska (2014) point to the weakening of the relationship between loan rates and the WIBOR interest rate since the Great Recession.

A similar phenomenon (a weakening of the relationship between loan rates and an interbank interest rate) took place in developed economies. The literature points to two main possible reasons. According to the results of the studies of Illes et al. (2015) and von Borstel et al. (2015), although the relationship between loan rates and the interbank interest rate has weakened, it has remained strong between loan rates and the weighted average cost of

liabilities. This indicates that in the environment of macro-financial disturbances an interbank interest rate might not be an adequate measure of the marginal cost of bank funding. The results of the analysis of Żoła (2013), Illes and Lombardi (2013), Darracq Paries et al. (2014), Gambacorta et al. (2015) and Blagov et al. (2015) indicate that loan rates are also affected by risk – macroeconomic, and of borrowers and lenders. This implies the possibility of the margin being time-varying.

The contribution of the third part of the dissertation to the literature is, first, to account for both above mentioned explanations within one empirical model. Second, it is the first study estimating the weighted average cost of liabilities for Poland.

The fourth, last part of the dissertation complements the rich, contemporary empirical literature on the general macroeconomic effects of monetary policy. Its beginning are the studies of Bernanke and Blinder (1992), as well as of Sims (1992) for the United States. This literature usually uses vector autoregressive (VAR) models, with GDP, inflation, an interest rate and possibly the exchange rate, credit or money supply as endogenous variables. It identifies monetary policy shocks, meaning their unexpected changes (or lack thereof), and then analyses their impact on the above mentioned variables. For Poland, the basic points of reference are the cyclical studies on the transmission mechanism of monetary policy carried out at NBP: Demchuk et al. (2012), Kapuściński et al. (2014) and Kapuściński et al. (2016). Furthermore, Arratibel and Michaelis (2014) and Darvas (2013) analysed changes in the transmission mechanism over time, using VAR models with time-varying parameters. Postek (2011) researched into non-linearities in the transmission mechanism, using non-linear VAR models. Gajewski (2015) used standard VAR models, but analysed the regional effects of monetary policy. Usually these studies indicate that monetary policy tightening is associated with a decrease in economic activity and inflation, both in Poland and in developed economies, such as the United States. However, sometimes results inconsistent with economic theory appear. For example, Sims (1992) pointed to an increase in inflation after an interest rate increase in the United States. In Poland, mixed are results regarding the impact of monetary policy on the exchange rate. Kapuściński et al. (2016) found a depreciation of the exchange rate after monetary tightening in some specifications. Darvas (2013) found a depreciation in initial periods, and an appreciation in subsequent ones. Arratibel and Michaelis (2014) as well as Jarociński (2010) assumed an appreciation (by imposing sign restrictions).

Bernanke at al. (2005) argued that some results inconsistent with economic theory might be a result of a small number of variables in standard VAR models, which does not allow for the correct identification of monetary policy shocks – in reality the members of monetary policy committees observe a much larger number of variables. Therefore, the authors proposed the use of factor-augmented VAR models, which implicitly can take into account a large number of variables. The approach of Bernanke et al. (2005) is to use economically uninterpretable factors (also known as diffusion indices) as endogenous variables in VAR models. Belviso and Milani (2006) proposed a modification to this method, in which factors have economic interpretation. Both studies use data for the United States.

The fourth part of the dissertation is the first study of the monetary policy transmission mechanism in Poland using fully fledged factor-augmented VAR models. Previously, Balabanova and Bruggemann (2017) only added factors estimated on foreign variables to the standard set of variables. Benkovskis et al. (2011) used factors estimated on domestic variables, but analysed the effects of foreign, not domestic monetary policy. Additionally, according to the author's knowledge the analysis is the first to compare the results of the approaches of Bernanke et al. (2005) and Belviso and Milani (2006).

Aims and research hypotheses

The general aim of the studies making up the dissertation was to establish what are the macroeconomic effects of monetary policy in Poland. I divided it into four detailed aims.

The first of them was to analyse the impact of current monetary policy and central bank communication regarding monetary policy in the future on financial asset prices: equity, government bonds and the exchange rate.

The second detailed aim was to check the operation of the bank lending channel in the monetary policy transmission mechanism, as formulated by Disyatat (2011): monetary policy tightening is associated with the deterioration of bank balance sheet strength (measured by the share of non-performing loans, profitability and the level of capital), which causes a decrease in credit supply.

The third detailed aim was to research into the impact of measures of the marginal cost of bank funding (the interbank interest rate or the weighted average cost of liabilities) and risk – macroeconomic, as well as of borrowers and lenders – on loan rates.

The fourth, last detailed aim was to establish how far do the effects of monetary policy reach in Poland: whether they are limited to GDP, inflation and the exchange rate, or are they broader. The fourth aim partially overlaps with remaining ones, however, the part of the dissertation that fulfils it uses a different empirical strategy. Therefore, it (partially) makes a sensitivity analysis (see Angrist and Pischke 2010).

In order to fulfil the first detailed aim of the dissertation, I used the following, two-step empirical strategy. In the first step I constructed measures of current monetary policy and central bank communication regarding monetary policy in the future. To this end, I used data on changes in rates reflecting the expected path of the NBP reference rate for the next 12 months: WIBOR 1M, as well as FRA 1x2, 2x3, 2x6 and 9x12, in two-day windows around MPC decisions. I carried out a factor analysis on them, first estimating economically uninterpretable factors, and then rotating them. In order to construct the above mentioned measures I had to assume that close to MPC decisions changes in short-term interest rates reflect mainly monetary policy (current or communicated future) and that their changes uncorrelated with changes in the WIBOR 1M rate are mainly the result of central bank communication regarding monetary policy in the future.

In the second step I carried out a regression analysis, in which the dependent variables were equity prices, government bond yields and the exchange rate, and the independent variables were earlier constructed measures of current monetary policy and central bank communication regarding monetary policy in the future. In order to isolate factors other than monetary policy, I used only observations from the days of MPC meetings (changes in two-day windows). However, additionally I controlled for foreign interest rates, measures of risk and surprises in macroeconomic data releases.

As a sensitivity analysis, first, I analysed changes in coefficients over time. Second, I narrowed the width of the observation window to one day. The limitation of the one-day window, however, is that a short time between the beginning of the conference after MPC meetings, on which the Council can communicate its future monetary policy, and the fixing of FRA rates, worsens the quality of the estimates of measures of central bank communication regarding monetary policy in the future. Third, in cases of equity prices and the exchange rate, I narrowed the width of observation windows to 30-60 minutes. In this case, due to the unavailability of data on short-term interest rates at sufficiently high frequency, I used

alternative measures of monetary policy: the difference between the actual NBP reference rate and the NBP reference rate expected by professional forecasters for current monetary policy, and for central bank communication regarding monetary policy in the future – a narrative measure of MPC bias implied from statements after its meetings, dummy variables for the days of the introduction and changes in forward guidance, as well as revisions in inflation and GDP projections.

In order to fulfil the second detailed aim of the dissertation, I used publicly unavailable bank level panel data. I proposed the following, three-step procedure. The first two steps check the fulfilment of necessary conditions for the operation of the bank lending channel. The last step allows to establish the economic significance of the channel. In the first step I estimated the parameters of panel VAR models, with measures of economic activity, current monetary policy (from the first part of the dissertation) as well as the share of non-performing loans, profitability, the level of capital (in relation to risk-weighted assets) and credit as endogenous variables. Then I calculated the responses of the above mentioned measures of bank balance sheet strength and credit to a monetary policy impulse. In the second step I estimated the parameters of panel regression models, in which the dependent variable was credit growth, and the independent variables were, among others, the measures of bank balance sheet strength. In the third step I compared the actual response of credit to a monetary policy impulse with a counterfactual one, which assumes that the bank lending channel does not operate. The difference in responses indicated the effect of this channel.

As a sensitivity analysis, first, I replaced the measure of current monetary policy in a panel VAR model with the interbank interest rate, thereby, identifying the monetary policy shock inside, rather than outside the model. Second, I added exogenous variables: inflation, house prices, foreign interest rates, the exchange rate or a measure of risk. Third, I changed the number of lags in a panel VAR model. I also checked whether the standard empirical strategy, in which interaction variables between a measure of monetary policy and (in this case) the measures of bank balance sheet strength are added to panel regression models explaining credit growth, would identify the operation of the bank lending channel. I added an interaction variable between a measure of monetary policy and the share of market-based bank funding to panel regression models as well. If a high share of market-based funding weakens the impact of monetary policy, that would be consistent with the operation of the bank lending channel formulated by Bernanke and Blinder (1988). In the opposite case – in a way formulated by Disyatat (2011).

As far as the fulfilment of the third detailed aim of the dissertation is concerned, I also used publicly unavailable bank level panel data. First, for each bank in the sample I estimated a weighted average cost of liabilities, as a measure of the marginal cost of funding alternative to the usually used interbank market interest rate. To this end, I used individual data on deposit rates, aggregated data on remaining interest rates (as an approximation of the individual data) and individual data on the structure of funding. Then, in a model-based and an out-of-model way, I studied the adequacy of the above mentioned measures of the bank cost of funding. As far as the out-of-model way is concerned, I compared differences between loan rates (individual data) and the weighted average cost of liabilities or the interbank market interest rate before and since the Great Recession. I analysed loans for house purchases, for sole proprietors and for non-financial corporations. Regarding model-based methods, I used three, based on panel error correction models, with a loan rate as a dependent variable. The first method was to check for which of the measures of the marginal cost of funding the long-run multiplier is closer to unity. The remaining two methods compared the fit of the models in-sample and out of sample, when forecasting loan rates since the Great Recession.

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As independent variables in some error correction models I also used measures of risk. As the measures of macroeconomic risk I used: GDP growth rate expected by professional forecasters one-year ahead and GDP forecast dispersion, for borrowers' risk: the share of non-performing loans, and for lenders' risk: the capital buffer, measured as the difference between the actual solvency ratio, and the minimal solvency ratio under which the Financial Supervision Authority allows for a dividend pay-out (in the last two cases individual data).

The last, fourth detailed aim of the dissertation I fulfilled, similarly as in case of the first aim, within a two-step empirical strategy, in which the first step was a factor analysis. I carried it out on 132 macroeconomic variables for Poland, making up the following seven groups: real economic activity, inflation, credit, money, interest rates, financial markets and expectations. I did this in two different ways. The first one, proposed by Bernanke et al. (2005), was to estimate a given number of economically uninterpretable factors. Based on the practice in the literature and on sensitivity analysis I set the adequate number of factors to four. The second way, proposed by Belviso and Milani (2006), was to estimate one factor from each group of variables. Therefore, they make structural factors, having economic interpretation.

In the second step I used factors (separately: economically uninterpretable and structural) as endogenous variables in VAR models. I supplemented them with a measure of monetary policy. The combination of factor analysis and VAR models is called factor-augmented vector autoregressive models (FAVAR). After estimating the parameters of FAVAR models, I first calculated the responses of factors, and then of all variables used to estimate factors, to a monetary policy impulse. In case of models with economically uninterpretable factors I omitted the analysis of the responses of factors, however. In order to check whether FAVAR models identify monetary policy shocks in a more adequate way, I compared impulse response functions from them with those from standard VAR models.

In the study I carried out a multi-directional sensitivity analysis. I checked the role of the number of lags in a model, the measure of monetary policy used, the way of inference (Bayesian estimation instead of classical one) and shock identification, as well as data transformation and frequency.

In the dissertation I made the following hypotheses:

1. Both current monetary policy and central bank communication regarding monetary policy in the future affect financial asset prices in Poland.
   a) Monetary policy tightening (current or communicated future) is associated with a decrease in equity prices.
   b) Monetary policy tightening is associated with an increase in government bond yields.
   c) Monetary policy tightening is associated with an appreciation of the exchange rate.
2. The bank lending channel in the monetary policy transmission mechanism operates in Poland.
   a) Monetary policy tightening causes a deterioration in bank balance sheet strength (an increase in the share of non-performing loans, a decrease in profitability and in the level of capital).
   b) The deterioration in the bank balance sheet strength causes a decrease in credit supply.
   c) The impact of monetary policy tightening on credit would be smaller, if it did not cause the deterioration in bank balance sheet strength.
3. Both the marginal cost of bank funding and risk affect loan rates in Poland.
   a) An increase in the bank funding cost is associated with an increase in loan rates.
   b) The weighted-average cost of liabilities is a more adequate measure of the marginal cost of bank funding than the interbank market interest rate.

c) An increase in risk (macroeconomic, of borrowers and lenders) is associated with an increase in loan rates.
4. Monetary policy tightening in Poland has far-reaching macroeconomic effects.
a) Monetary policy tightening causes a decrease in economic activity.
b) Monetary policy tightening causes a decrease in inflation.
c) Monetary policy tightening causes a decrease in credit and money supply.
d) Monetary policy tightening causes an increase in interest rates.
e) Monetary policy tightening causes a decrease in financial asset prices (except for the exchange rate, which appreciates).
f) Monetary policy tightening causes a deterioration in expectations regarding economic activity in the future and an increase in the difference between longer-term interest rates and a short-term interest rate.

Results

The results of the study from the first part of the dissertation indicate that both current monetary policy and central bank communication regarding monetary policy in the future affect financial asset prices in Poland. However, the results partially differ depending on the window of observation and sample.

Central bank communication regarding monetary policy in the future is significant for equity prices. Analysis in two-day, as well as 30- and 60-minute windows did not reveal significant decreases in equity prices following the tightening of current monetary policy, however, it was found in one-day windows. This means that the hypothesis 1a was at least partially confirmed.

The hypothesis 1b was verified positively. Both current monetary policy and MPC communication affect government bond yields.

The exchange rate used to depreciate after MPC statements signalling future monetary policy tightening, but such an impact disappeared at the end of the sample (after the Great Recession). In two-day windows, for the most of the sample, the exchange rate appreciated or did not change in a statistically significant way after an increase in the current interest rate. In 30- and 60-minute windows around the releases of MPC decisions since 2008 – it depreciated. This means that also the hypothesis 1c was verified positively partially.

It should be noted that econometric models used in the first part of the dissertation, but also in its remaining parts, are linear with respect to the direction of the change in the interest rate. This means that, for example, the expression "monetary policy tightening is associated with a decrease in equity prices" means that, on average, an interest rate increase causes a decrease in equity prices, and a decrease – a rise. The description of the effect of the tightening, not of the loosening of monetary policy is only a matter of normalisation.

According to the results of the analysis in the second part of the dissertation, the effects of monetary policy in Poland are amplified through the operation of the bank lending channel. The hypothesis 2a was confirmed. Monetary policy tightening is associated with an increase in the share of non-performing loans with some lag (after three quarters). This is reflected in the deterioration of the profitability of banks, and at first also in a decrease in their capital buffer. Afterwards, banks improve their capital position, to the extent larger than what would be sufficient to balance its earlier worsening. This might result from a response to a general increase in risk, reflected, for example, in a decrease in economic activity.

Hypothesis 2b was at least partially verified positively. Credit growth is the higher, the higher the bank profitability and the higher their capital buffer. The relationship between the share of non-performing loans and credit growth is negative, if the remaining measures of bank balance sheet strength are not controlled for. If they are, the relationship ceases to be statistically significant. However, the result might be the effect of collinearity between the measures of bank balance sheet strength.

Monetary policy tightening causes a decrease in credit (as compared to the case of no monetary shock). The counterfactual analysis showed that it would be smaller, if the higher interest rate was not associated with a deterioration in bank balance sheet strength (or, in other words, if the bank lending channel did not operate). The estimated effect of this channel differs somewhat depending of the specification of the model. Approximately, it accounts for about 23% of a decrease in credit after monetary policy tightening. This means that the hypothesis 2c was confirmed.

The sensitivity analysis did not bring qualitative changes in the results above. Furthermore, it turned out that the standard empirical strategy would not identify the operation of the bank lending channel. At the same time, a higher interest rate is associated with a stronger response of credit in banks with a higher share of market-based funding, which is consistent with the operation of the bank lending channel in a way formulated by Disyatat (2011), rather than by Bernanke and Blinder (2011).

The study from the third part of the dissertations showed that both the marginal cost of bank funding and risk affect loan rates, and that the way of measuring the marginal cost of funding matters. The hypothesis 3a was verified positively. In case of each analysed credit type an increase in the marginal cost of bank funding causes an increase in loan rates. Irrespectively of the way of measuring it, this variable explains the largest part of the variability of loan rates, and the relationship is either proportional or close to proportional.

The hypothesis 3b was partially verified positively. According to the out-of-model criterion, the weighted average cost of liabilities is a more adequate measure of the marginal cost of bank funding than the interbank market interest rate, because the difference between loan rates and the former measure increased less since the Great Recession than versus the latter measure (in case of loans for non-financial corporations even slightly decreased, remaining more stable). As far as the model-based criteria are concerned, first, the long-run multiplier was not statistically different from unity in a meaningfully larger number of cases for the weighted average cost of liabilities than for the interbank market interest rate. However, second, the fit of the models with the weighted average cost of liabilities in sample was worse. Third, out of sample (in the period since the Great Recession), in most cases models with the weighted average cost of liabilities had a better predictive quality. It means that this measure is more adequate according to three criteria out of four.

Regarding the impact of risk on loan rates, the results for the effects of the expected GDP growth and the dispersion of GDP growth forecasts were not robust. The former measure was statistically significant only in models with the interbank market interest rate, while the latter —only in models with the weighted average cost of liabilities. Similarly in case of the share of non-performing loans, which was significant only in models for rates on loans for non-financial corporations and sole proprietors with the interbank market interest rate. On the other hand, the relationship between the capital buffer and rates on loans for house purchases and for non-financial corporations turned out to be robust. Therefore, the hypothesis 3c also was confirmed partially.

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The results from the last, fourth part of the dissertation indicate that monetary policy tightening has far-reaching macroeconomic effects. A positive monetary impulse is associated with a decrease in the following (structural) factors: real economic activity, credit, money, financial markets and expectations, as well as with a decrease in the interest rate factor. This means that the responses of the variables, on which the factors were estimated, were in line with economic theory, with the exception of the response of the exchange rate, which depreciates (instead of appreciating) and of the difference between longer-term interest rates and the short-term interest rate, which decreases (instead of increasing). Their responses to monetary policy tightening are qualitatively similar to the results from the models with economically uninterpretable factors, although it seems that the first approach (structural factors) underestimates the impact on the labour market, while the second one (economically uninterpretable factors) gives less precise estimates. This means that in a finite sample the exact specification of FAVAR models might matter. As far as the impact of monetary policy on the key macroeconomic variables is concerned, the following results are robust: an increase in the interest rate causes a decrease in production, employment, job offers, prices, credit, equity prices and the exchange rate (in the last case meaning a depreciation), as well as an increase in unemployment and non-performing loans. Generally, hypotheses from 4a to 4d were largely confirmed, while hypotheses 4e and 4f were confirmed only partially.

The depreciation of the exchange rate after monetary policy tightening in data with monthly frequency, with an appreciation in data with high frequency (one of the results of the study from the first part of the dissertation), could be explained in at least two ways. According to the first one, in data with low frequency the impact of the interest rate on the risk premium (through its impact on economic activity) exceeds its consequences for the difference between rates on domestic and foreign deposits, effect of which dominates in data with high frequency. The second explanation indicates that although after monetary policy tightening domestic deposits become more attractive, equity might offer a lower return. This explanation is supported by a negative relationship between the current interest rate and equity prices in one-day windows around MPC decisions, as well as by the fact that as much as three-fours of the variability in the exchange rate and two-thirds of the variability in equity prices are explained by one factor (the financial market factor). Establishing which of these explanations (if any) is closer to the truth requires further research.

The results of the fourth part of the dissertation were not qualitatively sensitive to changes in the specification of the models. Furthermore, it turned out that the expanding of the information set in FAVAR models, as compared to the standard VAR model, might contribute to a better identification of monetary policy shocks. This is suggested by the disappearance of the price puzzle present in the latter model after including information from additional variables, used in FAVAR models, as well as no price puzzle in FAVAR models itself.

Concluding remarks

The results of the studies making up the dissertation have important implications for economic policy. First, the fact that central bank communication regarding monetary policy in the future affects financial asset prices means that the MPC could effectively use forward guidance in order to affect monetary conditions in case of binding zero lower bound for nominal interest rates. Although the probability of such an event in Poland remains low, with low inflation and low interest rates it has been elevated (Brzoza-Brzezina et al. 2016).

Second, the operation of the bank lending channel might, in some cases, make the interrelation between monetary and macroprudential policies non-trivial. On the one hand, for example, in the period of a positive output and credit gap, systematic (i.e. in line with the reaction function, including output and credit gap, respectively) monetary and macroprudential policies complement each other. On the other hand, the effects of a monetary shock are partially compensated by systematic macroprudential policy. This might require the coordination of policies in order to achieve optimal outcomes.

Third, the fact that rates on all bank liabilities, not only on unsecured loans on the interbank market, matter for loan rates sheds a new light on the transmission of the central bank interest rate to other interest rates. In economies in which non-banking sector deposits make up the main source of bank funding, the central bank policy rate affects loan rates to the extent that it affects deposit rates. In Poland, since the Great Recession deposit rates decreased less than rates on interbank loans, which partially explains persistent elevated credit spreads. A complementary explanation, also consistent with the results of the study, is a higher risk perception. This has also implications for the discussion on the effects of negative central bank interest rates, which (in previous cases of use) appear to affect rates on unsecured interbank loans more than on deposit rates. This means that they affect loan rates only to a limited extent, weakening the transmission of negative nominal interest rates to the real economy.

Fourth, the results of the last part of the dissertation confirm that changes in the NBP reference rate can support the achievement of the inflation target (a higher interest rate is associated with a lower inflation). However, it should be noted that quantitative effects from models are uncertain, as suggested by wide confidence intervals for the response of prices to a monetary policy impulse. For example, according to the point estimate, the lowering of inflation from 5 to 2.5% would require raising the interest rate by 2.94 percentage points (more than 11 hikes of 0.25 percentage points). However, 68-percent confidence intervals span between 1.92 and 6.25 percentage points. Furthermore, the maximum impact of each interest rate hike would occur after 15 months. This suggest gradualism on the one hand (see Bernanke 2004), and forward-lookingness on the other hand when conducting monetary policy.

The studies from respective parts of the dissertation can be extended in the future in the following directions. As far as the first part of the dissertation is concerned, it could be useful to check whether the results remain unchanged when the measure of MPC communication is constructed using the text mining method to analyse statements after the meetings of the Council (see, for example, Hansen and McMahon 2016). Regarding the second part of the dissertation, the role of the banking sector as a source, not only as an "amplifier" of shocks could be analysed, using the results of senior loan officer surveys (see, for example, Bassett et al. 2014, Altavila et al. 2015). The analysis from the fourth part of the dissertation could be supplemented with the use of mixed frequency data, adding, for example, quarterly GDP. The expectations maximisation algorithm could be used for that purpose. Furthermore, a less arbitrary choice and grouping of variables while estimating structural factors could be considered. In could also be interesting to combine the high frequency identification of monetary policy shocks with the approach of Romer and Romer (2004), by adding a forecast factor. Having a larger number of observations FAVAR models with time-varying parameters could be estimated as well.

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Appendix

Research and academic activity

Education:

1. Master studies, SGH Warsaw School of Economics, 2011-2013

Programme: economics

Title of master thesis: The effectiveness of non-standard monetary policy instruments. The case of the Federal Reserve (*Skuteczność niestandardowych instrumentów polityki pieniężnej. Przykładu Banku Rezerw Federalnych*)

Supervisor: prof. dr hab. Andrzej Sławiński

2. Bachelor studies, Nicolaus Copernicus University in Toruń, 2008-2011

Programme: economics

Journal articles:

1. Kapuściński M. (2018), How far does monetary policy reach? Evidence from factor-augmented vector autoregressions for Poland, *Bank i Kredyt*, Vol. 49, No. 3, p. 191-216.
2. Kapuściński M., Stanisławska E. (2018), Measuring bank funding costs in the analysis of interest rate pass-through: Evidence from Poland, *Economic Modelling*, Vol. 80, p. 288-300.
3. Kapuściński M. (2017), The role of bank balance sheets in monetary policy transmission: Evidence from Poland, *Eastern European Economics*, Vol. 55, p. 50-69.
4. Kapuściński M. (2017), Monetary policy and financial asset prices in Poland, *Bank i Kredyt*, Vol. 48, No. 3, p. 263-294.

Working papers:

1. Kapuściński M., Pietryka I. (2018), *The impact of the excess reserves of the banking sector on interest rates and money supply in Poland*, NBP Working Paper, No. 300, Narodowy Bank Polski.
2. Chmielewski T., Kapuściński M., Kocięcki A., Łyziak T., Przystupa J., Stanisławska E., Wróbel E. (2018), *Monetary policy transmission mechanism in Poland. What do we know in 2017?*, NBP Working Paper, No. 286, Narodowy Bank Polski. (Chmielewski T., Kapuściński M., Kocięcki A., Łyziak T., Przystupa J., Stanisławska E., Wróbel E. (2018), *Mechanizm transmisji polityki pieniężnej w Polsce. Stan wiedzy w 2017 roku*, Materiały i Studia, nr 330, Narodowy Bank Polski.)
3. Kapuściński M. (2017), *How far does monetary policy reach? Evidence from factor-augmented vector autoregressions for Poland*, NBP Working Paper, No. 274, Narodowy Bank Polski.
4. Kapuściński M., Stanisławska E. (2016), *Interest rate pass-through in Poland since the global financial crisis*, NBP Working Paper, No. 247, Narodowy Bank Polski.

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5. Kapuściński M. (2016), *The role of bank balance sheets in monetary policy transmission. Evidence from Poland*, NBP Working Paper, No. 245, Narodowy Bank Polski.

6. Kapuściński M., Kocięcki A., Kowalczyk H., Łyziak T., Przystupa J., Stanisławska E., Sznajderska A., Wróbel E. (2016), *Monetary policy transmission mechanism. What do we know in 2015?*, NBP Working Paper, No. 249, Narodowy Bank Polski. (Kapuściński M., Kocięcki A., Kowalczyk H., Łyziak T., Przystupa J., Stanisławska E., Sznajderska A., Wróbel E. (2016), *Mechanizm transmisji polityki pieniężnej w Polsce. Co wiemy w 2015 roku?*, Materiały i Studia, nr 323, Narodowy Bank Polski.)

7. Kapuściński M., Ścibisz D. (2016), *Quantitative easing, negative interest rates and money creation. What central banks can and cannot do?*, Institute of Economic Research Working Papers, No. 26/2016, Institute of Economic Research.

8. Kapuściński M. (2015), *Monetary policy and financial asset prices in Poland*, NBP Working Paper, No. 216, Narodowy Bank Polski.

9. Kapuściński M., Łyziak T., Przystupa J., Stanisławska E., Sznajderska A., Wróbel E. (2014), *Monetary policy transmission mechanism. What do we know in 2013?*, NBP Working Paper, No. 180, Narodowy Bank Polski. (Kapuściński M., Łyziak T., Przystupa J., Stanisławska E., Sznajderska A., Wróbel E. (2014), *Mechanizm transmisji polityki pieniężnej w Polsce. Co wiemy w 2013 roku?*, Materiały i Studia, nr 306, Narodowy Bank Polski.)

Teaching:

1. Econometrics – autumn semester 2017/2018, autumn semester 2016/2017, spring semester 2016/2017, autumn semester 2015/2016, autumn semester 2014/2015 (lectures 4 hours, exercise 258 hours)
2. Applied econometrics – autumn semester 2016/2017 (exercise 30 hours)

Conferences, seminars, workshops:

1. Conference: *The problems of the global economy (Problemy Gospodarki Światowej)*, Nicolaus Copernicus University in Toruń, Toruń, April 2018, presentation: *How far does monetary policy reach? Evidence from factor-augmented vector autoregressions for Poland (Jak daleko sięga polityka pieniężna? Wyniki z czynnikowych modeli wektorowej autoregresji dla Polski)*, co-hosting of the conference
2. *NBP Seminar*, Narodowy Bank Polski, Warsaw, January 2018, presentation: *How far does monetary policy reach? Evidence from factor-augmented vector autoregressions for Poland (Jak daleko sięga polityka pieniężna? Wyniki z czynnikowych modeli wektorowej autoregresji dla Polski)*
3. *Outdoor Economic Seminar*, Students' Research Association for Finance and Macroeconomics, Modlin, December 2017, presentation: *How far does monetary policy reach? Evidence from factor-augmented vector autoregressions for Poland (Jak daleko sięga polityka pieniężna? Wyniki z czynnikowych modeli wektorowej autoregresji dla Polski)*
4. Conference: *The problems of the global economy (Problemy Gospodarki Światowej)*, Nicolaus Copernicus University in Toruń, Toruń, kwiecień 2017, *The transmission of negative interest rates to loan and deposit rates in the euro area (Transmisja ujemnych stóp procentowych do oprocentowania kredytów i depozytów w strefie euro)*, co-organisation of the conference

5. *Seminar under technical cooperation addressed to developing countries,* Narodowy Bank Polski, Warsaw, December 2016, presentation: *(Structural) factor augmented vector autoregressions.*

6. *NBP and Deutsche Bundesbank workshop,* Narodowy Bank Polski, Cracov, September 2016, presentation: *Interest rate pass-through in Poland since the global financial crisis*

7. *NBP Summer Workshop,* Narodowy Bank Polski, Warsaw, June 2016, poster: *The role of bank balance sheets in monetary policy transmission. Evidence from Poland*

8. Conference: *The problems of the global economy (Problemy Gospodarki Światowej),* Nicolaus Copernicus University in Toruń, Toruń, April 2016, presentation: *Quantitative easing, negative interest rates and money creation. What central banks can and cannto do? (Luzowanie ilościowe i ujemne stopy procentowe a kreacja pieniądza. Co banki centralne mogą, a czego nie?)*

9. Conference: *Economic Challenges in Enlarged Europe,* Tallinn University of Technology, Talinn, June 2016, presentation: *The role of bank balance sheets in monetary policy transmission. Evidence from Poland*

10. Conference: *Advances in Macroeconomics and Finance,* The Rimini Centre for Economic Analysis, Rimini, May 2016, presentation: *Interest rate pass-through in Poland since the global financial crisis*

11. *NBP Seminar,* Narodowy Bank Polski, Warsaw, December 2015, presentation: Does the bank lending channel work in Poland? *(Czy w Polsce działa kanał kredytów bankowych?)*

12. Conference: *The problems of the global economy (Problemy Gospodarki Światowej),* Nicolaus Copernicus University in Toruń, April 2015, presentation: *Does the communication of the Monetary Policy Council Matter? (Czy komunikacja Rady Polityki Pieniężnej ma znaczenie?)*

13. *Outdoor Economic Seminar,* Students' Research Association for Finance and Macroeconomics, Teresin, April 2015, presentation: *Misconceptions on monetary policy and money and what to replace them with (Błędne przekonania o polityce pieniężnej i pieniądzu oraz czym je zastąpić)*

14. *Seminar under technical cooperation addressed to developing countries,* Narodowy Bank Polski, Warsaw, March 2015, presentation: *Does monetary policy affect credit supply? Panel data analysis*

Reviews:

1. NBP Working Papers
2. Economic and Social Overview – Students' Research Association for Finance and Macroeconomics – twice

Grants:

1. VIII NBP competition for research projects, The impact of the excess reserves of the banking sector on interest rates and money supply in Poland (Wpływ nadwyżkowych rezerw sektora bankowego na stopy procentowe i podaż pieniądza w Polsce), 2017-2018

2. NCN grants – Sonata, The role of the Chinese economy in the global economy and its impact on emerging economies – an application of the global VAR model (Rola gospodarki chińskiej w gospodarce światowej i jej wpływ na gospodarki wschodzące – zastosowanie globalnego modelu VAR), 2017-2020