

NBP Working Paper No. 249

Monetary policy transmission mechanism in Poland.

What do we know in 2015?

Mariusz Kapuściński, Andrzej Kocięcki, Halina Kowalczyk, Tomasz Łyziak,
Jan Przystupa, Ewa Stanisławska, Anna Sznajderska, Ewa Wróbel



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Introduction

“Unduly pessimistic view of what monetary policy can accomplish has been a more important source of policy errors and poor outcomes over the history of the Federal Reserve [than overinflated belief in the power of monetary policy].

Central bankers should have a balance of humility and hubris. They need a sound knowledge of both the limitations and the powers of monetary policy. That is, the most important characteristic to look for in central bankers is not their inherent optimism or pessimism about the effectiveness of monetary policy, but rather their understanding of how the economy works and the possible contributions of policy.”

(Romer and Romer, 2013)

Romer and Romer (2013) point out that insufficient confidence on the part of monetary authorities in their ability to influence the economy with monetary policy instruments was the reason for a number of errors committed by the Federal Reserve System in the last century – notably in the 1930s and 1970s. The authors point to signs of similar pessimism in statements by US central bankers in the first years after the onset of the global financial crisis. They put forward the argument that the belief that the impact of monetary policy on the economy is limited, coupled with concerns about the costs of such a policy, hampered the response of the Federal Reserve System to the weakening economic conditions.

Both an overestimation and underestimation of the effects of monetary policy may lead to errors in its implementation. For this reason, the monetary policy transmission mechanism, i.e. a complex set of interrelations through which monetary policy affects economic conditions and inflation, is an essential area of research and analysis for contemporary central banks.

Similar to the previous issues of the report (Demchuk *et al.*, 2012; Kapuściński *et al.*, 2014), the present, third issue of this report on the functioning of the transmission mechanism in Poland seeks to analyse the most important macroeconomic relations through which the central bank can pursue its monetary policy targets. Contrary to the occasionally expressed belief in a significant weakening of the economic impact of the basic monetary policy instruments of Narodowy Bank Polski, i.e. the short-term interest rate, we show that despite the shifts in the relative significance of the monetary transmission channels, due to structural changes, cyclical fluctuations, or shocks, the impact of monetary policy on the economy remains relatively stable. Therefore, referring to the observation by Romer and Romer (2013), we believe that while assessing the impact of monetary policy on the Polish economy, excessive pessimism is not justified.

Summary

Since 2011 r. the Bureau of Economic Research of the Economic Institute at NBP has been publishing a report on the functioning of the transmission mechanism in Poland. The aim of the report is to gather the results of the most recent studies in this area and to present them in a non-technical manner, allowing for their practical use in monetary policy analyses. Although studies on the transmission mechanism are conducted within the New-Keynesian paradigm, we treat its theoretical achievements – according to Mayer’s (1996) terminology – in terms of *empirical-science theory* rather than *formalistic theory*. Therefore, the studies presented in this report share a common empirical character and aim at finding the most comprehensive answer to the question on the role of monetary policy for the main economic variables in Poland.



In the previous report of this series (Kapuściński *et al.*, 2014) we demonstrated that changes in the transmission mechanism – referring both to the composition of effective transmission channels as well as the general strength of this mechanism – are of a diversified nature. On the one hand, they are associated with trends characteristic of the structure of the Polish economy, such as the growing scale of financial intermediation or increasing economic openness. On the other hand, these changes result from the cyclical properties of the monetary transmission mechanism and the asymmetry observed at some of its stages. Temporary shocks, e.g. those connected with the global financial crisis, represent another cause of changes in transmission mechanism.

At that time, we indicated two significant conclusions concerning the monetary policy transmission mechanism in Poland. First of all, we noted a sharp decline in the impact of the exchange rate changes on consumer prices (CPI), rendering the exchange rate channel relatively weaker and less effective. We recognised that the fall of the exchange rate pass-through is mainly of structural nature, reflecting changes in the production process associated with the growing share of international enterprises in production. Secondly, we indicated that despite the weakening of the exchange rate channel, the response of inflation to changes in policy interest rates remains relatively strong. We explained this effect with the change in the composition of the transmission channels – while on the one hand we noted a weakening of the exchange rate channel, on the other we indicated a faster and slightly stronger impact of demand shocks on prices and a heightened level of forward-lookingness in the economy.

In this report, we strive to verify the legitimacy of the above conclusions based on new data and extended methods of data analysis.

A new development observed in the Polish economy since mid-2014 and reflected in the content of the report is deflation. The environment of low and negative inflation leads to the question about the degree of anchoring of inflation expectations, and about the impact of inflation expectations on economic processes and their role in the monetary policy transmission mechanism.



In our analyses we use a number of model tools. In accordance with the trends observed in empirical literature, structural vector autoregression models (SVAR) provide an important tool for reasoning on the overall features of the monetary policy transmission mechanism in Poland as well as its selected channels and their effectiveness. In the study on the strength and lags in the transmission mechanism and channels of

central bank impact on the economy we also use classic structural models, i.e. a new version of the small structural transmission mechanism model (MMT 2.1) and QMOTR, model of the type of the Global Projection Models, adjusted to the specific nature of the Polish economy. In the study on individual transmission mechanism channels we use tools adjusted to research questions we raise. In the current version of the report we also focus more on the interpretation of individual data.



The presentation of the results of the models is preceded by an assessment of the structural features of the Polish economy with a potential impact on the functioning of the monetary policy transmission mechanism and its individual channels. This issue is addressed in the first part of the report.

International studies conducted on large groups of economies show that the most important factors responsible for the diversified reactions of the economy to changes in monetary policy instruments include: the level of financial development and openness of the economy, competition in the banking sector, labour market rigidities and production structure (share of goods production in the added value). The assessment of the potential role of those factors for the monetary policy transmission mechanism in Poland shows that the relatively low (as compared to the euro area) advancement of the financial intermediation system in Poland and the lower openness of the Polish economy may mean a weaker reaction of prices and production to changes in interest rates. Whereas the first of the above factors should result in reduced lags of the monetary policy transmission mechanism, the latter may contribute to their extension. Taking into account the structure of production, it seems that the share of manufacturing sectors in added value in Poland, exceeding the corresponding share in the euro area, should consequently strengthen the effects of the Polish monetary policy impact. On the other hand, lower price and wage rigidities should strengthen the response of inflation to monetary policy impulses while decreasing the effects of this policy for the economic conditions.

Adopting a dynamic perspective, we observe a gradual development of the financial system and an increasing openness of the economy, which should result in a trend toward a gradual strengthening of the monetary policy transmission mechanism in Poland. However, it should be remembered that this conclusion is formulated under the assumptions of all other conditions being constant (*ceteris paribus*). However, in relation to the impact of the openness of the economy on the transmission mechanism, there exist factors mitigating the impact of the exchange rate on economic activity and prices. To mention just a few, it is the growing share of Poland in the global value chains (GVC) as well as the decline in the level and volatility of inflation, in particular, in relation to the disinflation period.



In the second part of the report we assess the basic features of the monetary policy transmission mechanism.

In the beginning, using vector autoregressive models we present stylized facts of the monetary policy transmission mechanism in Poland. The picture obtained with these tools, irrespective of their specification, is quite homogenous.

- Exogenous interest rate shocks influence credit volumes, economic activity measures (GDP, consumption, investment, industrial production) and the level of prices in a statistically significant manner. These shocks explain a similar part of the variability of forecasts of industrial production and prices to a comparable extent as in the advanced economies.

- An exchange rate appreciation shock has a temporary negative effect on GDP through a slowdown in exports. However, in a long-term horizon, we face a positive impact of appreciation on the real sector due to the simultaneous decline in a short-term interest rate. The impact of exchange rate shock on prices is low.

We perform the identification of the strength and lags in the monetary policy transmission mechanism in Poland using MMT 2.1 and QMOTR 2 structural models, constructed according to the New-Keynesian paradigm. The transmission is assessed synthetically, taking into account the maximum response of the annual change of economic activity and inflation to changes in the short-term interest rate. It is worth noting that such reactions are determined not only by the construction features of the models used, but also by the nature of the monetary policy impulse (i.e. the period for which interest rate changes), the form of the monetary policy rule and the type of analysed economic activity and inflation indicators (level, quarterly growth, annual growth).

- An increase of 1 percentage point in the money market interest rate for a period of one quarter generates a maximum slowing of approximately 0.1-0.2 p.p. in the annual GDP growth. In the QMOTR model the response of economic activity to the monetary policy impulse is smaller than in the case of the MMT model and it also takes place with less lag. A monetary policy tightening also results in a decline in annual price growth. Core inflation excluding food and energy prices, decreases by a maximum of approximately 0.35 p.p. This decline is comparable in both models.
- The analysis of cyclical features of the monetary policy transmission mechanism in Poland, conducted with the use of the QMOTR model, indicates that at the recovery, the response of inflation to changes in short term interest rates is stronger and faster than at the recession. This may be partly associated with cyclical differences in the central bank response function, since in periods of recession we face a higher coefficient of interest rates smoothing than in recovery periods.
- In accordance with additional simulations performed with the use of the MMT model, the maximum response of the annual price growth to a rise in money market interest rate by 1 percentage point for a period of four quarters amounts to approx. -0.6 p.p. and takes place in the sixth quarter after this impulse. The extended period of interest rate impulse allows for a better separation of various transmission channels represented in the model. An attempt aimed at such decomposition shows that 70% of the maximum reaction of the annual price dynamics results from effects of the interest rate channel and credit channel and approx. 30% – from the exchange rate channel effects. Irrespective of the adopted decomposition method, in the strongest transmission horizon the strength of the interest rate channel is bigger than in the case of the credit channel.



The third part of the report presents the findings of selected studies on the functioning of individual monetary policy transmission channels.

The main conclusions concerning the pass-through from the NBP reference rate to money market rates and retail rates in the banking system are as follows:

- Following the disturbances of the severe phase of the global financial crisis, the transmission of monetary policy decisions to the interbank market has significantly improved. Money market rates adjust well and fast to monetary policy decisions, and spreads between them and the NBP reference rate remain at levels

close to zero. The level of the shortest money market rates is significantly affected not only by the NBP reference rate but also by the method of liquidity management used by the NBP.

- Spreads between deposit rates and WIBOR 3M rate remain higher than in the pre-crisis period; this refers, in particular, to deposits with a maturity of over 6 months. Lending spreads, in particular in the case of corporate loans, are much closer to those observed in the pre-crisis period.
- While decomposing lending spreads it can be noticed that factors affecting them were different in the pre-crisis period (until mid-2007), at the time of the financial crisis (from mid-2007 until the end of 2010) and after 2011, when the financial crisis turned into sovereign debt crisis. In all those periods, the monetary policy based on maintaining high liquidity, in particular during financial crisis, contributed to a reduction of spreads. On the one hand, in the financial crisis period, a strong rise in risk associated with the financing of sovereign debt triggered a significant increase in the spreads. On the other hand, credit risk associated with business operations has recently been perceived by banks as a factor responsible for lending spread developments.
- Another interpretation of the developments in the lending rate emphasises the role of the rising cost of bank financing. Until the outbreak of the financial crisis our indicator of banks' financing cost (constructed as the weighted average of different categories of banks' liabilities multiplied by the corresponding interest rates) maintained a fixed relation to the NBP reference rate. At the turn of 2008, as a result of rise in the interest rate on retail deposits, which constitute the banks' most important source of funding, the difference between banks' financing cost and the NBP reference rate increased rapidly, to subsequently decrease gradually. It still hovers above the pre-crisis level. The developments in the difference between banks' financing cost and the WIBOR 3M interbank market rate were similar, which implies that in the period after the Lehman Brothers collapse, the money market rate ceased to be used as a good approximation of banks' marginal financing cost. Analysing the developments in lending interest rates from this point of view, we observe that whereas in the crisis period lending spreads increased substantially in relation to the WIBOR 3M rate, spreads calculated against banks' financing costs remained relatively stable. It suggests, in accordance with the results of a similar analysis for the euro area (Illes *et al.*, 2015), that the policy of lending interest rate setting by banks has not changed as significantly as it would result from the analysis of lending interest rate spreads calculated against money market rates.
- Changes in short term money market interest rates are fully passed through to the average interest rate on household deposits, with the strongest adjustment for deposits with a maturity from 1 to 3 months (the financial crisis effect – at that time banks searched for liquidity with such maturity). In the case of corporate deposits, the adjustment of the interest paid on them to changes in money market rates is not full. On the other hand, the total lending interest rates, both to households and to firms, are fully adjusted to changes in market rates. The influence of the dummy variable showing the impact of the financial crisis on lending costs is clearly higher in the case of households than in the case of firms. However, it declines over time, reflecting the gradual absorbing of crisis disruptions.

Besides the analysis of the impact of short term money market interest rates on deposit and lending rates, we have also conducted studies on the monetary policy impact on yields on Treasury bonds and share prices:

- Irrespective of the maturity period, there exist long-term relationships between yields on Treasury bonds and the annual money market rate (WIBOR 1Y) – taken into account here instead of a shorter rate

(WIBOR 3M), in order to illustrate the effects of both monetary policy and central bank communication. The shorter the maturity of the bonds, the stronger they become.

- The impact of the current monetary policy and central bank communication on yields on Treasury bonds was also confirmed with higher frequency data, in the framework of the analysis conducted in two-day windows comprising decision-making meetings of the Monetary Policy Council. Yields on Treasury bonds increase following the current or expected future tightening of the monetary policy. Whereas in the case of yields on Treasury bonds both factors have a comparable impact, for the developments in share prices communication of future monetary policy decisions is found much more significant.

The significant role of central bank communication is confirmed by the assessment of the effects of direct signalling of future monetary policy – the so-called *forward guidance* – used by the Monetary Policy Council from September 2013 to June 2014. In the light of the presented results it seems that the use of this tool was effective in terms of its impact on the path of expectations related to future interest rates, also contributing to a stabilisation of those expectations (inter alia, their lower sensitivity to the so-called macroeconomic surprises).



While analysing the adjustment of loans to changes in short term interest rates, comprising both the effects of demand for loans and loan supply (the functioning of the credit channel of the transmission mechanism), we find the following patterns:

- In the period following the outbreak of the financial crisis the role of lending disturbances in explaining industrial production increased significantly. At the same time, the role of monetary policy disruptions in the loan volume developments clearly increased.
- It turns out that exogenous credit supply shocks arising as a result of a change in banks' preferences in granting loans, e.g. in connection with a change in the approach to risk (the so-called risk-taking channel), have significant macroeconomic effects, explaining a relatively large part of the variance in lending. The strong response of lending to small enterprises (micro-companies), to which banks probably attribute a higher level of risk, to changes in short-term interest rate, as well as the separation of non-observable loan demand and supply functions from the data on lending, suggests that the credit channel is functioning.
- In the direct identification of the bank lending channel effects, we use its new theoretical concept (Disyatat, 2010), according to which changes in central bank interest rates influence the strength of commercial banks' balance sheets (share of non-performing loans, profitability and capital buffer), and through them – the supply of bank loans. Studies performed on individual data indicate that an increase in interest rates raises the share of non-performing loans and reduces banks' profitability and capital buffer. This interaction boosts the response of lending to monetary policy disruptions. Consequently, the bank loan channel strengthens effects of the monetary policy in Poland.



Results of the latest studies on the exchange rate channel confirm our earlier observations that its functioning has changed significantly in recent years and that its relative weight in the transmission mechanism of monetary policy impulses in Poland has declined.

- The nominal effective exchange rate significantly depends on expectations concerning its future developments as well as on the risk premium, approximated by the output gap. The disparity of interest rates, although statistically significant and relatively stable over time, has a smaller role in explaining the exchange rate of the zloty. The response of the exchange rate to changes in the disparity is slightly stronger in periods of downturn as compared to periods of good economic conditions.
- The impact of changes in the exchange rate on the volume of the Polish exports has recently decreased significantly – whereas prior to Poland’s accession to the European Union the exchange rate explained approximately 30% of the growth in exports, currently this weight does not exceed 8%. At the same time, the role of external factors in explanation of the volume of exports has increased significantly. We interpret these results as an effect of growth in the role of international corporations making settlements within a capital group and the growth of trade within global value chains. Analysing the determinants of the volume of import we also identify a significant decline of the exchange rate role in favour of domestic factors and exports (considered as a proxy of import intensity of exports). The combination of the aforementioned results indicates that changes in the exchange rate have a limited impact on economic activity in Poland. In accordance with our estimates, a 1-per cent appreciation in the nominal effective exchange rate of the zloty leads to a merely temporary decline of approximately 0.04 percentage point in the annual growth of the real GDP.
- The estimations of the exchange rate pass-through effect to consumer prices confirm its significant weakening in the recent years. The exchange rate pass-through effect to consumer prices (CPI) estimated for a sample of observations covering years 1998-2010 amounted to approximately 0.20, whereas the latest assessment of the strength of this effect for 2000-2015 amounts to approximately 0.07-0.08, depending on the model applied. At the same time, we note the acceleration of price reactions to changes in the interest rate – currently almost 40% of price change takes place during the first quarter after the exchange rate change. We maintain that the changes in the exchange rate pass-through effect to consumer prices are of a permanent nature. They are associated with changes in the production process, demonstrated by the growing share of international corporations in industrial production and services as well as with NBP’s stabilising monetary policy implemented under the direct inflation targeting strategy. Due to the cyclical features of the pass-through effect, we expect fluctuations of this indicator, including the future insignificant growth of its strength, however, only to the level only slightly exceeding 10%.



In the report we highlight the process of forming inflation expectations as a significant condition for the monetary policy transmission mechanism. Its role is particularly significant amidst the low and negative inflation, which has persisted below the NBP inflation target for a considerable time. On the one hand, it is interesting to determine the model of formulating inflation expectations, including the level of their anchoring, and on the other hand – to analyse the impact of inflation expectations on the course of macroeconomic processes. The main conclusions of this part of the report are as follows:

- Taking into account survey-based measures of inflation expectations of corporations, financial sector analysts or consumers in the stylized New Keynesian structural model significantly improves the fit of this model to the data. This refers in particular to corporate inflation expectations. The fact that these expectations persist at close to zero may be one of the explanations for inflation remaining significantly below the NBP inflation target. On the other hand, consumers’ inflation expectations have scant influence on their willingness to make major purchases and on their spending, which – combined with

the insignificant percentage of consumers perceiving and anticipating the decline in prices – reduces the risk of transferring the deflationary phenomena to consumer decisions.

- The model of short-term inflation expectations formation by various groups of agents is highly diversified. In the case of corporate inflation expectations, the groups forming expectations based on extrapolation versus anticipation are relatively similar, and among the entities voicing their expectations the number of enterprises whose expectations meet the condition of unbiasedness of the rational expectations hypothesis is more or less equal to the number of those adopting the central bank inflation target as a point of reference. The method of formulating inflation expectations by enterprises changed after the outbreak of the financial crisis – the role of the NBP inflation target has decreased significantly whereas the percentage of firms formulating expectations both in extrapolation-based and in rational manner has increased. In particular, the importance of real variables for formulating inflation expectations by enterprises has increased in the recent years. Although it was accompanied by the decline of the role of the NBP inflation target, enterprises' expectations simultaneously started to respond to changes in the short-term interest rate. It means that the channel of expectations may play a growing role in the monetary policy transmission mechanism in Poland.
- Probabilistic inflation forecasts based on the NBP Survey of Professional Forecasters confirm that experts' forecasts are strongly anchored in the NBP inflation target. The anchoring is reflected, *inter alia*, in the fact that although current inflation outcomes significantly affects forecasts for the current year, the four- and eight-quarter-ahead forecasts are much less sensitive to changes in current inflation, more stable and closer to the NBP inflation target. Inflation projections of Narodowy Bank Polski seem to act as a factor stabilising inflation expectations of professional forecasters. Amid significant deviations of current inflation from the target, the distance of the distribution representing expectations of NBP SPF participants from the central projection is well below the average, which may illustrate greater attention paid to NBP forecasts in periods of high uncertainty.



Estimates of the effectiveness of monetary policy transmission channels, affected both by the identified elasticity of the relations of variables making up those channels, as well as the level of their statistical significance, confirm the growing role of credit. We have already highlighted the growing role of the credit channel in the previous report (Kapuściński *et al.*, 2014). The current surveys showing that this channel became stronger than effects of the exchange rate channel, confirm this conclusion. However, we still treat the interest rate channel as the basic monetary policy transmission channel. This gradation corresponds to the assessments of the relative strength of individual transmission channels performed using the structural MMT 2.1 model.



Summing up, we find that the monetary policy transmission mechanism in Poland is quite stable, although the relative strength of its channels has been changing. In particular, the decline in the role of the exchange channel over the recent years has been accompanied by the growing role of credit (and the credit channel) and the growing anticipation of economic agents. In connection with the latter, in the assessment of the economic impact of the monetary policy, not only decisions in the scope of short-term interest rates but also central bank communication should be taken into account.

1. Theory and structural conditions of the monetary policy transmission mechanism

1.1. Theory

The monetary policy transmission mechanism can be defined as the passage of monetary impulses to prices and the real sector. In the previous reports we divided the transmission channels into the interest rate channel (comprising the transmission of the reference rate to other interest rates and, subsequently, to consumption and investment through the intertemporal substitution channel and direct interest rate channel described below), the exchange rate channel and the credit channel. In this report we present the potential impact of the monetary policy on the economy so that attention of the Reader is drawn to the individual stages of this process. It also allows for more problem-oriented approach to the issue and showing new channels which have recently appeared in the literature on the subject. On the other hand, due to the tools we use, in the empirical part we have applied the traditional approach based on discussion of results related to the interest rate channel, the exchange rate channel and the credit channel.

1.1.1. Transmission to financial markets

Nowadays central banks most commonly pursue monetary policy by determining the interest rate in such a manner so as to achieve the inflation target in the medium term. However, the specific way to implement of the monetary policy varies among countries. The main interest rate of Narodowy Bank Polski (NBP) is the reference rate. The Domestic Operations Department conducts open market operations in order to ensure an adequate amount of reserves in the banking sector, owing to which the POLONIA rate, illustrating the average interest rate on overnight loans on the interbank market, approaches the reference rate. In accordance with the hypothesis of expectations related to term structure of interest rates, changes in the shortest interest rates pass through to longer interest rates on the interbank market, in Poland, inter alia, to WIBOR 1M, WIBOR 3M and WIBOR 6M. These rates are also affected by expectations of financial markets in terms of inflation, economic situation and the related reaction of the authorities determining interest rates (in Poland – the Monetary Policy Council, MPC) as well as by their signalling of the future level of interest rates. The interbank market rates most commonly provide basis for interest rates on loans and deposits in commercial banks. They also set prices of Treasury bonds and corporate bonds. After an increase of the interest rate controlled by the central bank their prices, as well as prices of shares and the currency exchange rate fall.

1.1.2. Transmission to the real sector

Channels based on consumption

In accordance with the contemporary macroeconomic models the transmission to the real sector takes place mainly owing to price rigidities, due to which a change in the nominal interest rates also means a change in the real interest rates, which are significant for consumption and investment. In the basic New Keynesian model (e.g. Galí, 2015) the monetary policy acts via the **intertemporal substitution channel**. Changes in interest rates alter the slope of consumption profile so that higher interest rates result in lower current consumption and higher future consumption. However, arguments exist about intertemporal substitution effects being insignificant and monetary impulses acting typically rather through the **re-distribution channel**

(Auclert, 2015; Sufi, 2015). This comprises, first of all, the **Fisher channel**, within which a rise in interest rates, to the extent it translates into inflation decline, causes a change in the real value of the balance sheets, so that nominal lenders gain whereas nominal borrowers lose. Secondly, monetary policy tightening means redistribution from households paying net interest dependent on the current level of rates from households receiving net interest – it is the **interest rate exposure channel**. In both cases, if the first of the aforementioned groups has a lower marginal propensity to consume, a rise in interest rates will result in a decline of aggregate expenditure. The **wealth channel** is also based on consumption. Increase in interest rates translates into an economic downturn as well as a decline in enterprises' profits and dividends and, consequently, share prices (alternative argumentation is based on the impact on demand for shares or the discount rate change). It reduces assets of households, resulting in the decline of consumption.

Channels based on investment

In more traditional approaches, the activity of monetary impulses through **direct interest rate channel** is stressed. A tightening of the monetary policy increases cost of capital, which results in a decline in investment. Contemporary investment theories also imply an impact through the so-called **Tobin's q channel**, where q is defined as the relation between the market value of corporations and the replacement cost of capital. After a rise in interest rates, translating into the decline of share prices and the q relation, enterprises must issue more shares to purchase a given quantity of investment goods; consequently, investment declines.

Channels based on international trade

A channel based on international trade is the **exchange rate channel**. In accordance with the uncovered interest rate parity, a tightening of monetary policy results in an appreciation of domestic currency and subsequently, if the domestic interest rate is higher than the foreign interest rate – in a depreciation in order to restore equality between the rates of return. In the case of a deviation of the exchange rate from the level defined by the uncovered interest rate parity, investors use a carry trade strategy, based on borrowing in countries with low interest rates and depositing cash in countries with high interest rates, which causes upward pressure on the exchange rate. Consequently, the price competitiveness of exports and foreign demand declines. At the same time, import prices decrease, reducing inflation and enhancing imports. Krugman (1999) indicates that this effect is partly compensated for if economic agents have net liabilities denominated in a foreign currency, since the appreciation of domestic currency means the decline in their value. The improvement in balance sheets subsequently translates into growth of expenditure.

Credit channel

The last group of channels, jointly referred to as the **credit channel**, operates due to such market imperfections as information asymmetry or segmentation. The asymmetry of information occurs between banks and borrowers whereas segmentation means limited access to financing sources other than a bank loan. If a rise in interest rates undermines borrowers' credibility or a banks' capacity to extend loans, expenditure will be lower and the effectiveness of the monetary policy will be enhanced. The first credit channel is the **bank lending channel**. The typical argument is that a tightening of monetary policy reduces bank reserves, subsequently decreasing credit supply. Such a mechanism is not compliant with contemporary institutional conditions (Disyatat, 2010, more on this issue in Box 1). However, the monetary policy impulse can translate into weakening of banks' balance sheets (first of all, worsening of capital

position occurs), growth of their external financing premium and interest rate on loans for the non-financial sector. A similar mechanism is also known as the **bank capital channel**. The next associated channel is the **risk-taking channel** (Borio and Zhu, 2008). Within this channel, changes in interest rates affect risk perception and tolerance (and consequently, risk level in the portfolios), pricing of assets as well as conditions and criteria of financing provision.

New Keynesian models with financial frictions usually include the **balance sheet channel**. A rise in interest rates results in a decline in economic agents' net assets, reducing their credibility and increasing the external financing premium. This mechanism is also known as the financial accelerator. During the financial crisis in 2007-2009 enterprises with limited access to external financing raised prices as compared to enterprises with better access to cash, most probably, in order to avoid additional profit reduction; it has limited the general decline of inflation. At the same time, the adverse impact of external financing premium on prices through worsening of the economic conditions in partly compensated (Gilchrist and Zakrajsek, 2015). A similar mechanism – **the cost channel** – may operate after the growth in interest rates, if the working capital growth is transferred to inflation (Barth and Ramey, 2000).

Box 1. Money and banks in contemporary economy

The standard approach to money and banks encountered in handbooks and theoretical models, is based on the concept of money creation multiplier and theory of banks as financial intermediaries. In accordance with the first concept, money creation takes place mainly when the central bank supplies banks with additional reserves which are subsequently multiplied up. The second concept indicates that the role of banks consists in intermediation between savers whose deposits are lend out and the borrowers. However, more contemporary studies – e.g. McLeay *et al.* (2014), Disyatat (2010), Jakab and Kumhof (2015) – indicate that these approaches do not reflect the contemporary institutional conditions very well. Creation of money (understood as monetary aggregates broader than M0), takes place mainly when commercial banks grant loans. Figure R1.1 shows changes in balance sheets of the central bank, commercial banks and enterprises after granting new loans. The money creation process consists in adding loans in assets of commercial banks and liabilities of enterprises, and deposits (new money) in liabilities of commercial banks and assets of enterprises.

Thus, while granting a loan, commercial banks do not act as intermediaries between savers and borrowers (or between patient and impatient economic agents), creating both a loans and a deposit for borrowers. Loan granting is the IOU (I owe you) exchange – on the one hand, an enterprise must repay a credit and, on the other hand, a bank must transfer a deposit to another account or exchange it into cash on demand.

Figure R1.1. Money creation

Operation	Central bank		Commercial banks		Auxiliary and service	
	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
Money creation by granting new credits			+Loans	+Deposits	+Deposits	+Loans

Initially, nothing changes in the balance sheet of the central bank. For a longer period it is a simplification, although a minor one. Typically, the direct role of the central bank in the money creation mechanism is limited to satisfying banks' demand for reserves, arising mainly from the reserve requirement, and to the replacement of reserves into cash on demand. It is necessary to accomplish the operating target, i.e. usually the short-term interest rate on the interbank market. The central bank may raise this rate in order to limit the demand for loans. Changes in its balance sheet will depend on the structural liquidity position of the banking sector against it. If banks have liquidity surplus (such situation occurs e.g. in Poland), in order to fulfil the additional reserve

requirement, they will purchase less central bank bills at the successive auction¹ or limit their participation in reverse repo transactions. Alternatively, under such conditions, the central bank may determine the operating target at a level of the deposit rate and refrain from absorbing the surplus liquidity or perform it to a limited extent (although it may have an adverse effect on transaction volume on the interbank market). On the other hand, if banks have a liquidity deficit (such a situation occurs, e.g. in the euro area), the central bank will supply additional reserve under the repo operation. It should be highlighted that reserves are used only in settlements between banks. Therefore, the aggregated banking sector may neither get rid of them nor otherwise acquire them in operations with the central bank (although they are also affected by the so-called autonomous factors). The operations described as well as the replacement of reserves by cash are shown in Figure R1.2.

Figure R1.2. Open market operations, replacement of reserves by cash

Operation	Central bank		Commercial banks	
	Assets	Liabilities	Assets	Liabilities
Reduction of liquidity absorption		-Bills (or -reverse repo) +Reserves	-Bills (or -reverse repo) +Reserves	
Increase of liquidity supply	+Repo	+Reserves	+Reserves	+Repo
Replacement of reserves by cash		-Reserves +Cash	-Reserves +Cash	

In exceptional cases, the central bank may directly influence money supply by conducting asset purchases (quantitative easing – QE) from non-monetary institutions, e.g. from pension funds. However, in order to ensure that the new money reaches the real sector, the funds must use it to purchase assets from the non-financial sector or its bonds on the primary market (households may possibly realise resources kept in funds for cash – Cloyne *et al.*, 2015). Therefore, the basic channel of quantitative easing impact is rather its influence on prices of financial assets, including bonds and, consequently, also on long-term interest rates. The road to the real sector is even longer when assets under the QE are purchased from commercial banks. Due to the fact that it is an operation between monetary institutions, it does not directly affect money supply, only reserves (both forms of QE are shown in Figure R1.3). In accordance with the money creation multiplier, the increase of reserves should result in growth of money supply, however, in reality, as mentioned above, reserves typically do not represent a binding constraint on lending and their growth does not determine it. The major limitations for loan granting rather include the capital buffer (thus, also the micro- and macroprudential policy), expected impact of new loans on banks' profitability and solvency, behaviour of economic agents (if they use new loans to repay old ones, the money supply will not change) and the monetary policy affecting the demand.

Figure R1.3. Quantitative easing

Operation	Central bank		Commercial banks		Pension funds	
	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
Repurchase of securities from pension funds	+Securities	+Reserves	+Reserves	+Deposits	-Securities +Deposits	
Repurchase of securities from banks	+Securities	+Reserves	-Securities +Reserves			

¹ In Poland, issuance of NBP bills is the basic method of surplus liquidity absorption, however, transactions on treasury bills/bonds or term deposits are also used in other countries.

1.2. Structural conditions

The strength and lag in transmission of monetary impulses to prices and production as well as operation of individual channels of the monetary policy transmission mechanism depends on a number of structural conditions. Similar to the previous reports (although in a slightly different form), below we shall describe conditions suggested by theory and empirical studies.

1.2.1. Conditions affecting the strength and lag of monetary impulse impact

The main factors which may affect the overall shape of the transmission mechanism, i.e. its strength and lag, analysed in this section, have been selected based on the literature of the subject, in particular, international comparative studies published recently, operating on data derived from a large number of economies:

- Mateju (2014)² indicates that the cumulated reaction of prices in the horizon of the monetary policy impact is bigger in countries with a higher loan-to-GDP relation, more open in terms of trade. The impact on inflation is bigger in countries pursuing the inflation target strategy (in Poland, since 1998/1999) and in the economies of the euro area. The monetary policy impact decreased in the period of the bank crisis, which means that the strength of banks' balance sheets described in the following section may play a certain role (1.2.2).
- In accordance with the study by Georgiadis (2012),³ the stronger the competition in the banking sector, the greater the role of bank loans and the higher the share of goods production in the value added (although in the latter case, the impact on price reaction is not clear-cut), the stronger is the reaction of production and prices.
- Havranek and Rusnak (2013)⁴ demonstrated that the level of financial development was the major factor influencing the diversity of the length of the lag in the reaction of prices to the monetary impulse – a higher level of financial development or, more strictly, diversity of financial instruments (e.g. *hedging*) results in a longer lag.⁵

The aforementioned factors can be divided into five groups: **financial development, competition in the banking sector, rigidities in the labour market, structure of production and openness of the economy**. Figure 1 presents selected measures of those characteristics for Poland and for the euro area which serves as a point of reference.

² The study conducted by Mateju (2014) on data for 33 OECD and EU member states, covering a maximum period from 1970 to 2010. The Bayesian VAR models with time-varying parameters, monetary policy shocks were estimated, identifying them through sign restrictions. Impulse responses were subsequently explained by structural characteristics within panel models.

³ In the study by Georgiadis (2012) data for 20 developed countries were used, for a period from 1995 to 2009. The reasons of differences in the transmission mechanism were examined traditionally, explaining impulse responses by structural characteristics. Besides, the PCHVAR model (*panel conditionally homogenous VAR model*) was used. Monetary policy shocks were identified by Cholesky decomposition.

⁴ The study of Havranek and Rusnak (2013) is based on a meta-analysis of 67 studies for 30 countries, mainly those developed and after transformation. The differences in impulse responses were explained with the use of Bayesian model averaging.

⁵ Factors diversifying the monetary policy transmission mechanism were also described by: Arnold and Vrugt (2004), Carlino and DeFina (1998), Dedola and Lippi (2000), Hayo and Uhlenbrock (1999) or Peersman and Smets (2005).

Firstly, the **financial development** of Poland, measured by financial assets of the financial sector and the debt of private non-financial sector, remains lower than the average in the euro area. Bijlsma i Zwart (2013), while conducting the analysis using a higher number of variables, confirm a limited development of the Polish economy, characteristic for the countries of Central and Eastern Europe. This should mean a decreased reaction of prices and production as well as reduced lags in the transmission mechanism. Financial intermediation is based on the banking sector. In accordance with the Eurostat data, in 2014 the share of the banking sector in the financial assets of the financial sector amounted to 70 per cent – slightly more than in the euro area (66 per cent).⁶

Secondly, findings related to **competition** in the banking sector are inconclusive. On the one hand, the share of five biggest banks in the assets of the banking sector in Poland is lower than the euro area average, which suggests more competition. A similar situation occurs if another concentration measure, i.e. the Herfindahl index, is used. According to the ECB data, in 2014 it reached 0.07 in Poland against 0.10 in the euro area. On the other hand, net interest income used for approximation of net income margin, is higher (although World Bank data series longer than shown in the chart indicates a downward tendency of net interest margin median in the banking sector – between 2001 and 2013 it decreased from 4.4 to 2.5 per cent of assets generating interest income). It may mean that the concentration translates into competition and margins to a limited extent. However, attention should be given to the fact that margins are affected by the level of interest rates (Borio *et al.*, 2015), which are higher in Poland than in the euro area. Other measure illustrating competition effects – relation of costs to income – is lower in Poland than in the euro area (in 2014 – 53 per cent against 61 per cent – ECB data).

Thirdly, **labour market rigidities (wages and employment conditions)** are lower in Poland than, on average, in the euro area, which, in accordance with the study performed by Georgiadis (2012), should reduce the reaction of prices and production. On the other hand, in the standard New Keynesian model, a lower rigidity of wages translates into an increased reaction of prices and a dampened reaction of production to monetary impulses. The share of trade union members in the number of employees is lower and shows a downward trend. Moreover, fewer employees are subject to collective bargaining (recent observations available in the ICTWSS database for individual countries indicate that the number amounts to 29 per cent against 65 per cent in the euro area), whereas bargaining takes place mainly at the level of enterprises (in the euro area it is mainly the level of enterprises or sectors), which additionally reduces the rigidity of wages. Protection of employment is lower than in the euro area and stable since 2004, whereas it refers only to standard contracts – the protection in the case of fixed-term employment is similar. The share of workers employed under the second, more flexible type of contracts is the highest in the European Union, amounting to 28 per cent in 2014 according to the Eurostat data. Following a prior rise of more than 100%, it has been relatively stable since 2007, which was probably fostered by introduction of the Act on mitigating the effects of the economic crisis for employees and entrepreneurs in 2009, limiting the application of fixed-term contracts.

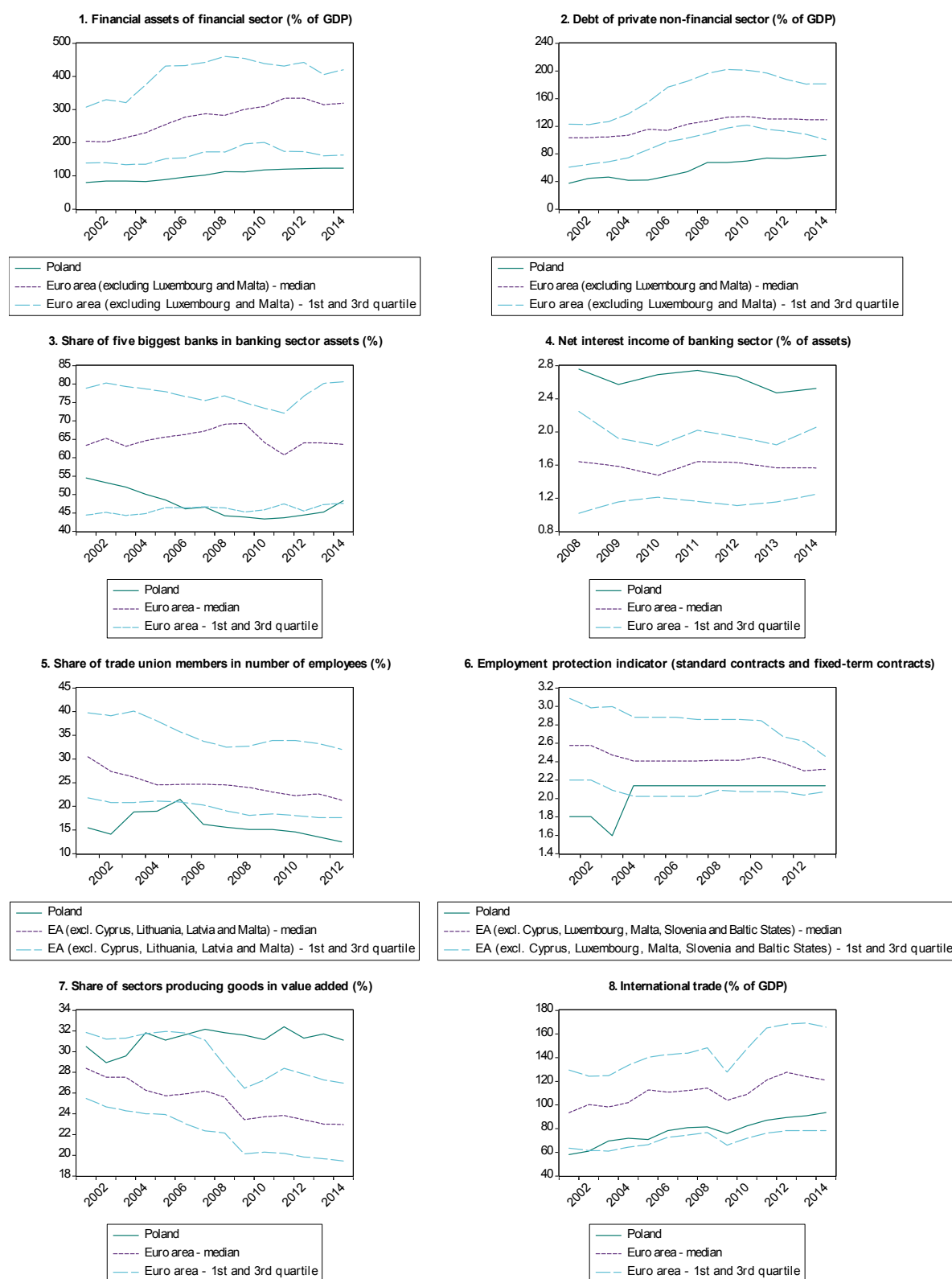
Besides wage rigidity, in the standard New Keynesian model, the reaction of prices and output is also affected by **price rigidities**. In accordance with the study by Macias and Makarski (2013), prices in Poland are

⁶ In accordance with the interpretation of Mateju (2014), a stronger transmission in economies more developed financially is based on a higher leverage. However, it may reduce the financial stability, with a limited positive impact on the economic growth. Sahay *et al.* (2015) indicate that considering the current level of Poland's financial development, the threat for financial stability is rather limited and the impact on the level and volatility of the economic growth – very favourable. Moreover, in 2014, in the group of 32 countries for which BIS collects data, debt servicing costs of the private non-financial sector (in Poland – 7.7 per cent of disposable income) were lower only in three countries – in the Czech Republic, Indonesia and Mexico. More information on the impact of debt servicing costs on financial and macroeconomic stability can be found in: Drehmann and Juselius (2012).

adjusted more frequently than in the euro area (once in 10.9 months against once in 13 months), acting towards an increased response of prices and a decreased response of production to monetary impulses.

Fourthly, the share of sectors producing goods (agriculture, forestry, hunting and fishing, mining and quarrying, manufacturing and construction) **in the value added structure** in Poland is higher than the euro area average – and stable. This should translate into a stronger response of production. The share of the largest among the goods-producing sectors – i.e. manufacturing is also higher (18 per cent against 14 per cent). Looking at GDP in terms of expenditure, previous reports (Demchuk *et al.*, 2012, Kapuściński *et al.*, 2014) indicate a stronger reaction of investments as compared to consumption. Their share in Poland is the same as in the euro area (20 per cent in 2014 – Eurostat data), declining after 2008. However, in Poland it is mainly associated with the change of relative prices – in prices of 2010 the share of investment in GDP was relatively stable in this period.

Fifth, assessing the **trade openness** of Poland, conclusions vary depending on whether it is compared with the overall foreign trade of euro area countries, or with the trade of euro area countries with non-euro area countries. The first measure is used in comparative studies. In accordance with the analysis performed by Mateju (2014), greater openness is associated with a stronger response of prices to the monetary policy impulse, and one of the models in the study of Havranek and Rusnak (2013) also indicates that the openness acts towards reduced lags in the transmission mechanism. On the other hand, the second measure seems more justified for the assessment of exposure to operation of the currency exchange channel. In Poland, foreign trade (in relation to GDP) is lower than the total average level in euro area countries (Figure 1, panel 8), but higher than foreign trade of euro area countries with non-euro area economies (94 per cent GDP for Poland, against the average of 62 per cent in euro area countries, including Spain, Ireland, Luxembourg and Malta, for which Eurostat does not provide harmonised data on geographical structure of trading both in goods and in services).

Figure 1. Structural conditions of the monetary policy transmission mechanism


Source: panels 1, 2, 7, 8 – Eurostat, 3, 4 – ECB, 5, 6 – OECD.

1.2.2. Additional conditions influencing the operation of monetary policy transmission mechanism channels

To go on to additional structural conditions influencing the operation of the individual channels of the monetary policy transmission mechanism, Egert and MacDonald (2008) provide various characteristics, divided into those affecting the interest rate channel, the exchange rate channel, the credit channel and the wealth channel (comprising the asset channel and the Tobin's q channel, described in section 1.1). A similar set of variables for Poland for 2002-2014 is shown below (Table 1-4).

In the case of the interest rate channel, transmission of interest rates may be hampered by an imperfect substitution between deposits and similar kinds of financial assets, as well as between loans and other sources of external financing. The private non-financial sector keeps deposits mainly in banks. Deposits in credit unions (SKOK) where interest rates are slightly higher (by 1.15 p.p. at the end of 2012, by 0.42 p.p. at the end of 2014 – FSA data) constitute a certain competition, however, their volume is low and it has been decreasing since the peak in 2013 (approx. 1 per cent of GDP). The value of bonds in the assets of households and non-financial enterprises is also low and continues to decrease. Banks also represent the most important source of external financing of the private non-financial sector. Poor balance sheets of credit unions (a negative solvency ratio and rate of return and approximately 1/3 of overdue loans in the sector) reduce their loans in relation to GDP after 2010. In the case of non-financial enterprises, the market of corporate bonds is gradually developing, however, it remains seven-fold smaller than the value of loans. Capitalisation of non-financial enterprises' stocks is over two-fold lower than the value of loans.

In addition, the transmission of changes in the money market interest rate to the interest rate on loans may become weaker along the increased adjustment of the term structure of loans and deposits.⁸ In the structure of deposits, short-term deposits prevail (although between 2012 and 2014 their share decreased), and in the structure of loans – long-term loans. Studies referred to in the Egert and MacDonald (2008) report also indicate that less liquid banks adjust interest rate faster, whereas banks with the majority of the state and foreign capital perform the adjustment faster and more strongly. The share of liquid securities in banking sector assets is relatively stable, amounting to approx. 1/5. Banks with the majority of state capital constitute approx. 1/4 and foreign banks – below 2/3 of the sector. Since the crisis, the share of the first group has slightly increased, whereas the share of the second group has declined, which resulted, to the great extent, from maintaining lending by the biggest bank with the majority of state capital (Piątkowski, 2015).

The strength of banks' balance sheets is another significant factor. In this case, in accordance with the aforementioned studies, banks with a lower level of capitalisation and more profitable adjust interest rates faster. The conclusions concerning the impact of impaired receivables share are not clear-cut. Following the growth of leverage in the period of credit boom, since 2009 banks have been restoring their capital position. It was fostered by determining of the solvency ratio level by the Polish Financial Supervision Authority, enabling the payment of the dividend at 10 per cent as of 2009, followed by 12 per cent as of 2012. Since 2014, instead of the solvency ratio, the total capital ratio has been calculated with the value enabling the payment of the dividend amounting to 12.5 per cent. However, attention should be paid to the fact that more criteria exist and for some groups of banks (systemically important and significantly engaged in loans denominated in foreign currency) they are more restrictive. Banks' profitability remains at a level lower than directly

⁸ Studies conducted for Poland suggest that the characteristics of banks have a limited impact on the transmission of interest rates whereas the highest influence is observed in the case of: the bank's size, its level of liquidity and the size of deposit base (Stanisławska, 2015).

before the global crisis and the share of non-performing loans – at a higher level. At the end of 2014 the highest share, divided into sectors and types of loans, was recorded in the case of consumer loans (12.8 per cent), followed by loans to non-financial enterprises (11.3 per cent). For housing loans, this share reached 3.1 per cent.

In relation to the exchange rate channel, factors reducing the pass-through of exchange rate changes to prices listed in literature include the decline in the level and volatility of inflation. In Poland, the period of gradual disinflation ended around 2002. Afterwards, the average 5-year level and volatility of inflation did not manifest a fixed trend, however, they were significantly lower than during the disinflation period. In 2004 the inflation target was determined at a level of 2.5 per cent ± 1 p.p. Until the end of 2014 inflation remained within this range over about 1/3 of time, whereas the maximum level amounted to 5 per cent and the minimum level – to -1 per cent (in 2015, deepening of deflation took place). Other factors permanently reducing the exchange rate pass-through effect include changes in the production process (production internationalisation) and reliability of the monetary policy implementing the direct inflation targeting strategy.

The structure of trade may be also significant. First of all, the pass-through of exchange rate changes should be greater for imported unprocessed goods. In Poland their share was relatively stable in 2002-2010, to subsequently increase slightly. Secondly, the sensitivity of prices (and consequently, also volumes) of imports and exports to exchange rate changes may be restricted by participation in global value chains (GVC).⁹ Between 2005 and 2011 (last available data) growth was recorded both for the component of GVC participation index calculated by the OECD and WTO, presented by us in Table 2, i.e. the share of foreign value added in exports, as well as for the index itself. It is a continuation of the tendency observed at least since mid-1990s (the first available data indicate that in 1995 the share of foreign value added constituted approx. 1/2, and the participation index – approx. 2/3 of the level of 2011).

As mentioned in section 1.1, if economic agents hold uncovered liabilities in foreign currency, the appreciation of the domestic currency results in improvement of their balance sheets and may increase the domestic demand, partly compensating the adverse impact on net exports. Following the amendments to S Recommendation of 2013, restricting access to housing loans denominated in foreign currency to individuals gaining income in foreign currency, the share of foreign currency loans has been decreasing (for information on other measures in the area of foreign currency loans, see Huttl, 2015). Recommendation S of 2013 has also reduced the loan to value for housing loans, in total, to 95 per cent by the end of 2014, followed by 90 per cent in 2015 and 85 or 90 per cent in 2016, depending on the collateral. In the first quarter of 2015, new housing loans denominated in foreign currency constituted less than 1 per cent. Following the earlier downward tendency, since 2010 the share of deposits denominated in foreign currency has been relatively stable.

The operation of the credit channel is fostered by a high share of small and medium-sized non-financial enterprises with a limited access to external financing sources other than the bank loan in the total number of non-financial enterprises (99.9 per cent). Their share in production is lower by approximately a half and stable after 2010. On the other hand, in 2012-2013 the share of bank loans in investment financing was below 10 per cent (for information on “credit impassiveness” of enterprises in Poland, see Sawicka and Tymoczko, 2014). Own funds represent the most important source of financing (72 per cent share in 2013). Trade credits

⁹ Comparative studies show that the participation in global value chains significantly restricts exports’ sensitivity to exchange rate changes (Ahmed *et al.*, 2015).

in relation to GDP have decreased slightly as compared to the global crisis period (Marzec and Pawłowska, 2011, indicate the substitution between the bank loan and trade credit in Poland).

Households' assets and stock market capitalisation may have an impact on the operation of the asset price channel. Since 2012 the financial assets have exceeded the level recorded during the peak of the boom before the global crisis. However, in 2014, cash and deposits constituted as much as 47 per cent. The effectiveness of the asset channel is also limited by the distribution of assets in the household sector. In accordance with the Social Diagnosis of 2013, only 40 per cent of households keep savings. In this group, 2 per cent hold securities listed on the stock exchange, 6.3 per cent – units of investment funds, 2.5 per cent – bonds and 46.4 and 66.6 per cent of households, respectively, hold cash and deposits. The value of the housing stock increases, however, at a pace slower than GDP, accordingly, the relation of those two variables dropped by approximately 39 p.p. in 2007-2014. On the other hand, stock market capitalisation, including the Warsaw Stock Exchange and the New Connect market (operating since 2007) has still not exceeded its all-time high (of 2007). At the end of 2014 on both markets, respectively, 471 and 431 companies were listed (including 420 and 421 domestic companies, respectively).

Table 1. Factors affecting the operation of the interest rate channel

	2002	2004	2006	2008	2010	2012	2014
Household and NPISH deposits at banks (% of GDP) ^{1, 2}	28.2	23.3	22.2	24.1	28.2	30.7	33.7
Household and NPISH deposits in credit unions (% of GDP) ^{2, 3, 4}	0.27	0.43	0.53	0.69	0.92	0.97	0.74
Bonds in household and NPISH assets (% of GDP) ²	0.8	1.2	0.8	0.7	0.5	0.6	0.3
NFC deposits (% of GDP) ²	7.0	9.9	12.7	13.0	13.6	12.4	13.8
Bonds in NFC assets (% of GDP) ²	0.7	1.3	1.5	1.2	1.0	0.5	0.6
Household and NPISH loans at banks (% of GDP) ^{1, 2}	10.4	11.5	14.9	23.8	30.6	32.3	33.1
Household and NPISH loans in credit unions (% of GDP) ^{2, 3, 4}	0.21	0.31	0.38	0.54	0.67	0.61	0.55
NFC loans (% of GDP) ²	29.3	25.3	27.4	35.6	33.2	35.9	37.2
NFC bonds (% of GDP) ²	2.9	3.0	1.9	1.9	2.3	3.4	5.0
NFC stocks (% of GDP) ²	4.9	10.1	19.4	9.8	19.4	17.1	16.2
Household and NPISH short-term deposits (percentage) ¹	91.2	91.8	95.1	96.1	95.6	95.8	90.1
NFC short-term deposits (%) ¹	99.0	99.4	99.5	99.5	99.2	99.0	99.5
NFS short-term deposits (%) ¹	92.6	93.7	96.4	97.2	96.7	96.7	92.5
Household and NPISH short-term loans (%) ¹	32.3	26.1	18.3	13.8	11.5	9.2	8.8
NFC short-term loans (%) ¹	43.5	38.5	35.8	35.2	31.8	31.4	30.7
NFS short-term loans (%) ¹	38.9	32.7	26.2	22.2	18.2	16.5	15.9
Securities of central bank and treasury securities in banks' assets (%) ¹	20.3	19.7	19.4	14.9	20.5	16.8	18.0
Share of banks with the majority state capital in assets (%) ¹	24.6	23.8	20.1	18.3	21.7	23.0	24.2
Share of banks with majority foreign capital in assets (%) ¹	62.2	62.9	66.0	67.2	62.6	59.9	61.0
Non-performing loans (until 2008)/impaired loans (%) ¹	19.8	17.6	9.3	4.7	8.5	8.6	8.3
ROA (%) ¹	0.47	1.29	1.58	1.47	0.96	1.10	1.01
Solvency ratio (to 2014 Q1)/total capital ratio (%) ^{1, 4}	13.9	15.1	13.9	11.2	13.8	14.1	14.8

Notes: NPISH – non-profit institutions serving households, NFC – non-financial corporations, NFS – non-financial sector.

Source: 1 – NBP, 2 – Eurostat, 3 – CSO, 4 – FSA, 5 – OECD, 6 – WSE, New Connect.

Table 2. Factors affecting the operation of the exchange rate channel

	2002	2004	2006	2008	2010	2012	2014
Inflation level (5-year average) ³	7.3	4.4	1.9	2.7	2.8	3.7	2.3
Inflation volatility (5-year standard deviation) ³	3.7	3.4	1.3	1.4	1.2	0.8	1.7
Imports of unprocessed goods (%) ²	11.1	10.7	11.0	12.0	12.3	15.3	13.1
Participation in GVC ⁵			50 [2005]	52.7	53	55.6 [2011]	
Foreign value added in exports (%) ⁵			28.2 [2005]	31	31.2	32.3 [2011]	
Household and NPISH foreign currency deposits (%) ¹	17.1	16.6	13.9	9.0	7.6	7.3	7.7
NFC foreign currency deposits (%) ¹	21.6	19.1	21.6	17.6	14.7	16.9	15.9
NFS foreign currency deposits (%) ¹	17.9	17.2	16.3	11.7	9.6	9.9	9.8
Household and NPISH foreign currency loans (%) ¹	21.8	26.3	31.2	32.3	37.4	37.3	30.6
NFC foreign currency loans (%) ¹	30.2	29.0	22.4	19.4	24.5	24.3	26.1
NFS foreign currency loans (%) ¹	26.7	27.7	27.3	27.3	33.3	33.2	29.2

Source: 1 – NBP, 2 – Eurostat, 3 – CSO, 4 – FSA, 5 – OECD, 6 – WSE, New Connect.

Table 3. Factors affecting the operation of the credit channel

	2002	2004	2006	2008	2010	2012	2014
Share of SMEs number (%) ³	99.8 [2003]	99.8	99.9	99.8	99.8	99.9	99.9 [2013]
Share of SMEs production (%) ³	62.3 [2003]	61.7	59.3	58.7	56.9	55.8	56.4 [2013]
Share of bank loans in investment financing (%) ³	15.0	12.2	12.9	13.8	12.4	9.3	9.3 [2013]
NFC trade credits (% of GDP) ²	9.3	6.3	7.1	8.2	8.0	7.1	7.3

Source: 1 – NBP, 2 – Eurostat, 3 – CSO, 4 – FSA, 5 – OECD, 6 – WSE, New Connect.

Table 4. Factors affecting the operation of asset price channel

	2002	2004	2006	2008	2010	2012	2014
Financial assets of households (% of GDP) ²	56.0	72.6	82.9	74.2	82.9	87.1	94.1
Housing assets of households (% of GDP) ^{1, 2}		184.9 [2005]	194.0	213.3	195.0	180.5	177.0
Stock market capitalisation (% of GDP) ^{2, 6}	13.6	31.5	59.7	36.5	55.5	45.7	73.4

Source: 1 – NBP, 2 – Eurostat, 3 – CSO, 4 – FSA, 5 – OECD, 6 – WSE, New Connect.

2. General shape of the monetary policy transmission mechanism

2.1. Analysis based on (S)VAR-models

This part of the report shows general features of the monetary transmission mechanism and the so-called stylized facts. The results were obtained based on (structural) models or vector autoregressions, (S)VAR, in which we use a relatively limited number of assumptions, fewer than in the case of structural models. Therefore, we let the data speak.

The basic assumption underpinning the results derived from (S)VAR models concerns the monetary policy rule and lags in the monetary transmission mechanism. A monetary policy rule in a VAR framework is a set of macroeconomic variables which are considered by the decision-making body when setting the level of the monetary policy instrument (the interest rate). We assume that in Poland, this includes inflation (the consumer price index – CPI or HICP) and economic conditions. In particular, we assume that while determining the level of interest rate in time t , the central bank has information concerning the current (i.e. in time t) developments of the CPI and the Gross Domestic Product. Due to rigidities in the economy, *inter alia*, price rigidity and habit formation in consumption, we assume that the real sector and prices react to interest rate changes with a delay. The financial crisis significantly enhanced the role of credit among macroeconomic variables analysed by central banks. Therefore, we supplemented the basic set of variables used in (S)VAR models with zloty denominated loans.

Disturbance, or, in other words, monetary policy shock is extracted using two decompositions. In the first one we allow the exchange rate react simultaneously with the interest rate, which seems to be a relevant assumption for an open economy. On the other hand, in the second decomposition we assume that the developments in the interest rate are affected by the past ($t-1$) exchange rate behaviour, i.e. we use the ordinary Cholesky decomposition.

As in the previous report (Kapuściński *et al.*, 2014), we use quarterly and monthly data. The monthly data serve mostly to verify the results obtained using the quarterly data as well as for the analysis of the impact of the monetary policy (interest rate) on other macroeconomic variables, like bank loans, unemployment rate and retail sales of goods and services.

For quarterly data we build the basic benchmark (S)VAR model comprising five endogenous variables: GDP, prices (HICP)¹⁰, loans denominated in zloty granted to households and firms, interest rate (the central bank rate is approximated by WIBOR 3M rate)¹¹ and the real effective exchange rate. As the exogenous variable, i.e. those affecting the variables of the model but are not themselves affected by them, we use the foreign

¹⁰ The HICP index is also used in structural models. It allows for a correct estimation of the real exchange rate (prices in the euro area correspond to the HICP). We use stylized facts derived from SVAR models to verify results obtained from structural models, therefore the HICP appeared in SVAR quarterly models. In the (S)VAR GDP, HICP models presented herein, loans denominated in zloty, WIBOR rate and the currency exchange rate are in levels.

¹¹ The central bank rate is a reference rate, however, due to its low volatility it cannot be used in models. The POLONIA rate, i.e. a transaction rate which is the closest to the central bank interest rate, has been calculated since 2005, therefore, its series is too short to be used in the (S)VAR models. Thus we use WIBOR rates, representing money market quotation rates. In quarterly models, a 3-month rate and in monthly models – a 1-month rate is used.

demand (euro area GDP) and a foreign interest rate (EURIBOR 3M).¹² We also use a set of dummy variables in order to eliminate autocorrelation and obtain normally distributed residuals of the model (or at least unskewed). These are dummy variables eliminating the problem of year 2000, known as “Y2K” (a rapid growth in interest rates at the end of 1999), the Russian crisis of 1998 which, due to a halting of exports to Russia, resulted in the supply shock in Poland, and Poland’s EU accession in May 2004 which resulted in the transitional, strong growth of purchases and inflation.

To provide a more detailed analysis of the stylized facts and determine how the principal GDP components react, we alter the basic model slightly: we introduce private consumption and private investment, however, we do not include loans. The decision to skip loans arises from the need to maintain the model as parsimonious as possible since (S)VAR-type models rapidly lose degrees of freedom. We believe that elimination of other variable (e. g. prices) would result in an even bigger error in estimates.

The monthly model comprises a slightly different set of variables than the basic quarterly model: GDP has been replaced by industrial production and, as the respective exogenous variable, we introduce industrial production of the euro area. We use prices of consumer goods and services (CPI) and a 1-month WIBOR rate which seems to better fit to monthly data and – for technical reasons – the nominal effective exchange rate.

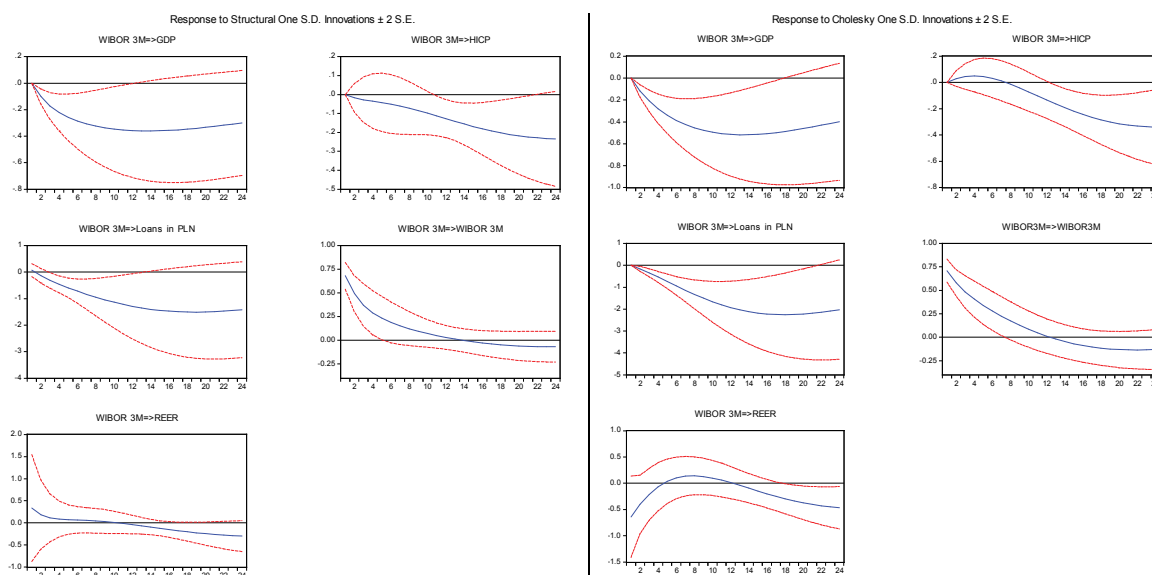
The sample on which we build the basic quarterly (S)VAR models starts in the first quarter of 1998 and ends in the first quarter of 2015¹³, for monthly data we use a shorter, more homogeneous sample, starting in January 2001 and ending in June 2015. The number of lags in the models is determined on the basis of the Schwartz information criterion; we also take into consideration the autocorrelation of the random component and the distribution of residuals.

In the quarterly model, the impulse response function (IRF thereafter) of GDP to the interest rate shock is statistically significant (Figure 2), the level of loans denominated in zloty decreases quite rapidly and this reaction is also statistically significant. We observe a slow decline of prices in the decomposition where the currency exchange rate may react simultaneously with the interest rate (left panel). In the results coming from the Cholesky decomposition, a slight but persistent “price puzzle” is visible, i.e. an increase in the price index after interest rate increase (right panel). The price puzzle is often caused by problems related to the specification of (S)VAR models, however, in our results it may be the problem arising from exchange rate reaction to the monetary policy shock, rather than from omitted variables significant in terms of monetary transmission. The reason is that in the Cholesky decomposition the interest rate shock is not followed by an appreciation resulting from the interest rate disparity between Poland and abroad, but rather by depreciation which is possibly the effect of investors’ concerns related to the worsening economic fundamentals. It is worth noting that in the structural decomposition the exchange rate does not react to the interest rate shock at all. It means that after an interest rate rise we may face two different price responses, depending on the behaviour of the exchange rate. In situations when, despite an increase in disparity of interest rates, depreciation of the zloty takes place, the decline in the level of prices may occur with delay, or even its transitional, slight growth may occur. A similar effect may arise from the operation of the cost channel since a rise in interest rate means higher credit costs, and if the credit is incurred for financing of variable costs (wages), it will be reflected in prices.

¹² To variables other than interest rates a logarithm has been applied.

¹³ The model designed for the analysis of consumption and private investment behaviour is estimated on the basis of a sample from 2002 Q1 to 2015 Q2, due to the lack of data related to GDP components re-estimated backwards for the base year 2010.

Figure 2. Impulse response functions to a contractionary interest rate shock from decomposition allowing for a simultaneous reaction of exchange rate and interest rate (left panel) and ordinary Cholesky decomposition (right panel), models with 1 lag

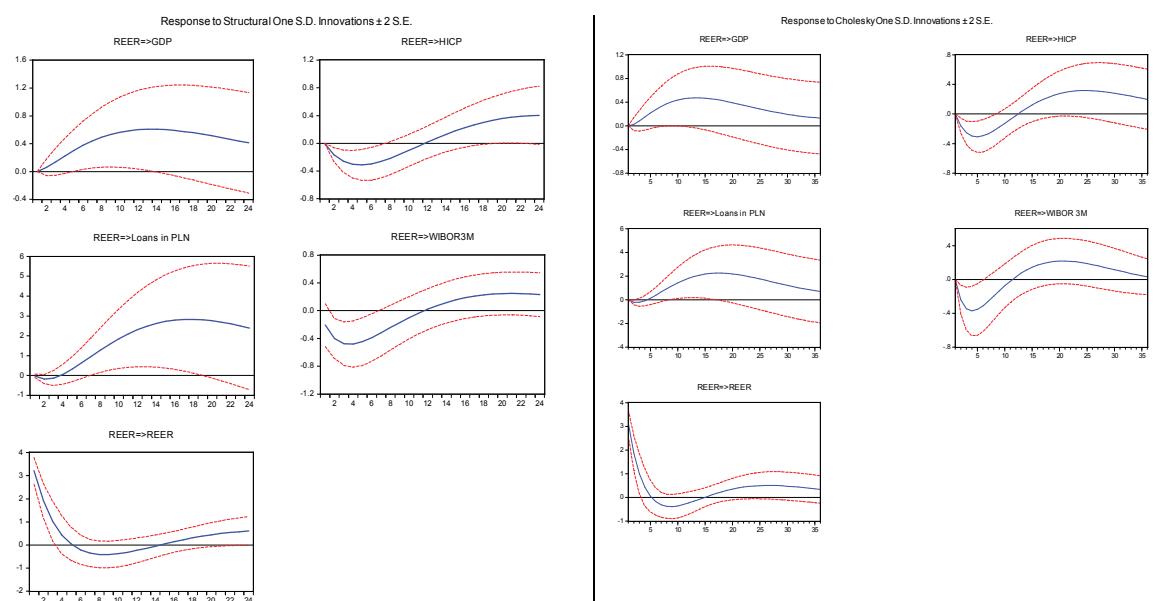


Source: own calculations.

The exchange rate shock has an impact on the activity of the real sector as measured by GDP (Figure 3). Following the unexpected appreciation of the real exchange rate, GDP grows despite a decline in exports. On the basis of the more detailed model, we can see that after the shock to the exchange rate investment, consumption and zloty denominated loans tend to grow with a certain lag (Figure 4). It is also worth noting that in this model, calculated with two lags and capturing the dynamics of macroeconomic processes better than the basic model, GDP initially falls over a short period of time – this is exactly the effect of decline in exports. We obtained a similar result from the structural model, (see section 3.2.2). A positive impact of the appreciation on GDP, investment and consumption is not obvious. On the one hand, it may result from a marked decline in interest rate, decreasing the level of the monetary policy restrictiveness as well as stimulating investment and consumption and, on the other hand, from cheaper import of intermediate and final goods which may foster net exports in a longer-term horizon.

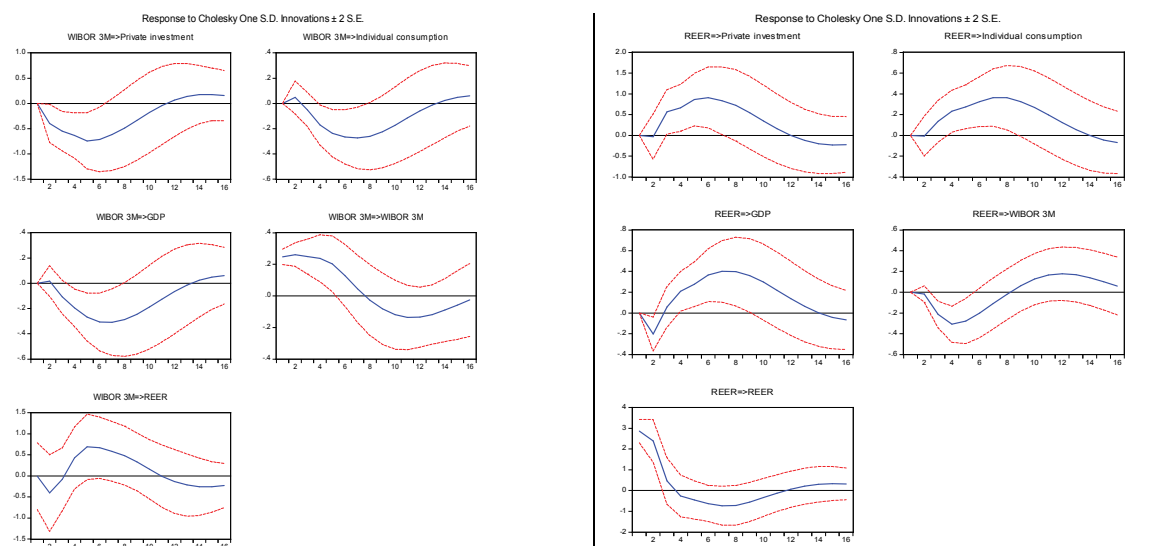
The influence of the exchange rate on consumer prices in the models described here is small (approximately 4% after 4 quarters). It is lower than estimated in the previous report (7-8%).

Figure 3. Impulse response functions to the exchange rate shock (appreciation) from decomposition allowing for a simultaneous reaction of exchange rate and interest rate (left panel) and ordinary Cholesky decomposition (right panel), models with 1 lag



Source: own calculations.

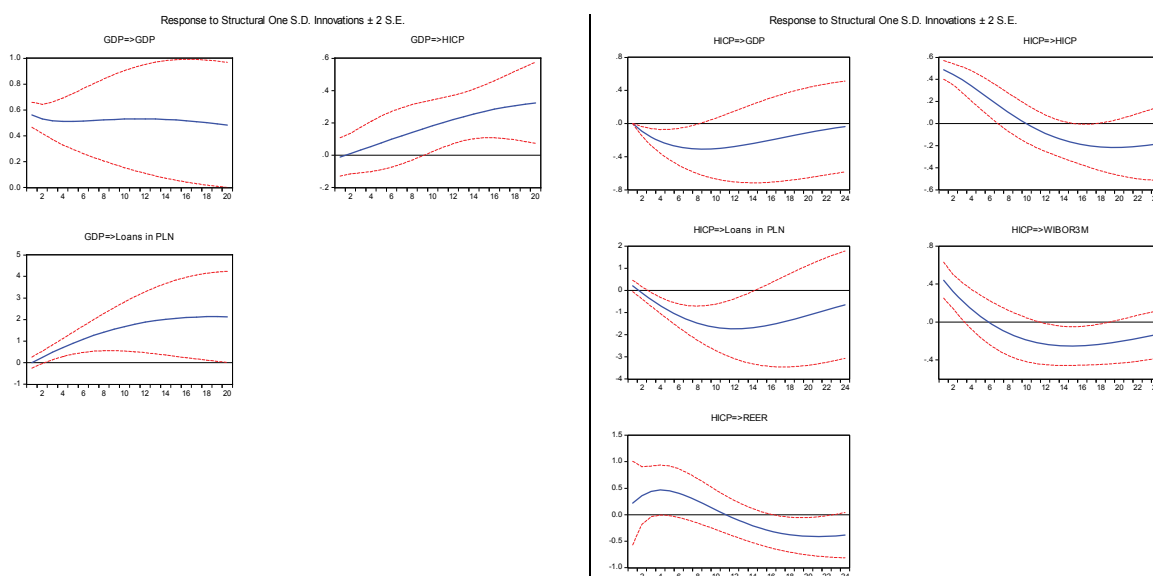
Figure 4. Impulse response functions to a contractionary interest rate shock (left panel) and to the real exchange rate appreciation (right panel): reaction of private investment, individual consumption and GDP, sample 2002.1-2015.2, ordinary Cholesky decomposition (right panel), models with 2 lags



Source: own calculations.

The inflation shock has a negative impact on GDP and – as may be expected in a country pursuing the direct inflation targeting – leads to an increase in the interest rate. On the other hand, a positive shock of domestic demand raises prices and increases the demand for bank loans. The responses to inflation shock and demand shock are similar in both decompositions, therefore we limit our presentation in the charts only to results where we allow for a simultaneous reaction of the exchange rate and the interest rate (Figure 5). A positive shock to loans raises prices, however, it is not transmitted to GDP (we do not show this result due to the limited volume of the report).

Figure 5. Selected impulse response functions to the domestic demand shock (left panel) and price shock (right panel), decomposition allowing for a simultaneous reaction of exchange rate and interest rate

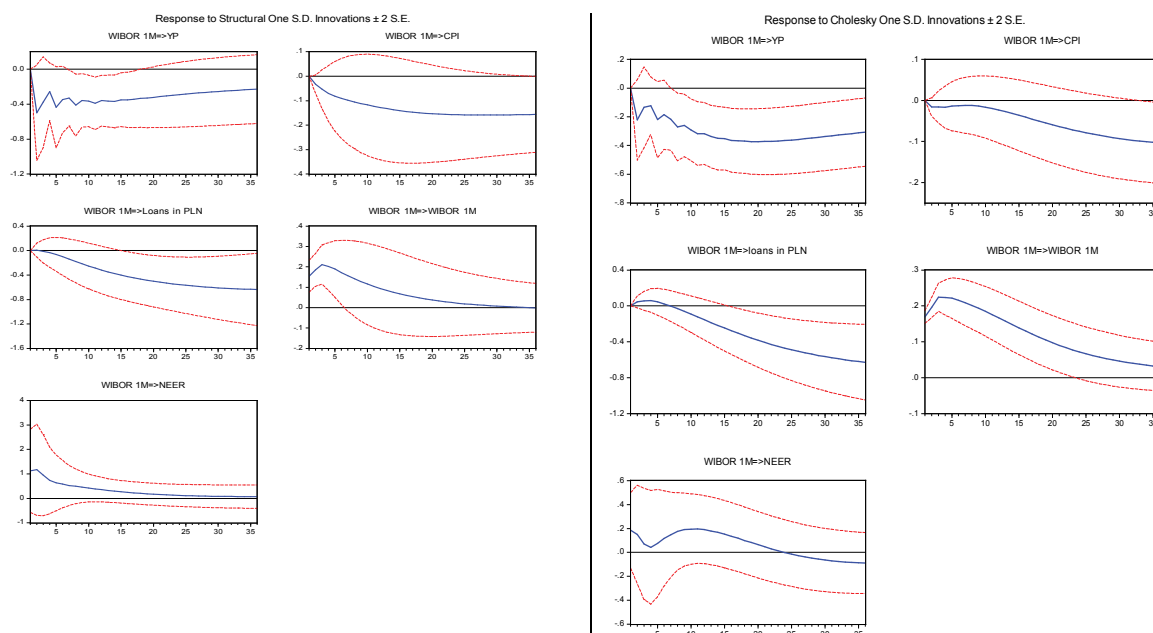


Source: own calculations.

(S)VAR models of monthly frequency largely confirm the results obtained from quarterly models. After an interest rate shock (Figure 6) industrial production and prices fall. The response of production is, at least in certain periods, statistically significant, whereas the decline in prices is significant with a considerable lag, however there is no price puzzle.¹⁴ The level of zloty denominated loans decreases, in the structural decomposition (left panel) this decline takes place immediately after the interest rate shock, whereas in the Cholesky decomposition (right panel) – with a lag. The exchange rate does not react in any of the presented decompositions.

¹⁴ The price puzzle on monthly data is observed on a sample comprising data prior to 2001.

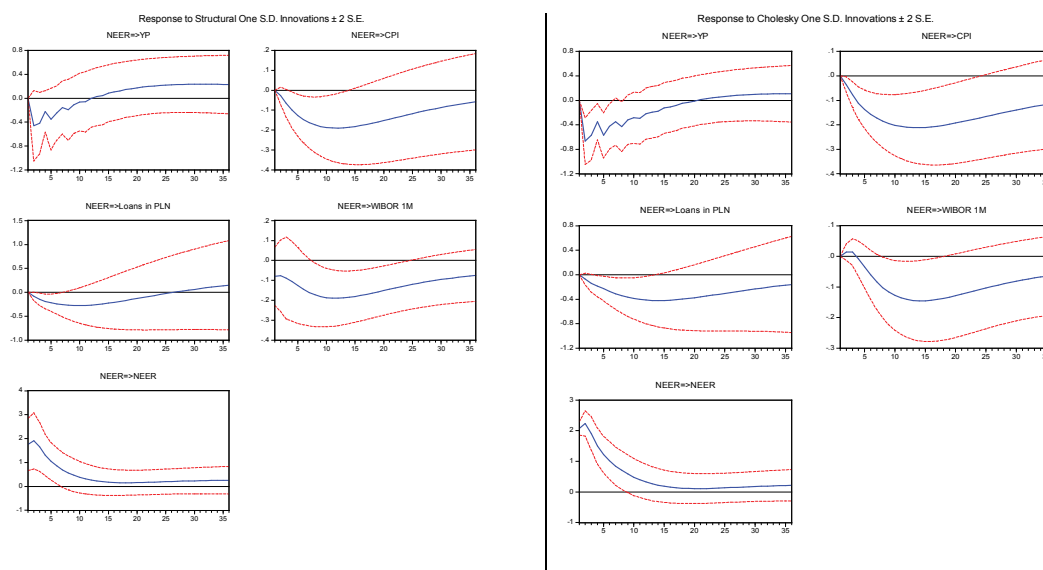
Figure 6. Impulse response functions to a contractionary interest rate shock from decomposition allowing for a simultaneous reaction of exchange rate and interest rate (left panel) and ordinary Cholesky decomposition (right panel)



Source: own calculations.

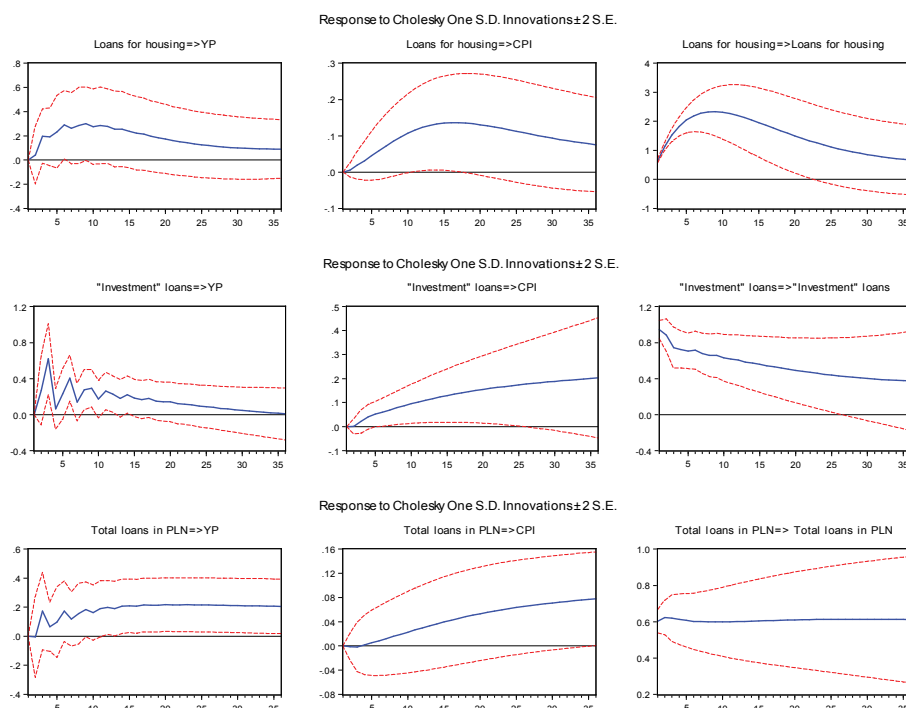
After the exchange rate shock (Figure 7) industrial production practically does not react in the structural decomposition (its decline is statistically insignificant) or falls over a period of approximately 7 months (Cholesky decomposition, right panel). That corresponds to the transitional GDP decline in the model in which we analyse the behaviour of GDP components. Prices decline but the *pass-through* effect is lower than in quarterly models, amounting only to approximately 2% after 12 months. The impact of the exchange rate shock on zloty-denominated loans, although at first sight it may seem different than in the quarterly model, is not inconsistent – there is a slight initial decline of loans (lasting approximately 6 months), which is also visible in quarterly models; afterwards the reaction is statistically insignificant, with big error bands. It should be also remembered that in the case of quarterly models we show responses which are much more spread over time (24 or 36 quarters), whereas in monthly models – 36 months. Responses of credit in the quarterly model are better estimated and statistically significant, thus it may be expected that in a longer time horizon the behaviour of zloty-denominated loans after a zloty appreciation is close to that shown in Figure 3. The positive shocks of zloty-denominated loans for households and firms, which we interpret as loan supply shocks cause production growth, which confirms the operation of the loan channel in the economy (a broader analysis of the loan channel is contained in section 3.3). Such impact exhibit, in particular, housing loans to individuals and some corporate loans (in the report they are dubbed “investment” loans, i.e. loans with the maturity from over 1 year to over 5 years (Figure 8).

Figure 7. Impulse response functions to the exchange rate shock (appreciation) from decomposition allowing for a simultaneous reaction of exchange rate and interest rate (left panel) and ordinary Cholesky decomposition (right panel)



Source: own calculations.

Figure 8. Impulse response functions of industrial production and CPI to a shock of selected zloty-denominated loans

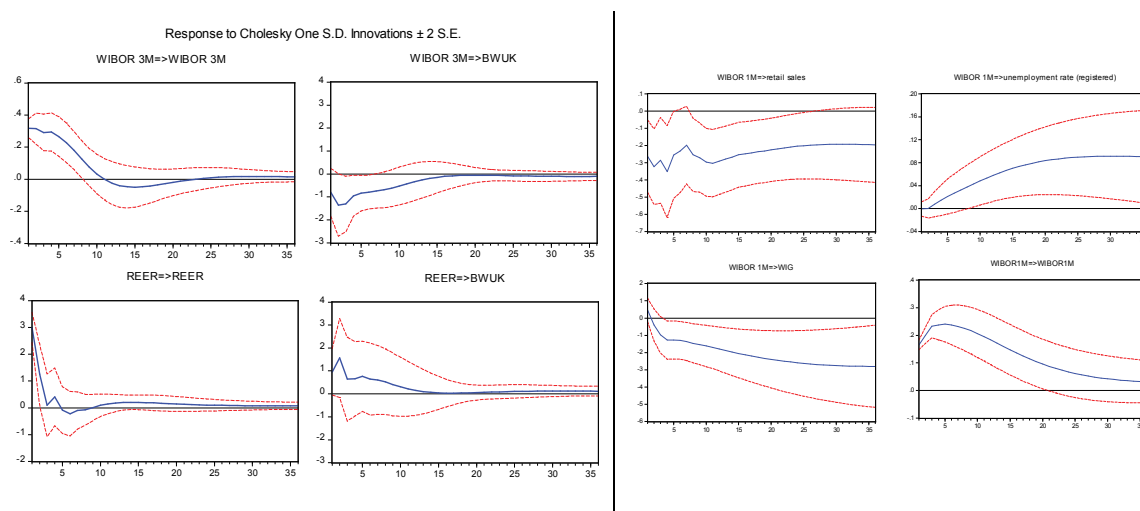


Notes: The figure presents the responses of the following zloty-denominated loans: housing loans to individuals, corporate loans from 1 to 5 years, and total credits and loans to households and firms.

Source: own calculations.

Additional models show that after the interest rate shock, retail sales and prices of financial assets (WIG index in real terms) decrease in the statistically significant way, whereas the registered unemployment rate increases. It was also examined how the current consumer confidence indicator CSO data – GUS) – representing the arithmetic mean of the evaluations of the previous and predicted (over the following 12 months) changes concerning the household's financial condition as well as the general economic situation of the country and major purchases currently made – responded to the interest rate shock and exchange rate shock. It turns out that in the former case it falls whereas in the latter it increases (this result is close to statistical significance), which corresponds well with the IRFs of individual consumption and retail sales (Figure 9, left panel).

Figure 9. Impulse response functions of consumer sentiment index (BWUK) to a contractionary interest rate shock (WIBOR 3M), Cholesky decomposition, quarterly data (left panel), and retail sales of goods and services, unemployment rate and prices of financial assets (WIG) to the contractionary interest rate shock (WIBOR 1M), Cholesky decomposition, monthly data (right panel)



Source: own calculations.

All the above results were obtained on the basis of the classic form of identifying (S)VAR models, i.e. through imposition of zero restrictions on coefficients of the model. This has its advantages, but also weaknesses. The main advantage is that the results are unambiguous (for the assumed model structure). At the same time, it is a weakness of the method because, while changing the assumptions of the model structure, we may obtain other results related to the monetary transmission mechanism. Therefore we decided to conduct a certain type of robustness analysis of our results with respect to the assumptions of the model structure. Instead of zero restrictions we used sign restrictions. The interpretation of the IRF based on such a method is different. In the classic approach, the functions of the impulse response are explicitly associated with a single model structure. Using sign restrictions, we can determine what IRFs consistent with an infinite number of model structures look like, under the condition of compliance of the latter with the assumed signs for coefficients, or certain functions of coefficients (e.g. the IRF of a certain variable to a certain shock after some time).

Figure 10 presents the impact of a monetary policy shock (identified as an exogenous rise in the WIBOR 1M interest rate) on industrial production (YP), prices (CPI), zloty-denominated loans (LOANS IN PLN) and the nominal effective exchange rate (NEER, rise means zloty appreciation). In order to identify the monetary policy shock only sign restrictions of the IRF were used. Thus, it is a significant departure from the classic identification of shocks based on the assumption of a sufficient number of zero restrictions imposed on the

model coefficients. We mostly relied on the approach proposed by Uhlig (2005). In particular, it has been assumed that a monetary tightening does not result in a rise in prices and a rise in loans in the 3rd, 4th and 5th month following shock. Moreover, after a monetary tightening, its relaxation does not occur immediately, and the WIBOR 1M rate is maintained over a certain time at an increased level. The green continuous line denotes the median of the IRF probability distribution whereas red dotted lines determine the 68-per cent error bands for the median. What attracts attention when analysing the impulse response functions is the absence of the monetary policy impact on the industrial production. This result is correspondent with that obtained for the US economy in the study by Uhlig (2005). On the other hand, a monetary tightening results in an immediate decline in prices and loans, reaching the maximum effect after approximately half a year. It should be stressed that it happens despite the fact that we have not enforced the decline of prices and loans over a period of two months following the emergence of the shock. Finally, taking into account the median of the exchange rate IRF, the monetary tightening results in immediate zloty appreciation by approximately half of percentage point, however, this effect is not statistically significant.

A natural question arises whether the lack of response of the real sector to the monetary policy shock (see Figure 10) is an undeniable fact, or whether it rather results from the absolutely minimal assumptions related to the interest rate economic impact imposed on the model. We claim that the latter hypothesis is more likely to be true. In order to document this claim, we have introduced additional restrictions. We have considered the situation in the context of the monetary policy rule which describes the link between the interest rate, inflation and the difference between industrial production and its potential (the output gap). Standard concepts do not allow a negative reaction of the interest rate to a rise in inflation and the output gap. The former model implies, on the other hand, that the coefficient on the output gap is negative with 43% probability and that the coefficient on the inflation is negative with 55% probability. Therefore, it seems reasonable to avoid such a situation *a priori*. Following Arias *et al.* (2015) we have thus assumed that the interest rate does not fall in response to an increase in both the output gap and inflation (*ceteris paribus*). Moreover, we have assumed that both industrial production and prices will not react immediately to changes in loans.

Figure 11 presents effects of adoption of these additional assumptions. Contrary to the previous version of the model, we obtain a statistically significant impact of monetary policy on industrial production. It is an immediate effect continuing over a period of about half a year, leading to a decline in production by approximately 0.5%. Responses of other economic categories to a monetary policy shock are very close to those shown in Figure 10. However, a more rapid and deeper decline in interest rate after its initial increase attracts attention. It is certainly associated with sign restrictions imposed on the monetary policy rule: an immediate decline in output gap and prices results in the strong pressure on the monetary policy easing. Moreover, we observe statistically significant exchange rate depreciation after approximately a year since the occurrence of the monetary policy shock. It is probably the result of two effects: a significant decline in interest rates and weakening of the economic fundamentals. Finally, the decline in loans in response to the monetary tightening is outlined more strongly than in the previous version of the model. It is worth stressing that the probability that the interest rate falls as a response to the loan growth (*ceteris paribus*) reaches only 3%. Compared to restrictions imposed on the monetary policy rule (i.e. coefficients on inflation and output gap are not negative), it provides a consistent picture of the extended monetary policy rule, also comprising loans, besides the aforementioned two underlying variables.

Besides the IRF to an exogenous monetary policy shock, the second element of the presentation of the results obtained on the basis of (S)VAR models is the so-called variance decomposition. It responds to the question concerning the percentage of variance in the forecast error of individual economic variables (for a given

horizon) which is explained by exogenous monetary policy shocks. The results concerning the variance decomposition of the industrial production are as follows. In the horizon of one year, monetary policy shocks explain approximately 10% of industrial production forecast error variance. However, the uncertainty related to this estimate is significant: a 68-per cent error band for this estimator is contained between 3% and 32%. Interestingly, within the horizon of four years, the estimate remains at a level of 10%, whereas the precision of this estimator increases: a 68-per cent error band is already contained between 4% and 23%. It confirms the finding, well-documented in literature, that exogenous monetary policy shocks probably explain rather a limited part of industrial production forecast error variance (see e.g. Ramey, 2015, as well as Cochrane, 1994; Sims and Zha, 2006). It should be stressed that the above conclusion has positive implications. The reason is that monetary policy in Poland has been carried out in a systematic and predictable manner and any deviations from the monetary policy rule have not influenced the real sector significantly. This statement is reinforced by the fact that the economic analysis constituting foundation for this conclusion was based on very soft model assumptions (restrictions on signs resulting in a slightly different interpretation of results, which we referred to above).

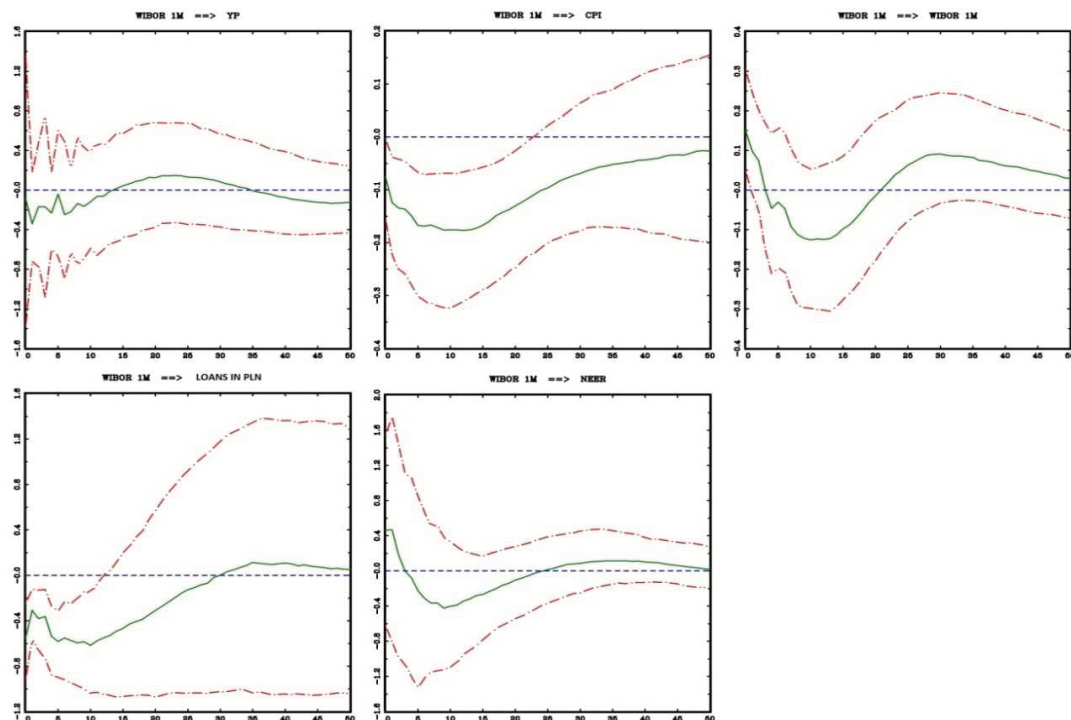
In the context of the study on the transmission mechanism, the variance decomposition of prices is also worth looking at. Within the horizon of one year, monetary policy shocks explain approximately 20% of the variance of prices forecast error (68-per cent of error band is contained between 5% and 45%). Within the horizon of four years, the share of monetary policy shock in explaining the forecast error variance remains at a similar level amounting to 18% (68-per cent of error band is contained between 8% and 33%). The above results are consistent with the results obtained by Uhlig (2005) for the US economy, yet, they are in a clear conflict with the study by Christiano *et al.* (1999). The latter authors estimated the share of the monetary policy in explaining the variance of prices forecast error (within the horizon of three years) at 2.5%. However, their methodology was limited exclusively to recursive models (identification based on the Cholesky decomposition).

We analyse the impact of foreign interest policy shock on the Polish economy in a similar way. To that end, we build a quarterly model consisting of three foreign and three domestic variables and the real bilateral exchange rate. Thus, we use the euro area variables: GDP, HICP and EURIBOR 3M as proxies of foreign demand, foreign prices and foreign short-term interest rate, analogical variables for Poland and the EUR/PLN exchange rate¹⁵ deflated with retail prices (HICP). We use sign restrictions, as in Uhlig (2005); however, we additionally introduce lags for reaction of foreign prices and real sector to the foreign interest rate shock. The foreign monetary policy shock is therefore identified as an increase in EURIBOR 3M rate leading, with a lag of one quarter, to a decline in foreign GDP and prices. All restrictions are maintained for one quarter. Other variables of the model are not subject to any restrictions. Continuous lines in Figure 12 denote the median of the IRF probability distribution and dotted lines – its 68-per cent error bands.

Monetary policy tightening in the euro area is transmitted to Poland through the trade channel – a decline in external demand causes a decline in exports, which, in turn, results in GDP decline; a rise in the WIBOR 3M interest rate is not statistically significant, the real bilateral exchange rate does not react and prices also do not change.

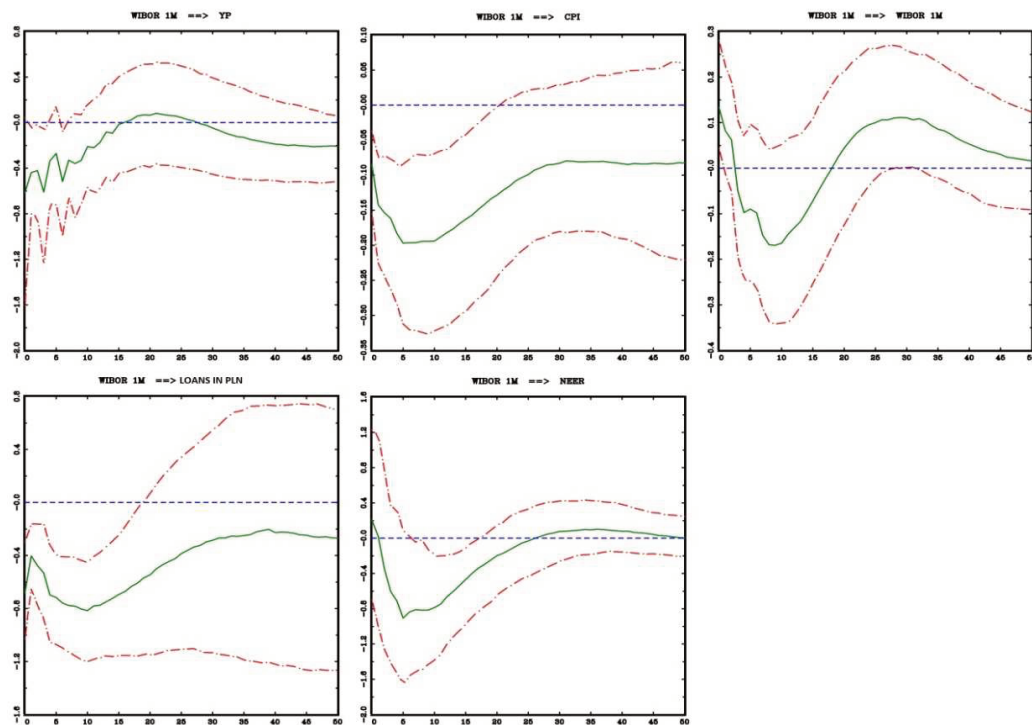
¹⁵ In this case, a rise means zloty depreciation against euro.

Figure 10. Impulse response functions to a contractionary monetary policy shock: only sign restrictions imposed on selected response functions



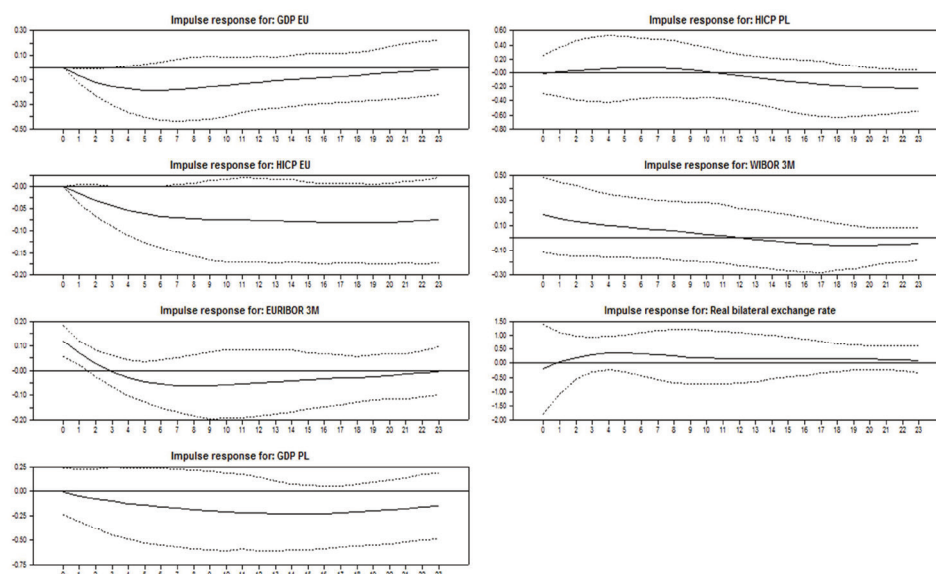
Source: own calculations.

Figure 11. Impulse response functions to a contractionary monetary policy shock: sign restrictions imposed on selected response functions and on coefficients in the monetary policy rule



Source: own calculations.

Figure 12. Impulse response functions of GDP, prices and interest rate to a foreign (euro area) contractionary interest rate shock (EURIBOR 3M)



Source: own calculations.

Summing up, (S)VAR type models, both these traditional and those with sign restrictions, show that the exogenous positive monetary policy shock results in the decline of economic activity – GDP, consumption and investment, loans and prices.

The exchange rate shock influences retail prices, however, the *pass-through* effect seems low. The appreciation of zloty has a transitional adverse effect on GDP through a slowdown in exports. Results showing a positive impact of appreciation to the real sector seem dependent on the simultaneous decline in the interest rate, reducing monetary policy tightness.

2.2. Simulations on structural models

2.2.1. MMT 2.1 and QMOTR 2 structural models used for simulations

In this part of the report we show monetary transmission mechanism from the perspective of structural models, i.e. constructions with a much higher number of embedded assumptions than vector autoregressive models. The non-technical description of the models is included in Appendix 1. The set of variables we use is very close to that presented in the previous section.

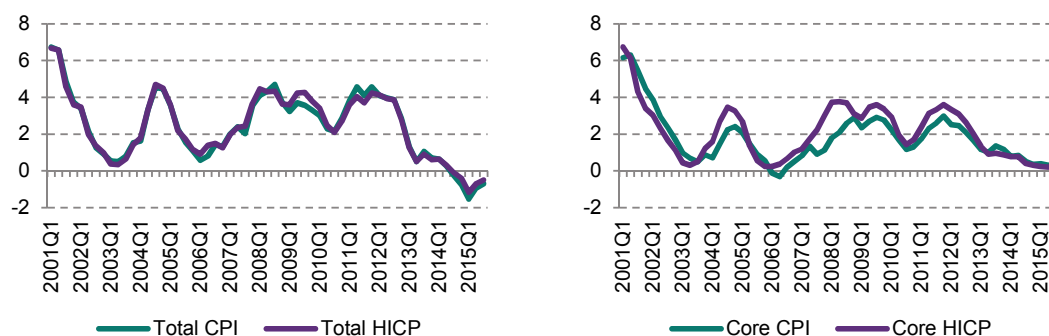
The first model is the Small Model of Monetary Transmission, MMT 2.1. It is similar to the model used by the Bank of Israel (Argov *et al.*, 2007) and consistent in terms of specification with its version used in the previous report (Kapuściński *et al.*, 2014). The model was estimated on data from 1999 Q1 to 2015 Q1. Due to inclusion of three interest rates (money market rate, interest rate on loans, yield on Treasury bonds) and the volume of loans, the model takes into account the financial sector (for the details see Appendix 1).

The second tool is the QMOTR 2 model (Quarterly Model of (Monetary) Transmission) with stochastic shocks, built on the basis of Global Projections Models (GPM), developed by the International Monetary Fund (see e.g. Carabenciov *et al.*, 2008). In the QMOTR model we try to combine standard features of economies described by the classic GPM model with features specific for Poland. Contrary to MMT 2.1, in the QMOTR 2 model more attention was paid to the real sector. To enrich the model, we have added two blocks: the block of foreign trade and the block of government expenditure. Moreover, residuals (shocks) in the main equations have been disaggregated. The model was estimated for a period from 2000 Q1 to 2015 Q2 with the use of Bayesian methods (for the details see Appendix 1).

There are two main features linking MMT 2.1 and QMOTR 2 models. Both models describe the monetary policy transmission mechanism in the spirit of New Keynesian Economics and in both models, the basic economic categories are expressed as deviations of those variables from their respective long-term equilibria. On the other hand, endogenisation of the level of basic macroeconomic equilibria¹⁶ and a degree of forward-lookingness (which is higher in the QMOTR model) are the essential features distinguishing these models.

The core HICP inflation (excluding foodstuffs and energy prices) is the main measure of inflation used in both models. The main reason for replacing CPI inflation with HICP inflation was the need to ensure comparability between domestic and foreign variables (in this way, the real exchange rate and the real interest rate are deflated with the same type of price index). For the sample period used to estimate both models, the levels of both indices were similar (Figure 13). The correlation coefficient between the total CPI and HICP inflation was approx. 0.99, while correlation between core measures of CPI and HICP inflation – approx. 0.89. The correlation coefficient between core HICP inflation and CPI overall inflation in this period was about 0.94.

Figure 13. CPI and HICP total inflation (left panel) and CPI and HICP core inflation, excluding food and energy prices (right panel)



Source: NBP and ECB data.

¹⁶ In MMT 2.1 and QMOTR 2 models, equilibria are directly embedded in the structure of the models. At the same time, in the MMT 2.1 model trends are obtained from Hodrick-Prescott filters and then incorporated into a model as autoregressive processes, whereas in the QMOTR 2 model they are embedded in its structure as state space models. Therefore, equilibria in MMT 2.1 have a smaller variance (while deviations of each variable from its equilibrium – greater) than in the QMOTR 2 model. It is one of the constructional factors explaining the results presented later in this section, according to which at the same level of starting shocks, the speed of reaction is higher in QMOTR 2 than in MMT 2.1, whereas the opposite is true for the length of the reaction.

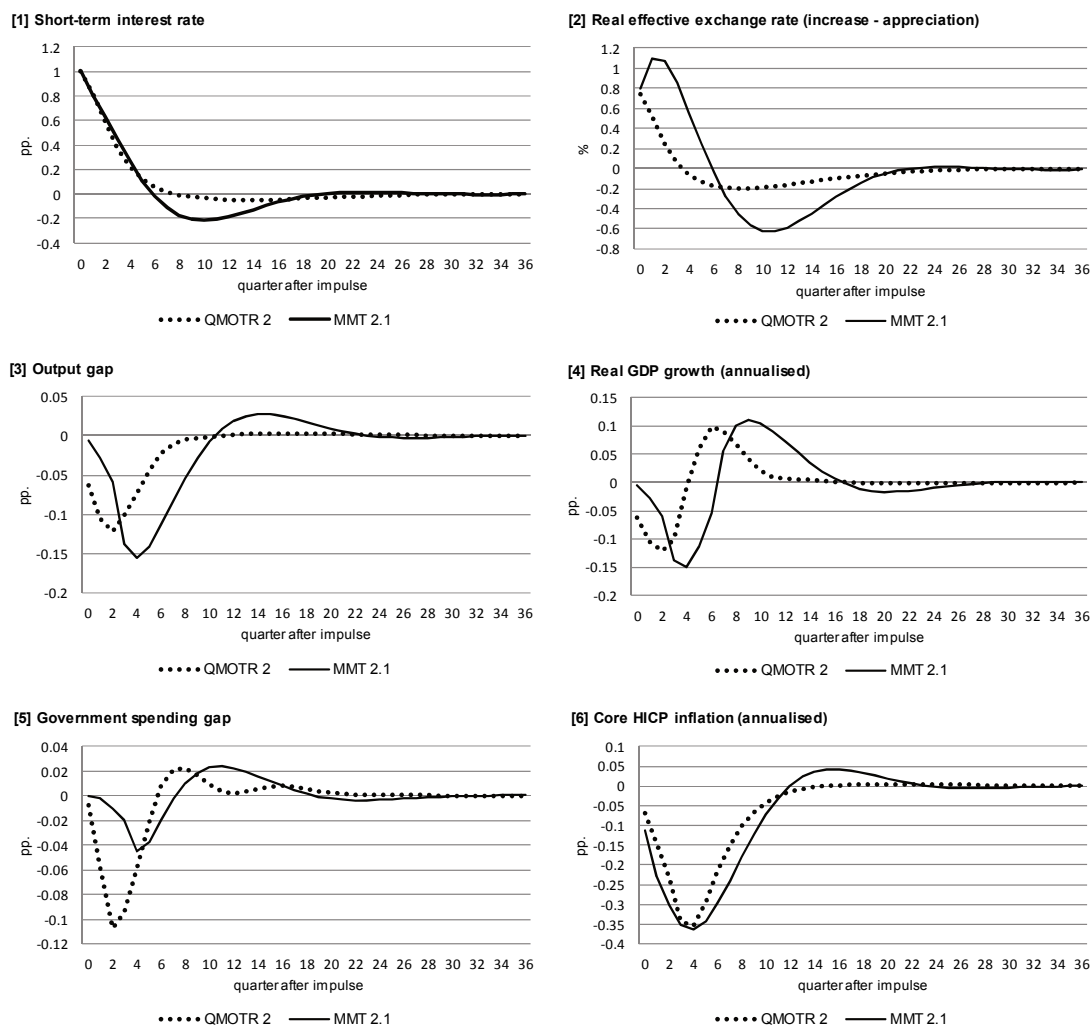
2.2.2. Strength and delays in the monetary transmission mechanism obtained from the structural models

To assess the strength and delays of the transmission of monetary policy impulses, we have run a simulation, in which the interest rate (WIBOR 3M) is increased by 1 p.p. for a period of one quarter and then it is allowed to develop according to the estimated monetary policy rule.

The results of the simulation obtained from the Small Model of (Monetary) Transmission (MMT 2.1) and the QMOTR 2 are the same in the case of inflation reaction and similar in terms of the maximum reaction of other variables to interest rate growth. On the other hand, the models differ in terms of reaction time and lags. The responses based on the QMOTR model are usually faster and shorter since it is more forward-looking. The maximum response of annual GDP growth reaches the level from -0.12 p.p. in the QMOTR model in the 2nd quarter after the impulse, amounting to -0.15 p.p. in the MMT model in the 4th quarter after the impulse. On the other hand, core inflation (annualised quarterly HICP index) decreases in both models by approx. 0.35 p.p. in the 4th quarter after the impulse (Figure 14, Table 5).

In the models, the monetary transmission mechanism operates in the following way: after the growth of the WIBOR 3M rate, the interest rate on loans and yields on Treasury securities grow (in the model they are represented by 1-year benchmark bonds). The growth of interest rates leads to the decline of demand for zloty-denominated loans. The supply of loans also decreases. On the one hand, the reason is that the slowdown in the real sector translates into a gradual deterioration of the loan portfolio quality, forcing banks to increase their capital. On the other hand, costs of refinancing in the interbank market increase, whereas at least a part of interest rate on loans grows with a certain delay. Zloty appreciation causes the decline in domestic prices of imported goods and – because of high import intensity of Polish exports – the decline of exported goods. Growth in the volume of import increases, the dynamics of exports volume declines (QMOTR), the output gap, GDP growth rate and inflation decreases. Due to the fact that after a lapse of a quarter the interest rate rule operates in the models, where inflation and the output gap are the explanatory variables (in the QMOTR model – additionally the exchange rate), their declines result in the corresponding monetary policy easing.

Below we present the response of the real effective exchange rate, output gap, GDP growth, government expenditure gap and HICP inflation, excluding foodstuffs and energy to the monetary policy impulse (Figure 14, Table 5).

Figure 14. Monetary transmission mechanism – results from MMT 2.1 and QMOTR 2 models

Source: own calculations.

Table 5. Monetary transmission mechanism – synthesis of results from MMT 2.1 and QMOTR 2 models

	MMT 2.1	QMOTR 2
Real effective exchange rate (decrease - appreciation)		
strength of maximum response (in per cent)	-1.1	-1.1
lag of maximum response (quarter)	1-2	2
Output gap		
strength of maximum response (in p.p.)	-0.15	-0.12
lag of maximum response (quarter)	3-4	2
GDP growth (annualised)		
strength of maximum response (in p.p.)	-0.15	-0.13
lag of maximum response (quarter)	4	2
Core HICP inflation (annualised)		
strength of maximum response (in p.p.)	-0.36	-0.35
lag of maximum response (quarter)	4	4

Source: own calculations.

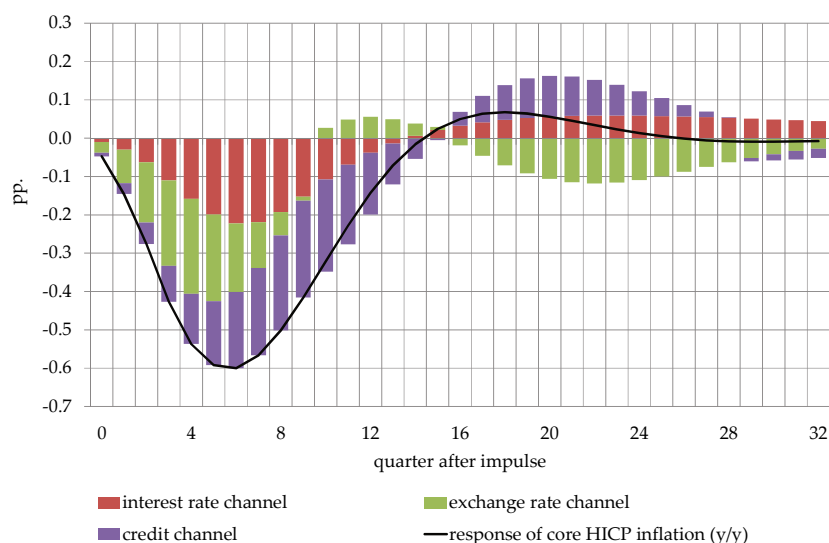
2.2.3. Attempt to assess the relative strength of respective channels of the monetary transmission mechanism

The analysis of inflation response to the monetary policy impulse contains the effects of various transmission mechanism channels. The aim of the next simulation, carried out using the MMT 2.1 model is the approximate evaluation of their relative strength. In the model, the following channels are represented: the interest rate channel, the exchange rate channel and the credit channel. In the case of the last channel, we assume that the credit variable in the aggregate demand (IS) curve represents mainly the effects of the loan supply, since the main determinants of the loan demand (interest rate, economic activity) appear in this equation separately. However, we are aware that the assumption that the credit variable in the IS curve represents solely the effects of loan supply can overestimate the role of the credit channel in the model. Accordingly, in the additional simulation we adopt the technical assumption that a half of the credit variable is developed by demand factors and the other half – by the supply factors. It may be safely assumed that the role of the credit channel is contained within the scopes shown in Figure 15 and Figure 16.

The exercise was run in three steps. In the first step, we evaluated the response of inflation to an increase of 1 p.p. in the short-term interest rate for a period of four quarters. This period is longer than in the simulations of the transmission mechanism described in section 2.2.2, which makes the effects of individual transmission channels more visible and the overall inflation response is comparable with the results described in the previous report (Kapuściński *et al.*, 2014). Subsequently, in an analogical simulation, we fixed the nominal effective exchange rate, thus rendered an approximation of the effect of interest rates on inflation through channels other than the exchange rate channel (i.e. through the interest rate channel and the credit channel). In the last step, we fixed a variable representing the credit channel, i.e. the volume of credit in the aggregate demand curve, obtaining the proxied estimation of effects of this channel.

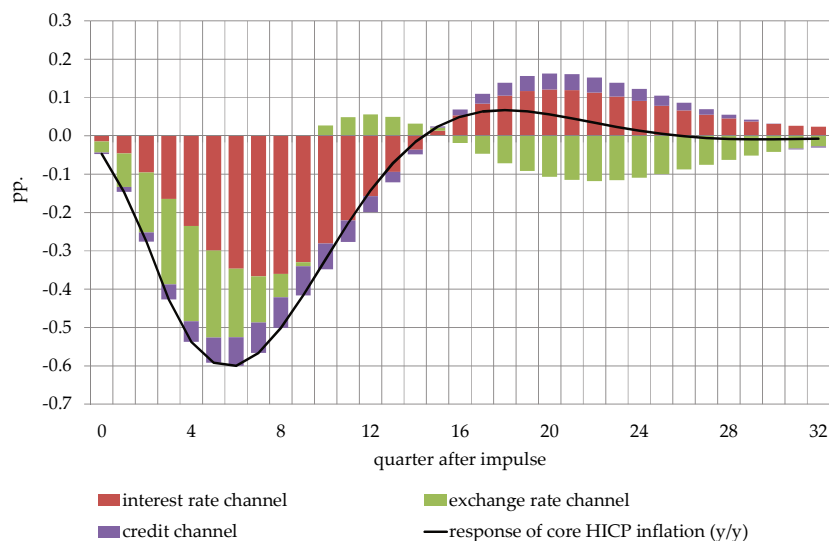
The results obtained from the simulation with all models' feedbacks show that the maximum response of inflation to a 1 p.p. rise in short-term interest rate for a period of four quarters occurs with a 6-quarter lag after this impulse and amounts approx. to -0.6 p.p. (Figure 15, Figure 16). The analysis of the strength of individual monetary policy transmission channels indicates that the interest rate channel and the credit channel are significantly stronger than the exchange rate channel, although the latter dominates in the period of first 3-4 quarters following the change in the interest rate. 70% of the maximum reaction of the annual price dynamics results from effects of the interest rate channel and credit channel and approx. 30% – from the exchange rate channel. Within the horizon of the strongest transmission, the strength of the interest rate channel is bigger than that of the credit channel, however, the scale of this prevalence significantly depends on the adopted decomposition method, i.e. on the method of interpreting the credit variable in the IS curve.

Figure 15. Strength of the individual channels of the monetary transmission assuming that the credit variable in the IS curve represents effects of the credit supply



Source: own calculations.

Figure 16. Strength of the individual channels of the monetary transmission assuming that the credit variable in the IS curve represents effects of the credit supply and the credit demand



Source: own calculations.

Comparing the strength and delays of the monetary transmission mechanism in the MMT 2.1 model with the results of a similar simulation based on the previous version of the model (MMT 2.0) and a shorter sample of observations (Kapuściński *et al.*, 2014) we notice that in both models the maximum response of the annual price growth to the monetary policy impulse occurs with a lag of approx. 6 quarters. The strength of this response is currently slightly smaller than in the previous version of the model (Table 6) owing to a lower value of the parameter at the real interest rate in the IS curve obtained in the estimation of MMT 2.1. However, it lies within the error band obtained in the previous version of the model, MMT 2.0 (the previous estimate is also contained within the error band of the current estimate). Should the previous estimate of the parameter at the real interest rate be applied in the current version of the model, the response of inflation

would be similar as in the previous version of the model. Therefore, no premises exist to claim that a more serious change in the strength of the monetary transmission mechanism occurred. Moreover, dynamic properties of the model support adopting of the reduced estimate.

Table 6. Monetary transmission mechanism – summary of results from MMT 2.1 and MMT 2.0 (Kapuściński *et al.*, 2014)

	MMT 2.1	MMT 2.0 (Kapuściński <i>et al.</i> , 2014)
Interest rate on loans in PLN		
strength of maximum response (in p.p.)	1.05	0.90
lag of maximum response (quarter)	3	4
Real effective exchange rate (decrease - appreciation)		
strength of maximum response (in per cent)	-1.54	-1.24
lag of maximum response (quarter)	3	3
Output gap		
strength of maximum response (in p.p.)	-0.22	-0.43
lag of maximum response (quarter)	6	5
GDP growth y/y		
strength of maximum response (in p.p.)	-0.21	-0.33
lag of maximum response (quarter)	6	5
Core inflation HICP y/y		
strength of maximum response (in p.p.)	-0.60	-0.70
lag of maximum response (quarter)	6	6

Note: HICP core inflation excluding foodstuffs and energy.

Source: own calculations.

2.3. Cyclical properties of the transmission mechanism in the QMOTR model

2.3.1. Methodology used for studying the cyclical features of the transmission mechanism

In this section we present the findings of studies on cyclical properties of the monetary policy transmission mechanism in Poland. Whereas the previous studies in this area have focused on the analysis of selected transmission mechanism relations (see e.g. Kapuściński *et al.*, 2014, section 3.6, Przystupa and Wróbel, 2011, Sznajderska, 2014), the current analysis is based on the overall QMOTR model.

A typical example of the study describing the asymmetry in the economy's response to changes in interest rates in various phases of the business cycle is the study by Ming (2002).¹⁷ It is based on the analysis of changes in state of the economy (various coefficients in equations describing the same economy in different phases of the cycle), assuming that the series describing the economy meet the properties of Markov processes, i.e. that the probability of realisation of an event in t period depends entirely on the probability of realisation of this event in the $t-1$ period.

The methodology of cyclical studies on the properties of the monetary policy transmission mechanism is similar to that applied in the aforementioned work. In the first step, the standard shape of the QMOTR model described in Appendix 1 has been estimated. Besides the version estimated for the overall period (2000 Q1-2015 Q2), four models with the analogical structure have been estimated for periods corresponding to various phases or periods of the business cycle.

The key assumption adopted is that changes in the output gap approximate the business cycle. The consequence of this assumption is the method of defining phases and periods of the cycle (see Figure 17):¹⁸

- Model 1 corresponds to the **recession** phase, i.e. a period when the output gap (y), in at least three consecutive periods (quarters) decreases ($y_t \leq y_{t-1}$).
- Model 2 corresponds to the **recovery** phase, when the output gap grows in at least three consecutive periods (quarters) ($y_t \leq y_{t-1}$).
- Model 3 describes a period of **slump**, in which the output gap assumes values below the defined threshold (τ). Resolving the QMOTR model for the whole period, with the inflation target equal to 2.5%, the determined values of the output gap were derived at a level of 0.2% of the potential product.¹⁹ Assuming this value as a threshold, the area of function defining a crisis period was determined for $y < 0.2$. This period comprises the late phase of recession and the early phase of recovery.
- Model 4 corresponds to a period of **prosperity** in which the output gap assumes values higher or equal to 0.2. The period so defined comprises the late phase of recovery and the early phase of recession.

In this convention, the analysis of asymmetry focuses on the relevant determination of domain of a function and on estimation of this function. If the difference between the estimated parameters is significant (the Wald test), the asymmetry of the reaction to the determined shocks between various phases of the business cycle

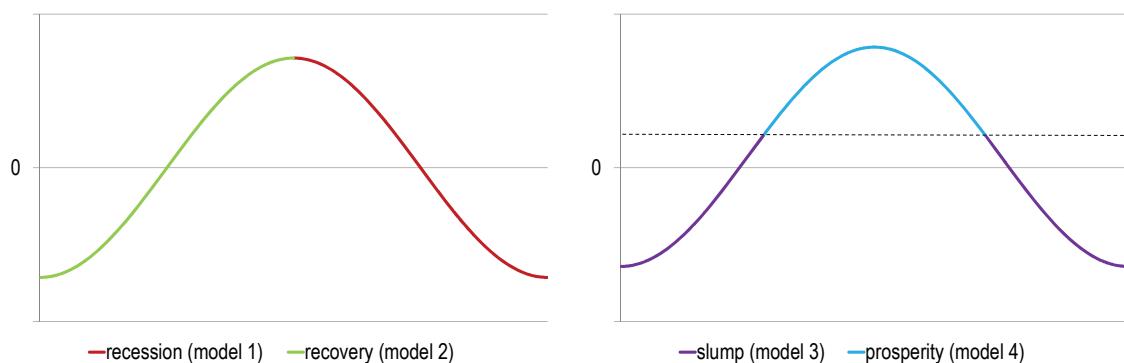
¹⁷ The results of this study, conducted on the data obtained for the US economy, indicate that the rigidity of prices is not fixed, but changes depending on the phase of the cycle as well as the direction and intensity of changes in the monetary policy. Moreover, prices are less susceptible to stimuli working towards their decrease than to stimuli acting in a pro-inflationary way. This leads to an asymmetry in reaction to the monetary policy since each growth in the aggregate demand results, in the first place, in the growth of prices whereas the decline of demand causes, in the first place, response from the supply. It means that responsiveness of the real sector to restrictive monetary policy is higher than its vulnerability to expansive policy. Therefore, if a policy of inflation limitation is pursued, the activity in the real sector will decrease first and prices will react later. The effect of expansive policy is opposite – prices will react first, followed by the response of the real sector. In addition, the response to growth in prices will be the reduction of policy expansiveness level – which will decrease a positive impact of the policy on the real sector. At the same time, in the period of recession, a strong and short-term impulse arising from the monetary policy (i.e. a large reduction in interest rates, concentrated over time) generates a higher growth of activity in the real sector than a minor reduction of interest rates, spread over time.

¹⁸ The method of defining phases and periods of the business cycle was subordinated to the purpose of the study – the analysis of cyclical properties of the monetary policy transmission mechanism. From this point of view, the issue of cycle dating is less significant than determining the number of quarters subordinated to phases and periods of growth/decline in economic activity. The issues of dating and describing of the business cycle in Poland are discussed, e.g. in Gradzewicz *et al.* (2010), Skrzypczyńska (2013).

¹⁹ Reduction of the inflation target (parameter of the model) from 2.5% to 1.6% causes the output gap steady state converges to zero. This may indicate a real concentration on the accomplishment of the target equal to 1.6%.

occurs. The determining of domain of the function in accordance with the definition provided earlier causes that the number of observations in each of four models described above is approximately equal to half of the observations for the full estimation period.

Figure 17. Stylised output gap and visualisation of business cycle periods taken into account during estimation of QMOTR models



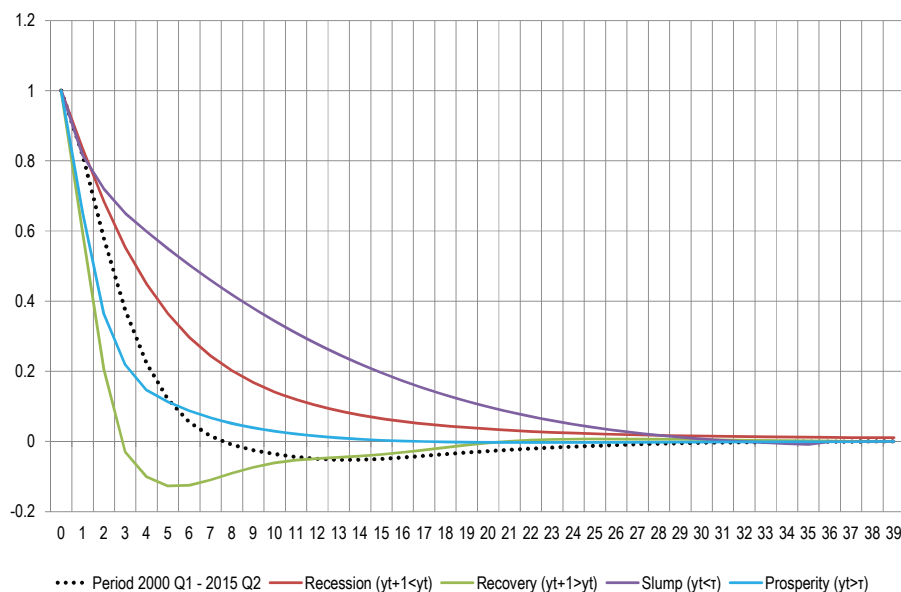
Source: own study.

Taking into account that the reaction of the economy to shocks may be different in an early recession phase, when y values are above the (τ) threshold, and in the late phase, when y values are below this threshold (similarly, diversification of the reaction may occur in the recovery phase), the additional advantage of the adopted determination of domain of the function is a possibility of approximate reasoning concerning the behaviour of economic categories in sub-periods comprising: the early recession phase (the output gap above the calculated threshold, but its growth is negative), late recession phase (the output gap below the calculated threshold and its growth is negative), early recovery phase (the output gap below the calculated threshold, but its growth is positive) and the late recovery phase (the output gap above the calculated threshold and its growth is positive).

2.3.2. Cyclicity of the response of the economic activity and inflation to monetary policy shocks

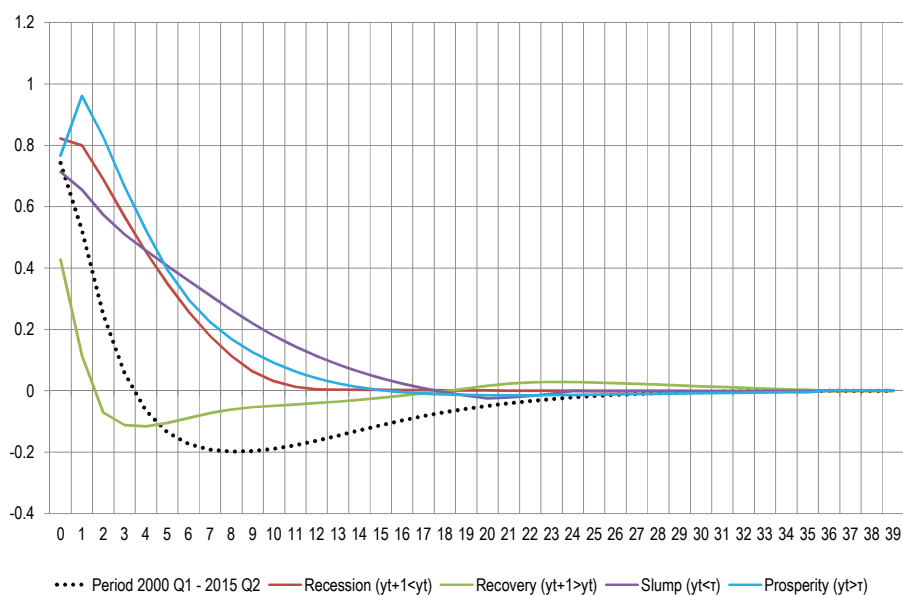
Impulse response functions (IRF) of basic economic categories estimated in the QMOTR model to an interest rate impulse, derived from models estimated for various phases and periods of the business cycle are presented in the following figures. We have adopted the convention assuming that in order to ensure better comparability, irrespective of the considered period of the cycle, we show responses to the increase of the interest rate. Nevertheless, in the interpretation we refer to effects of monetary policy tightening in positive phases of the business cycle, i.e. in the recovery phase and in the period of prosperity and to monetary policy easing in negative phases of the cycle, i.e. in the recession phase and in the slump.

The path of interest rate shock waning (Figure 18) is fairly similar to the response estimated on the full sample only in the prosperity. In the recovery phase, in which increased responsiveness of the real sector to restrictive monetary policy, interest rates quite quickly recover to their base level (the smoothing ratio in the Taylor rule is equal to 0.6). On the other hand, in the negative phases of the cycle (recession and slump), monetary policy easing continues over a relatively longer period (the smoothing ratio in the Taylor rule is equal to, respectively, 0.7 and over 0.9).

Figure 18. Domestic interest rate shock (WIBOR 3M) of 1 p.p.

Source: own calculations.

The short-term response of the nominal effective exchange rate to domestic interest rate shock (Figure 19) is diversified between the prosperity and recession phases. In the prosperity, tightening of the monetary policy leads to the relatively stronger change in the exchange rate (appreciation) than the analogical monetary policy easing in the recession phase (depreciation).

Figure 19. Response of the nominal effective exchange rate growth to domestic interest rate shock, in p.p. (increase – appreciation)

Source: own calculations.

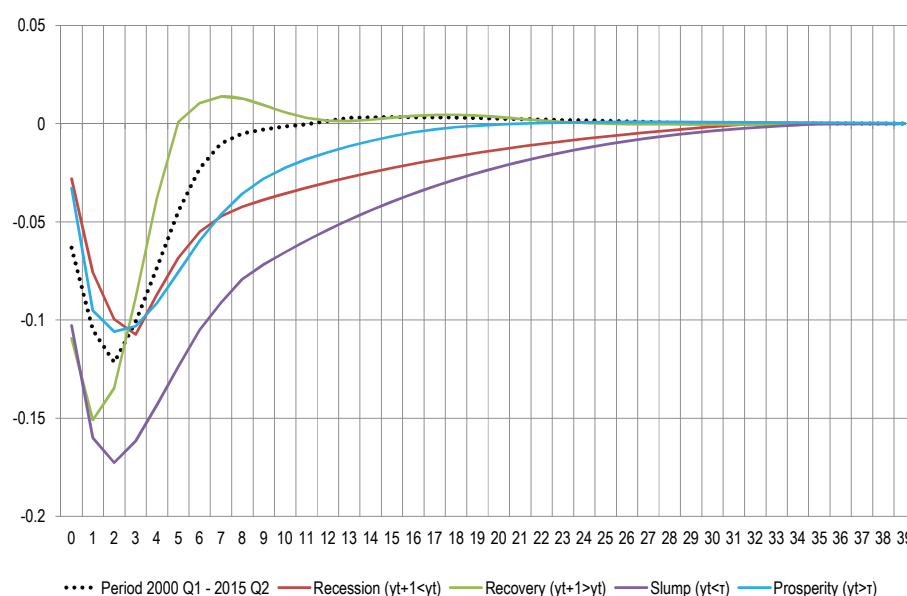
In the recovery phase, the maximum response of economic activity to a short-term interest rate shock is reached in the second quarter after the shock, resulting in a decline of approx. 0.15 p.p. in the output gap and the annual GDP growth (Figure 20, Figure 21), which precedes the peak response of inflation (decreasing by approx. 0.37 p.p.) by one quarter (Figure 22). It confirms the argument contained in the study by Ming (2002) stating that if a policy of inflation lowering is pursued, the activity in the real sector will decrease first and prices will react later.

The behaviour of the output gap in the period of prosperity is slightly different. In this period, consisting of the late recovery phase and the early recession phase, the response of the output gap to interest rate growth is weaker (decline by approximately 0.1 p.p.) whereas in the case of inflation – it is definitely stronger (decline by 0.44 p.p.) and relatively fast. In this period, the lowest cost of inflation reduction is observed (e.g. Filardo, 1998).

Stimulation of the economy is quite effective in the slump period (comprising both a part of the recession phase and a part of the recovery phase), whereas the lowest probability of inflation growth due to a decline of short-term interest rates – in the recession phase.

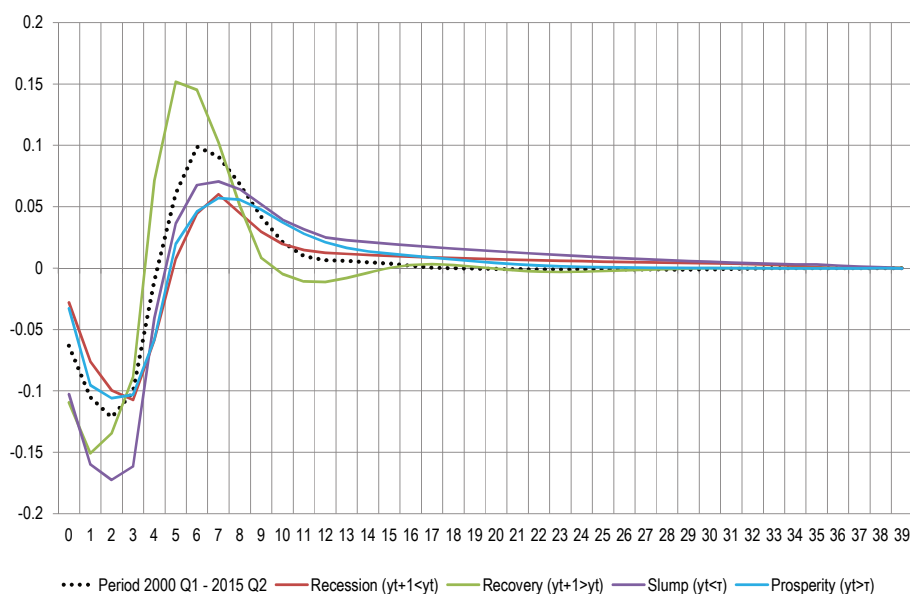
The division of the business cycle into periods of prosperity and slump enables us to define precisely in which specific period the change in particular behaviours of various economic categories takes place. In this convention, monetary policy seems to stimulate the economy most effectively (the highest growth of output gap, with the lowest probability of inflation growth) in the late recession phase, combating inflation most effectively in the entire prosperity.

Figure 20. Response of output gap to domestic interest rate shock, in p.p.



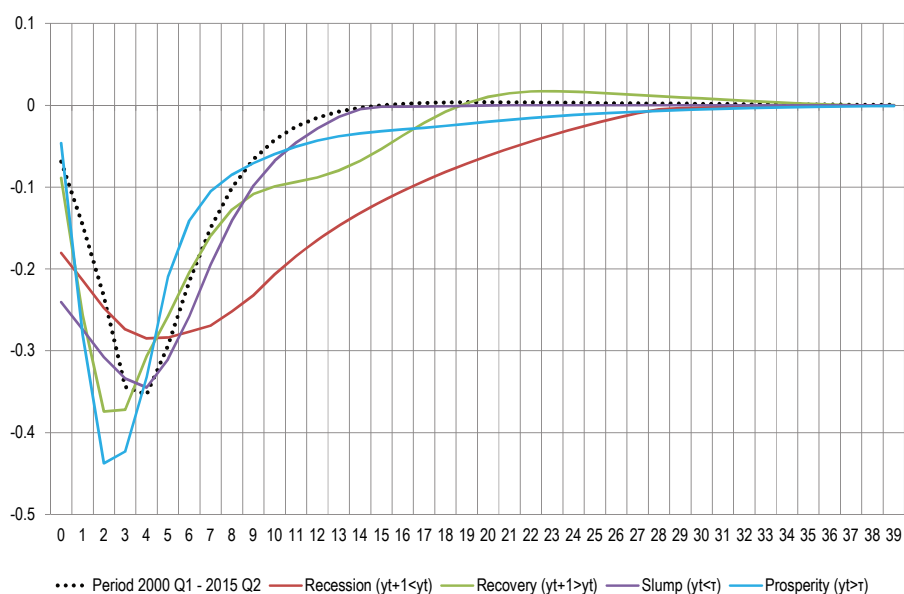
Source: own calculations.

Figure 21. Response of GDP growth (annualised) to domestic interest rate shock, in p.p.



Source: own calculations.

Figure 22. Response of HICP inflation (annualised) to domestic interest rate shock, in p.p.



Source: own calculations.

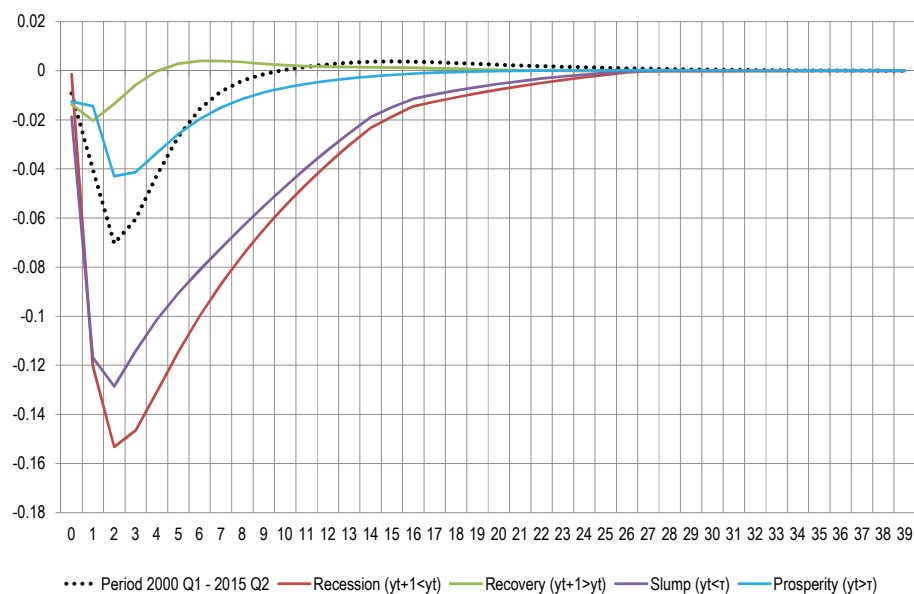
2.3.3. Cyclicity of the response of the volume of exports and imports to monetary policy shock

The growing openness of the Polish economy and the associated growth in foreign trade role causes that describing of response of import and exports volumes to changes in monetary policy seems justified (Figure 23, Figure 24).

The growth in the volume of import in the recovery phase is neglected and only in the first quarter after the interest rate impulse it can be associated with zloty appreciation (Figure 24). In subsequent quarters the response is rather connected with decreasing export growth (high import intensity of exports).

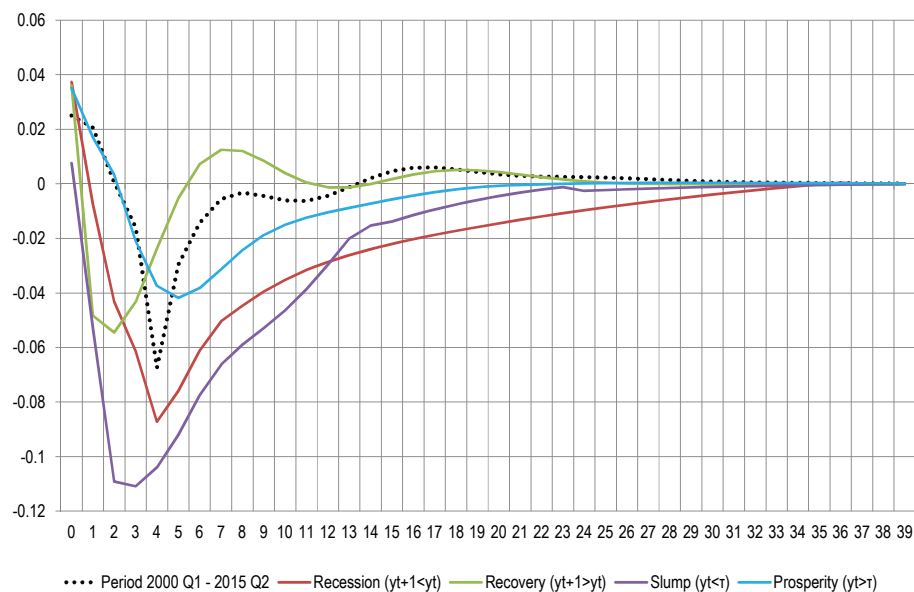
In the period of slump, the relation of the import volume growth rate with the exchange rate depreciation disappears in favour of the dependence on changing export volume growth.

Figure 23. Response of export growth (annualised) to a domestic interest rate shock, in p.p.



Source: own calculations.

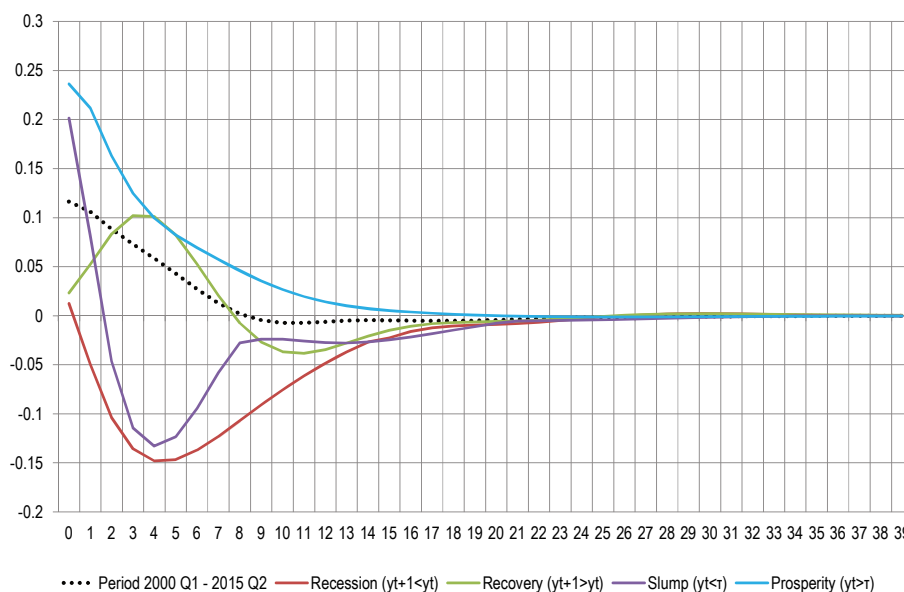
Figure 24. Response of import growth (annualised) to a domestic interest rate shock, in p.p.



Source: own calculations.

Changes in the growth of export and import volume in response to a rise in interest rate in the period of recovery result in the growth of net export gap²⁰ that reaches 0.24 p.p. in the second quarter following the shock (Figure 25). The positive effect of the trade balance confirms increased importance of reduced demand for imports as compared to import growth, due to zloty appreciation. On the other hand, in the decline phases of the business cycle, the expansionary monetary policy leads to deterioration in the trade balance within a short period (3 quarters). After three quarters the decline in the growth of export volume and the associated slowdown in import growth improve the balance of trading in goods and services.

Figure 25. Response net export gap to a domestic interest rate shock, in p.p.

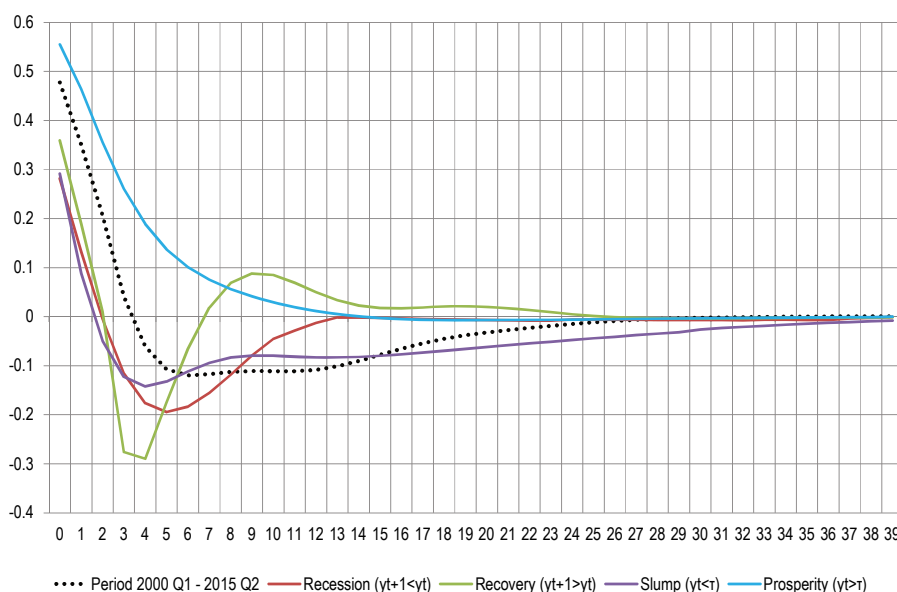


Source: own calculations.

Improvement in net exports in the prosperity period results in a zloty over-valuation of 0.6% (Figure 26). On the other hand, in decline phases of the cycle, a monetary policy easing results in an over-valuation of the exchange rate in the first quarter by 0.3%, in connection with the growth of interest rate disparity, and from the third quarter – in increasing under-valuation of zloty associated with deterioration of the trade balance.

²⁰ The net export gap is the difference between net exports and potential net exports. In the steady state, the net export gap develops so as to provide for the stability of trade balance share in GDP. The steady state determines the threshold above which, assuming the fixed share of primary and secondary income in the current account balance, international investment position of Poland improves (it remains unchanged in the equilibrium). The threshold has been estimated at -4.4% of potential GDP.

Figure 26. Deviation of the exchange rate from the equilibrium exchange rate in response to a domestic interest rate shock (in %)



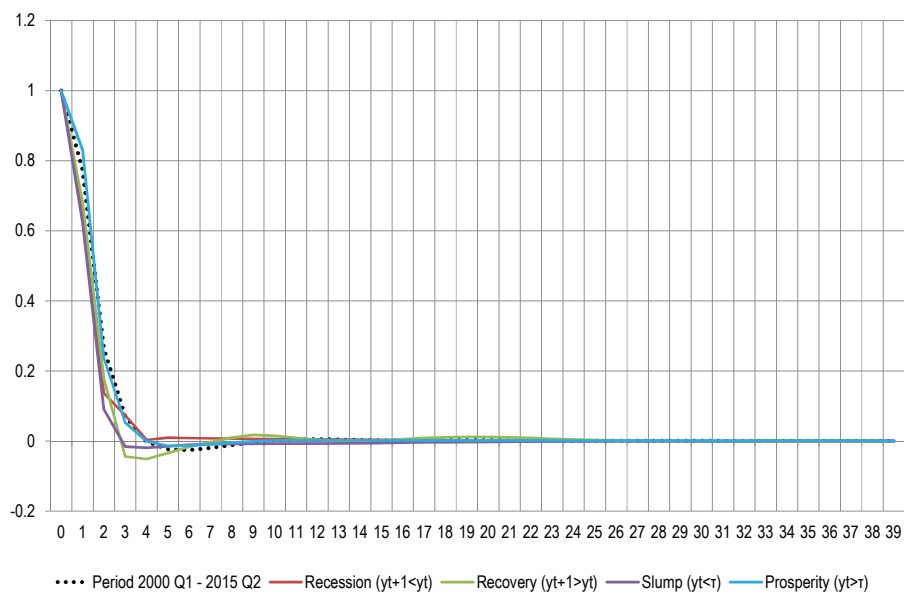
Source: own calculations.

2.3.4. Cyclicity of response of the economic activity and inflation to exchange rate shocks

In section 3.2.2 it has been shown that for the full period of estimation the response of the output gap to appreciation of the nominal effective zloty exchange rate by 1% changes from -0.04 p.p. in the first quarter after the exchange rate shock to 0.03 p.p. in the fourth quarter. The oscillations expire after 12 quarters, generating a cumulated effect close to zero. However, a similar behaviour of zloty exchange rate in various phases and periods of the business cycle (Figure 27) does not mean the identical real sector response. The strongest output gap response is recorded in the period of prosperity (Figure 28). During the first two quarters, similar to the full period of estimation, demand effects prevail, i.e. an increase in the growth of import volume and a decline in exports volume. In the subsequent three quarters the import decline effect prevails, associated with decreased exports dynamics (positive net exports). The cumulative effect of appreciation increases the output gap during prosperity by 0.3% of the potential GDP. The GDP growth rate in the fifth quarter after the appreciation is higher by 0.09 p.p., whereas the cumulative effect is close to zero (Figure 29).

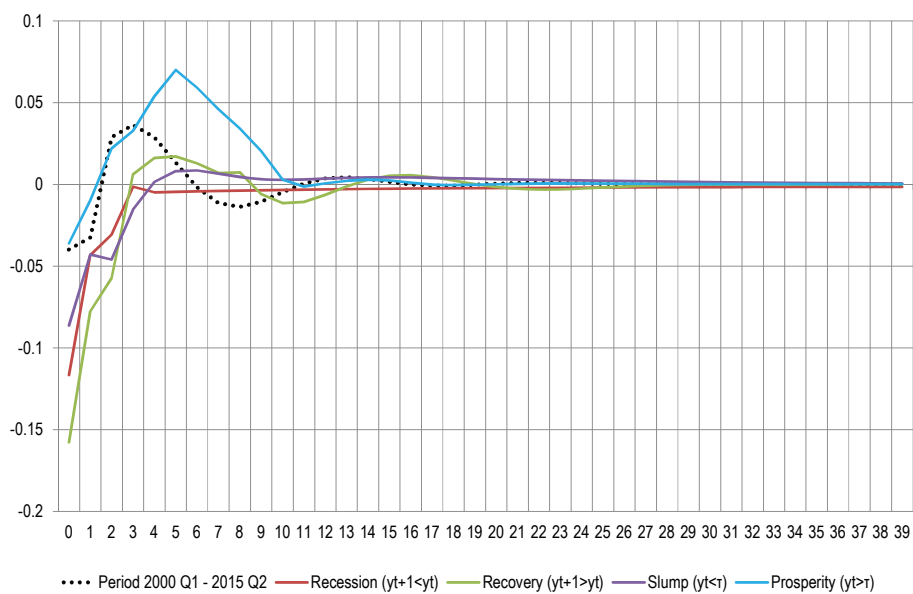
The strongest response of inflation to an exchange rate appreciation (Figure 30) occurs in the recovery phase and in the period of prosperity, when companies are more willing to raise prices (section 3.2.3). At the same time, in those periods the absorption of exchange rate changes is the slowest: during prosperity, 36% of the full effect is absorbed in the first quarter, 58% – after two quarters, whereas in the recovery phase – 51% and 69%, respectively. In period of worsening business conditions, the response of prices is weaker; however, the effects of a change in the exchange rate are absorbed faster: 63% after the first quarter and 72% after two quarters during slump and 56% and 81%, respectively, in the recession phase. In this scope, results obtained from the QMOTR model confirm the increase in the pace of price response to changes in exchange rate, derived from the McCarthy SVAR model (section 3.2.3).

Figure 27. Shock to nominal effective exchange rate growth (increase – appreciation) by 1 p.p.



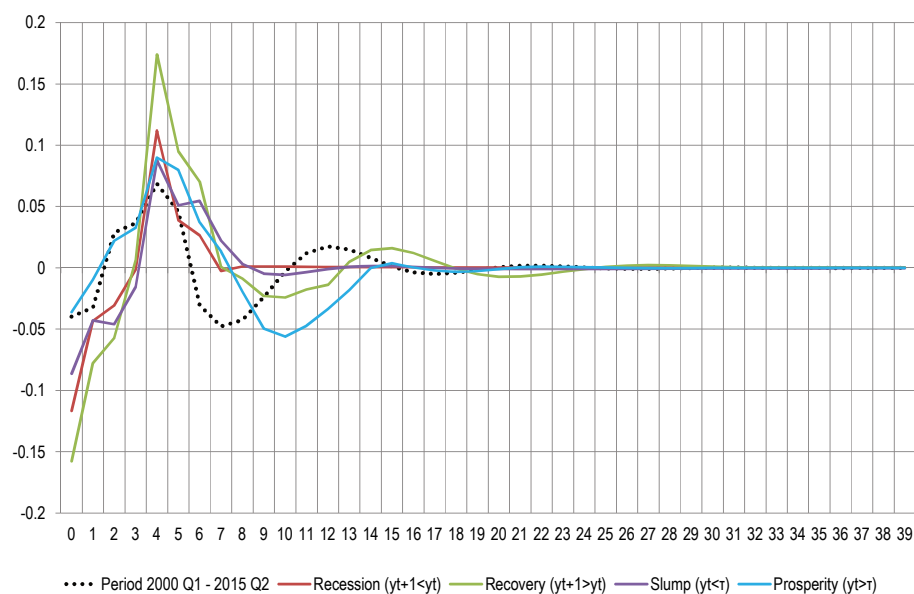
Source: own calculations.

Figure 28. Response of output gap to the exchange rate shock, in p.p.



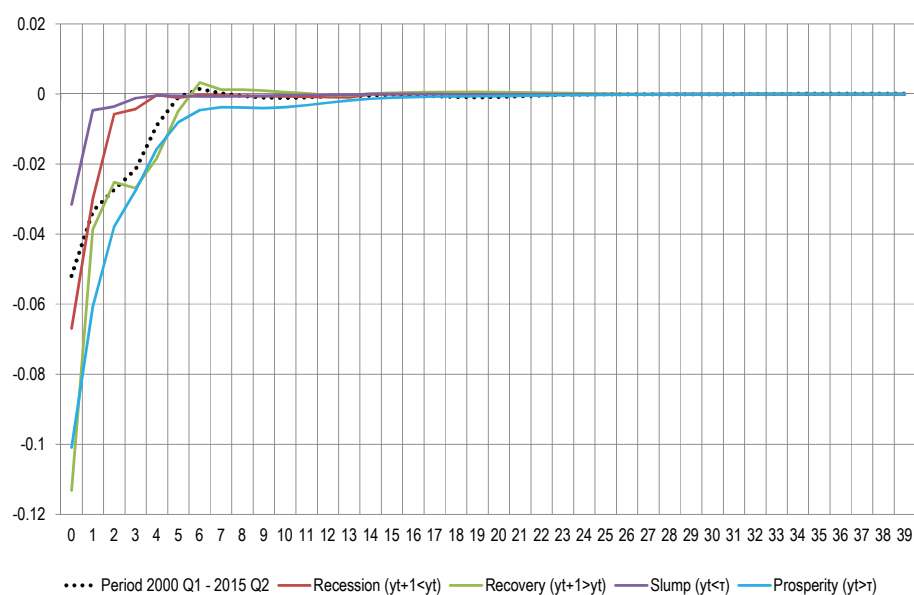
Source: own calculations.

Figure 29. Response of GDP growth (annualised) to the exchange rate shock, in p.p.



Source: own calculations.

Figure 30. Response of HICP core inflation (annualised) to the exchange rate shock, in p.p.



Source: own calculations.

3. Functioning of monetary policy transmission mechanism channels

3.1. Interest rate channel

In this subsection we analyse the pass-through of policy rate to interest rates in various financial markets (interbank deposit market, retail deposit and loan market, government bond market) and impact of interest rates on the volume of loans. In addition, we present the findings of the event study on the effect of current monetary policy and MPC communication on prices of financial assets.

The transmission of policy rate is examined in two stages: the first one is the pass-through of NBP reference rate to interbank market rates; the second involves the pass-through from interbank market rates to other interest rates (interest rate on retail deposits and loans, bond yields). At both stages of the transmission we check whether a long-run relationship between the analysed rates occurs (with the use of cointegration tests). We employ cointegrating regressions and/or error correction models to draw conclusions on the features of interest rate transmission. In error correction models the change in the money market rate (retail rate on deposits/loans or bond yield at the second stage of transmission) is explained by a contemporaneous change of the NBP reference rate (money market rate at the second stage), deviation from the equilibrium (i.e. error correction term) and, potentially, lagged changes of both interest rates. The parameter at the contemporaneous change of the NBP reference rate (money market rate) describes the immediate reaction of the examined interest rate. The parameter at the error correction term (in other words, loading parameter) describes the speed of adjustment towards the equilibrium. The long-run multiplier is derived from cointegrating regression (in the case of two-step method) or it is estimated directly within the error correction model.

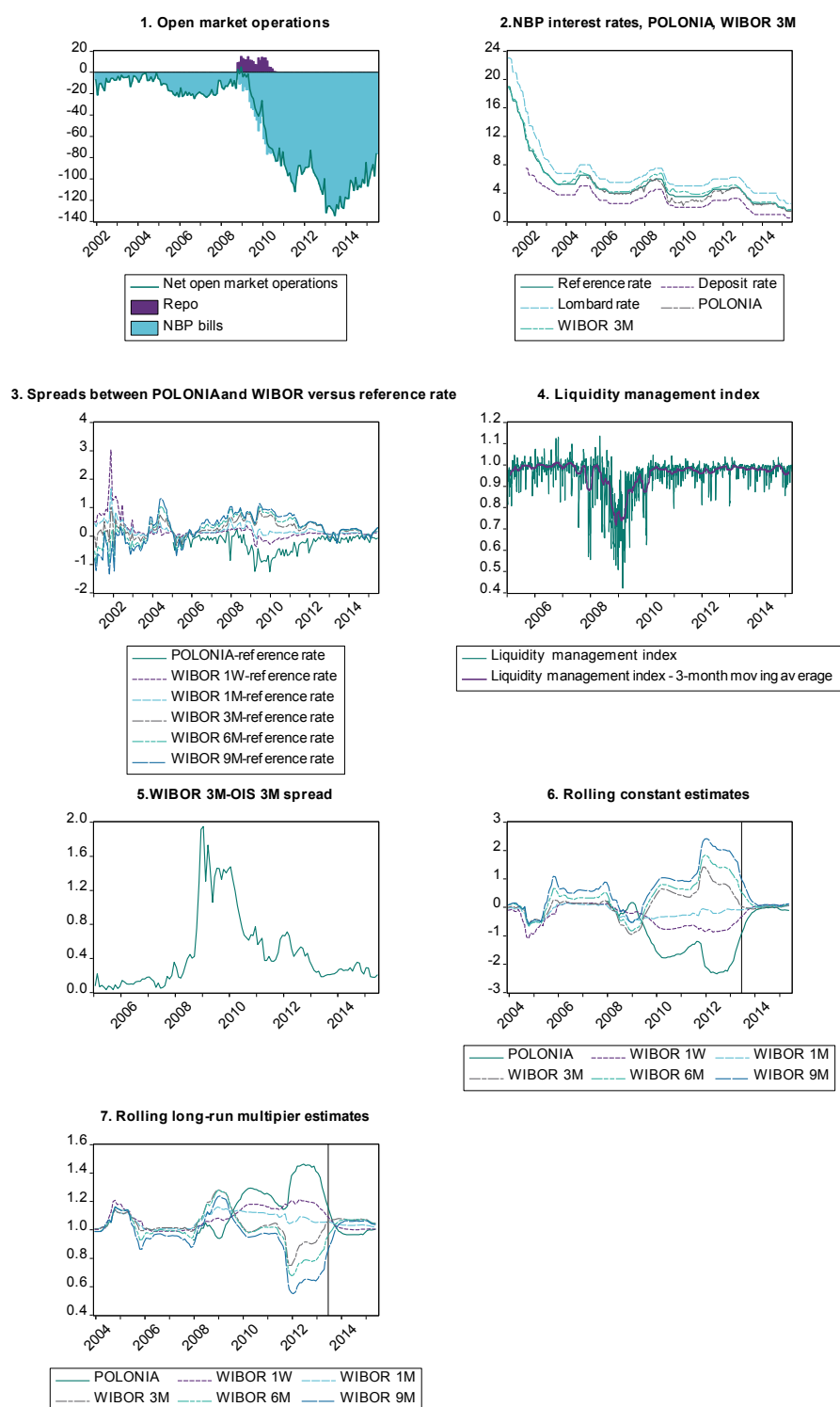
The analysis comprises the period from January 2001 (and in the case of retail rates – from January 2005) until the end of 2015 Q1 or the first half of 2015 (depending on the data).

3.1.1. Transmission in the money market

In the period following the previous report (mid-2013 – mid-2015) monetary policy continued to be pursued in the environment of surplus liquidity in the banking sector (Figure 31, panel 1). The POLONIA rate, as the NBP operating target, was maintained close to the reference rate owing to the use of main and fine-tuning open market operations, and the fluctuation corridor was determined by the deposit rate and the lombard rate (Figure 31, panel 2).

Spreads between interest rates on uncovered loans in the interbank market and the reference rate have remained relatively low since 2013 (Figure 31, panel 3). This implies the improvement in the monetary policy transmission to the interbank market following the disturbances of the period of the global financial crisis. In the case of the short end of the yield curve, it was fostered by maintaining banks' reserves close to the reserve requirement, owing to conducting of operations liquidity-absorbing at a relevant scale. It is illustrated by the level of the liquidity management index (Sznajderska, 2016), calculated as a relation between liquidity absorption by NBP and the liquidity above the reserve requirement – after the termination of the Confidence Package in November 2010 it did not fall significantly below 1 (Figure 31, panel 4). Typically it is close to, but below this level, since banks maintain a certain buffer besides funds on the reserve requirement account.

Figure 31. Transmission in the money market



Source: Datastream, NBP data, own calculations.

The lack of absorption of reserves above the level arising from those two motives brings the shortest interest rates closer to the deposit rate (more in: Box 2). On the other hand, for longer periods to maturity the decline in the risk premium, for which the WIBOR-OIS spread (OIS – overnight index swap²¹ – the measure of the average expected O/N rate, Figure 31, panel 5) may serve as a proxy, was of key importance, as well as stable expectations related to the level of the rates in the future. In addition, Table 7 shows that in periods of reference rate changes (monetary policy tightening/easing cycles) adjustments of money market rates were increasing along the decrease of the period to maturity (for shorter rates – proportional, for longer rates – less proportional). Such a situation occurs due to the fact that longer rates change in advance (prior to the start of the rate increase/decrease cycle) if the MPC measures are expected.

Table 7. Cumulative changes in selected interest rates in periods of monetary policy tightening and easing (calculations for monthly data)

Period	Reference rate	WIBOR 1W	WIBOR 1M	WIBOR 3M	WIBOR 6M	WIBOR 9M
2004:07-2004:09	1.25	1.34	1.25	1.21	1.04	0.84
2005:03-2006:03	-2.50	-2.39	-2.43	-2.42	-2.34	-2.20
2007:04-2008:07	2.00	2.06	2.14	2.40	2.37	2.35
2008:11-2009:07*	-2.50	-2.98	-2.92	-2.54	-2.38	-2.31
2011:01-2011:07	1.00	1.10	0.97	0.79	0.62	0.50
2012:05-2012:06	0.25	0.23	0.20	0.18	0.17	0.18
2012:11-2013:08	-2.25	-2.22	-2.21	-2.12	-2.11	-2.09
2014:10-2015:04	-1.00	-0.95	-0.88	-0.80	-0.78	-0.77

Notes: * It should be stressed that the relatively sharp decline in WIBOR rates in this period resulted from their growth at the beginning of the financial crisis, at a fixed NBP reference rate.

Source: own calculations.

We estimated error correction models for relations between POLONIA and WIBOR rates and the reference rate with the use of estimator for cointegration regression parameters other than in the previous report (DOLS), which facilitated the statistical inference (see Verbeek, 2008). Moreover, excluding the POLONIA rate calculated since the beginning of 2005, models for other rates were estimated based on data collected since the beginning of 2001 (to June 2015). Below we present the most important results derived from models estimated on a full sample and estimates of cointegrating regression parameters in 36-month windows (Figure 31, panel 6 and 7), due to which changes in transmission over time may be evaluated using the comparable models.

First of all, a long-term relationship exists between each examined interbank market rate and the reference rate (based on the ADF test, with critical values relevant for cointegration testing, we reject hypothesis about non-stationary of residuals). Wald tests indicate that the transmission is full (long-run multipliers are not

²¹ *Overnight Index Swap* – a derivative transaction obliging parties to the contract to pay a difference in interest payments calculated according to the floating and fixed interest rate (OIS rate) against the defined nominal amount. The floating interest rate is calculated through assuming daily O/N reference rates during the transaction. The net settlement (without exchange of the OIS nominal amount) is performed on the next business day following the transaction maturity date, see e.g. *Financial Stability Report*, NBP, July 2015, p. 124.

different than 1) in the case of all rates besides WIBOR 1W and 1M, however, for the latter, it is associated with disturbances of the crisis period.²³

The results of a rolling regression confirm disturbances in transmission during the crisis and their termination in the recent years. For a short end of the yield curve, a downward shift of the constant and an upward shift of the long-run multiplier took place, in the case of longer rates – the opposite situation occurred. In a sample additionally available in this report, estimates of parameters stabilised.

Table 8. Estimation results – error correction models for interbank market rates

	POLONIA	WIBOR 1W	WIBOR 1M	WIBOR 3M	WIBOR 6M	WIBOR 9M
Constant	-0.17** (0.08)	-0.20*** (0.08)	-0.02 (0.04)	0.20*** (0.07)	0.37*** (0.10)	0.47*** (0.11)
Long-run multiplier	1.01*** (0.02)	1.06*** (0.02)	1.04*** (0.01)	1.02*** (0.01)	1.00*** (0.02)	0.99*** (0.02)
Immediate reaction	0.94*** (0.09)	1.05*** (0.10)	0.93*** (0.08)	0.77*** (0.09)	0.70*** (0.10)	0.68*** (0.10)
Loading parameter	-0.71*** (0.11)	-0.38*** (0.13)	-0.37*** (0.14)	-0.17* (0.10)	-0.10* (0.06)	-0.07 (0.05)
Are interest rates cointegrated? [Value p of ADF test]	yes*** [0.00]	yes*** [0.00]	yes*** [0.00]	yes*** [0.00]	yes*** [0.00]	yes** [0.03]
Is long-run multiplier=1? [Value p of Wald test]	yes*** [0.76]	no [0.00]	no [0.00]	yes** [0.07]	yes*** [0.87]	yes*** [0.71]
R² – cointegrating regression	0.97	1.00	1.00	0.99	0.99	0.99
Non-centred R² – error correction model	0.57	0.74	0.83	0.63	0.52	0.47

Notes: In parenthesis, standard errors robust to heteroscedasticity and autocorrelation have been provided. In square brackets p value of the relevant test has been provided (ADF in the case of cointegration testing, Wald in the test on long-run adjustment completeness). *, ** and *** mean: for estimates of parameters – statistical significance; for decisions in the ADF test – rejecting the hypothesis on the lack of cointegrating relation at the 10%, 5% and 1% significance level, respectively; for decisions in the Wald test – lack of grounds for rejecting the hypothesis that the long-run multiplier=1, at the 10%, 5% and 1% significance level, respectively. In the cointegrating regression for the POLONIA rate, a dummy variable has been taken into account, assuming 1 for the Sentiment Package period (September 2008 – November 2010).

Source: own calculations.

Box 2. The shortest interbank market rates and liquidity management

In this box we show how NBP liquidity management influences the level of the POLONIA and WIBOR 1W rates, i.e. the rates with the shortest maturity period. The analysis was performed on data with a daily frequency. Due to data availability, in the case of the POLONIA rate a period from 25 January 2005 to 30 March 2015 was considered, and in the case of WIBOR 1W rate – a period from 3 January 2005 to 30 March 2015. Table R2.1 presents the results of the regression of the spread between the reference rate and the POLONIA and WIBOR 1W rates with the following explanatory variables: liquidity management index, index of fine-tuning operations, dummy variable equal to 1 at the end of the reserve requirement period, lagged explanatory variable and a constant.

²³ The transmission periods calculated for POLONIA, WIBOR 1W, 1M, 3M, 6M and 9M rates amount to 0.10, 0.04, 0.28, 1.50, 3.09 and 4.54 months, respectively, however, due to the fact that the market takes into account future changes in interest rates in advance, their interpretation capacity is limited. Half-life periods (periods required for interest rates in the interbank market to cover half of the path to the equilibrium, determined by a long-term relation with the reference rate) amount to 0.56, 1.45, 1.49, 3.73, 6.70 and 9.57 months, respectively.

The liquidity management index illustrates the relation between the level of liquidity absorbed by NBP and the level of short-term liquidity of the banking sector. The level of liquidity absorbed by NBP was calculated as a sum of main operations, fine-tuning operations, NBP bonds and foreign currency swaps. The level of short-term liquidity of the banking sector was determined as a sum of main operations, fine-tuning operations, NBP bonds, foreign currency swaps, deposit facility and the average deviation of the current account from the reserve requirement level. Thus, in periods when the central bank absorbs all surplus liquidity and banks do not keep any liquidity buffer, the liquidity management index equals 1.

The index of fine-tuning operations is the relation between the balance of fine-tuning operations and sum of main operations, fine-tuning operations, NBP bonds, foreign currency swaps, deposit facility and the average deviation of the current account from the reserve requirement level.

The coefficients standing at the liquidity management index are negative and statistically significant. An increase in the liquidity management index may be associated with a higher liquidity absorption by NBP, which leads to a decline in spreads. It is worth recalling that in the period from February 2009 to May 2009 the bank deliberately left liquidity surpluses in the system through limiting the level of the main operations. In this period, the POLONIA rate was close to the deposit rate, the liquidity management index decreased, and the spread between the reference rate and the POLONIA rate increased, in accordance with the results under discussion.

The results show that fine-tuning operations contributed to a reduction of the spread between the reference rate and the POLONIA rate (the coefficient is negative and statistically significant). On the other hand, fine-tuning operations did not have a statistically significant impact on the spread between the reference rate and the WIBOR 1W rate. It confirms that the fine-tuning operations were mainly addressed to POLONIA, instead of WIBOR rates (it is also confirmed by the Granger causality tests; Sznajderska, 2016).

In the analysed period, the variable related to the end of the reserve requirement settlement period was found statistically insignificant. Slightly different results were obtained while analysing the period from 2008:01:01 to 2015:03:30 (see also Sznajderska, 2016), where a positive relation had been shown between the spread for the POLONIA rate and the end of the reserve requirement settlement period. In those periods, a higher surplus liquidity occurs since banks maintain such a level of funds on their accounts in the central bank which enables them to comply with the reserve requirement.

In the case of the equation for the POLONIA rate, results of the formal statistical Wald test do not confirm the hypothesis that the absolute value of coefficient standing at the liquidity management index is equal to the estimated constant. This may be associated with the fact that the liquidity management index does not assume the value equal exactly to 1 in the period when NBP absorbs the whole liquidity, since banks keep liquidity buffers.

Table R2.1. Estimation results – linear regression models for the shortest money market rates

	Reference rate – POLONIA		Reference rate – WIBOR 1W	
	estimation of parameter	standard error	estimation of parameter	standard error
Liquidity management index	-3.17***	(0.29)	-0.15**	(0.02)
Index of fine-tuning operations	-1.58***	(0.36)	0.07	(0.05)
Reserve requirement	0.06	(0.05)	-0.01	(0.01)
constant	3.29***	(0.28)	0.08	(0.07)
AR(1)	0.79***	(0.02)	0.94***	(0.01)
Adjusted R²	0.71		0.90	
Wald test (p value)	0.00		0.09**	

Notes: In parenthesis, robust Newey-West errors have been provided, *, ** and *** means: for estimates of parameters – statistical significance; for decisions in the Wald test -lack of grounds to reject the hypothesis that the constant is equal to the coefficient standing at the liquidity management index with a negative sign, at a 1%, 5% and 10% significance level, respectively.

Source: Sznajderska (2016).

3.1.2. Transmission to deposit and lending rates in commercial banks

In the analysis of transmission to retail rates we used data on interest rates on new deposit and loan agreements (in PLN) of households and firms. We have analysed interest rates of new deposits and loans of these groups of entities, in total and according to the breakdown into main categories (Table 9, Table 10). New term deposits, from both households and firms, are dominated by deposits with a maturity term up to 1 month. In the case of households, deposits with the primary term over 1 year, and in the case of firms – deposits with the primary term over 3 months, have minor importance. Consumer loans account for almost half of newly incurred household loans. Housing loans represent the second category significant in terms of size. Among corporate loans, large credits prevail, i.e. exceeding the value of PLN 4 million.

Table 9. Structure of zloty-denominated term deposits of households and firms (new agreements)

Household deposits	Share	Corporate deposits	Share
up to 1 month	47%	up to 1 month	86%
from 1 to 3 months	24%	from 1 to 3 months	12%
from 3 to 6 months	15%	over 3 months	3%
from 6 to 12 months	11%		
over 12 months	3%		

Note: Average in the period 2005:01-2015:03 in the group of banks taking part in interest rate statistics.

Source: Own calculations based on NBP data.

Table 10. Structure of types of zloty-denominated loans of households and firms (new agreements)

Household loans	Share	Corporate loans	Share
for consumption purposes	47%	to PLN 4 million	35%
for housing purposes	32%	over PLN 4 million	65%
for sole proprietors	10%		
for other purposes	11%		

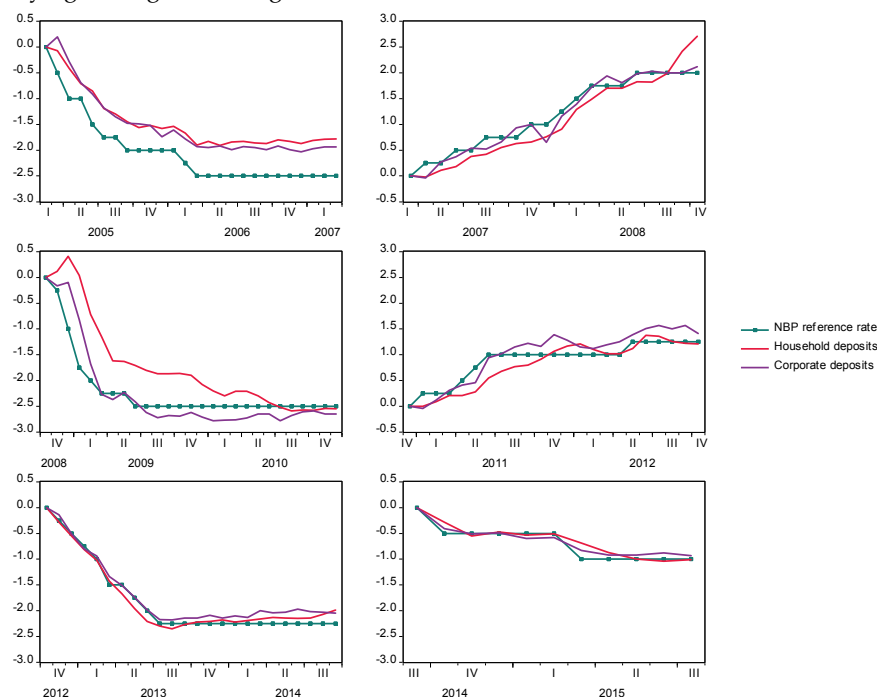
Note: Average in the period 2005:01-2015:03 in the group of banks taking part in interest rate statistics.

Source: Own calculations based on NBP data.

Figure 32 and Figure 33 illustrate how the interest rates on deposits and loans of the non-financial sector changed in periods of monetary policy easing and tightening.²⁴ Changes in interest rates on consumer loans are loosely linked with changes in the reference rate. The interest rates on other products follow changes in the policy rate, although the scale of those changes does not always fully correspond to the scale of changes in the reference rate, whereas time needed for full adjustment of deposit and loan rates may be long. It is particularly visible in the period directly following the outbreak of the global financial crisis (September 2008 - November 2010) when only corporate deposits quickly adjusted to changes in the policy rate. A period of approximately a year was needed for the declines in household deposits, housing loans and corporate loans to compensate for the decline in the reference rate whereas the interest rate on loans for sole proprietors, even after this period, did not fully reflect changes in the reference rate (in total, it decreased by 1.5 p.p. as compared to the decline in the reference rate by 2.5 p.p.).

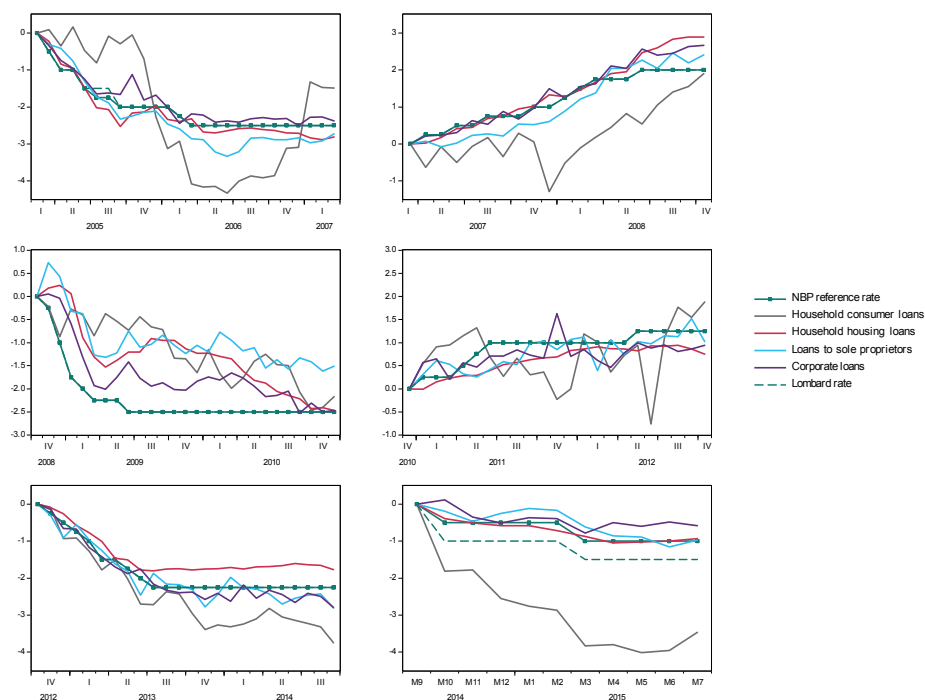
²⁴ From the first change in the reference rate in a given cycle until the last month prior to the start of the subsequent cycle.

Figure 32. Cumulative changes in interest rates on household and corporate deposits in periods of monetary policy tightening and easing



Source: NBP data

Figure 33. Cumulative changes in interest rates on household and corporate loans in periods of monetary policy tightening and easing



Notes: Nominal rates except for consumer and housing loans for which annual percentage rates of charge (incorporating all charges paid by the borrower) are presented.

Source: NBP data

In the previous issues of the report (Demchuk *et al.*, 2012; Kapuściński *et al.*, 2014) we discussed the impact of disturbances in the interbank market in the period following the outbreak of the global financial crisis on the interest rate pass-through. The studies confirmed that the cointegrating relations between interbank market and retail market rates had not been broken (excluding consumer loans), however, spreads between those rates had changed. Moreover, there were some signs of strengthening of long-term adjustment of deposit rates and weakening of long-term adjustment of lending rates to changes in WIBOR rate. In this part of the report, using aggregated and individual data, we analyse the reasons of changes in credit spreads and evaluate the strength of interest rate transmission.

Analysis of spreads between retail rates and interbank market rates

Spreads between the WIBOR 3M rate and the retail interest rate on deposits remain at an increased level comparing to the pre-crisis period; it refers to the most limited extent to deposits of up to 1 month for firms and deposits of the same category for households and - to the greatest extent - to deposits with the maturity of over 6 months to 12 months. Credit spreads are much closer to the level observed prior to the collapse of the Lehman Brothers bank, in particular, in the case of credits to firms (Figure 34). A significant decline in the spread for consumer loans is also noticeable – it is lower than before the crisis, however, on the other hand, comparing the interest rate on consumer loans arising from “price lists” and the annual percentage rate of change (APRC, i.e. the interest rate which includes any fees or commissions associated with the transaction), it is visible that since 2014 banks have been increasing additional lending costs while reducing the interest rates.

As Illes and Lombardi (2013), we split the spread between the loan rate and the monetary policy rate, i.e. NBP reference rate ($i^l - i^{ref}$) into a sum of three spreads, i.e. the spread between the loan rate and the yield of 1-year Treasury bond ($i^l - i^g$), the spread between the yield of 1-year Treasury bond and the money market rate ($i^g - i^m$) and the spread between the money market rate and the NBP reference rate ($i^m - i^{ref}$). In the analysis we have used the average interest rate on total loans, loans to households and to firms as well as data concerning the yield of benchmark bonds. The POLONIA rate has been employed as the money market rate.

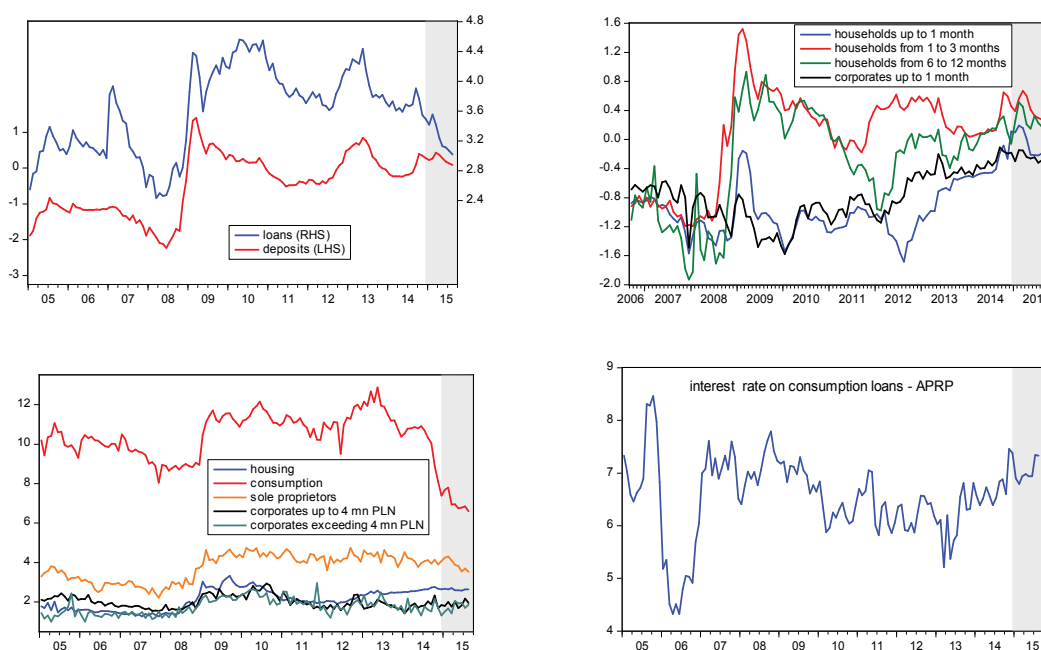
Due to the fact that POLONIA is the monetary policy target, it should be close to the reference rate, therefore the spread ($i^m - i^{ref}$) shows liquidity risk or counterparty risk involved in lending to banks. A negative spread means that the central bank maintains surplus liquidity in the banking system. On the other hand, the spread ($i^g - i^m$) shows both the term premium and the credit risk of the government. This component is negative when the term premium is low as well as when investors believe that practically there is no risk with servicing of a country's debt. Finally, the last component, ($i^l - i^g$), shows the relation of the risk of crediting the government and the economy (firms, households); it also reflects banks' propensity to take on such risk. Illes and Lombardi (2013) stress that this component is high in the periods of poor business conditions since the risk of business activity increases at that time.

Figure 35 shows that since the outbreak of the financial crisis the policy of the central bank based on maintaining high liquidity contributed to reducing the credit spread. In the same period, and to a lesser extent, also in the period from 2006 to the financial crisis, investors perceived the risk of financing public debt as significant and this factor pushed the spread up. Only since the second half of 2012 up till now (September 2015) this risk has not play a significant role. The factor accountable for most of the spread developments was the risk associated with business activity and the risk perceived by banks. Since 2014, both the monetary

policy, term premium and the fiscal policy of the government was neutral. A much higher spread of interest rate on loans to households as compared to credits to firms, visible also in Figure 16, is noticeable.

Considering the behaviour of WIBOR 3M-OIS 3M spread (see Figure 31), we divided the period under analysis into three subperiods – the first one, from January 2005 to June 2007, when the risk was insignificant, the second one, comprising the acute phase of the financial crisis – from July 2007 to December 2010, and the third period – from January 2011 to August 2015, when the financial crisis turned into the debt crisis, with the risk significantly reduced, albeit exhibiting substantial volatility. As Figure 36 shows, the average weights of particular spreads in the acute crisis phase differed from those in the remaining two subperiods. A strong rise in the risk associated with financing debt of the government is clearly visible, whose negative impact was mitigated by expansive monetary policy. The monetary policy also reduced the spread in the debt crisis period.

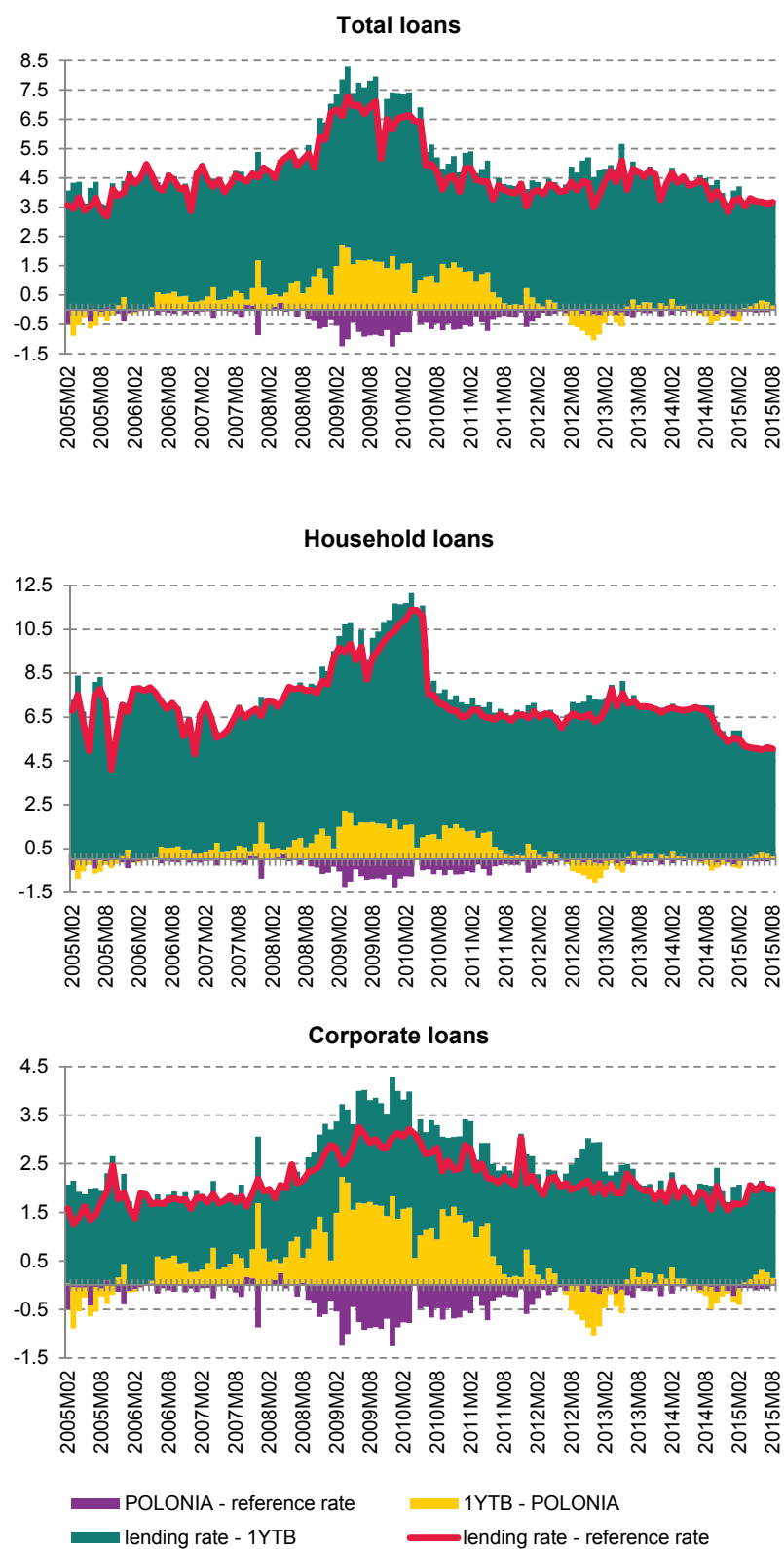
Figure 34. Spread between the WIBOR 3M rate and (i) the average weighted interest rate on new loans and deposits (retail rate - WIBOR 3M), top left panel, (ii) the average weighted interest rate on new term deposits, top right panel, (iii) the average weighted interest rate on selected types of new loans, bottom left panel; (iv) the difference between the average interest rate on consumer loans and the respective annual percentage rate of change (APRC), bottom right panel



Notes: A period in which the statistics of retail interest rates are not fully comparable with the previous period is marked grey.

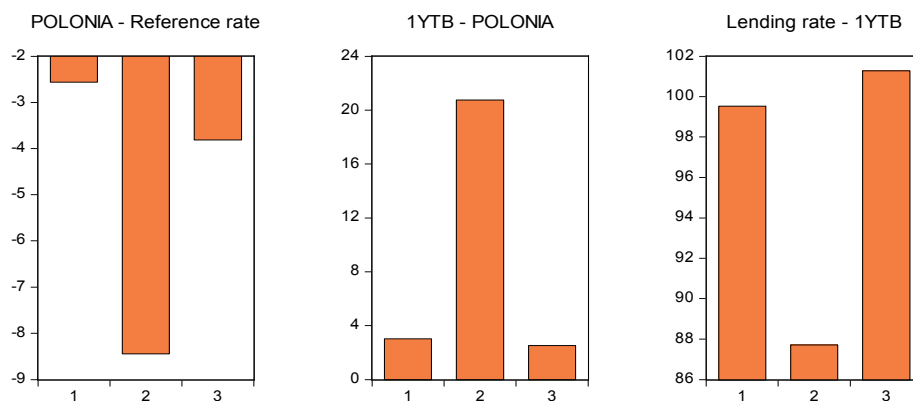
Source: NBP data

Figure 35. Decomposition of lending rate spreads



Source: NBP data

Figure 36. Average weights (in per cent) of spreads in the three subperiods – (1) 2005.01-2007.06, (2) 2007.07-2010.12, (3) 2011.01-2015.08



Source: own calculations.

Analysis of long-term adjustment of retail interest rates

Due to disturbances in the transmission of money market interest rates to retail interest rates after the collapse of the Lehman Brothers (more on this issue, see Demchuk *et al.*, 2012), in the estimations on aggregated data we have introduced a dummy variable into the cointegrating vector. The dummy takes zero in the period to August 2008 and one from September 2008 until the end of the sample. It is supposed to show a systematic impact of the crisis on the method of determining retail rates in the banking sector, e.g. a permanent change in the approach to risk. The second variable we have introduced into the cointegrating vector, as in Frisanchio-Mariscal and Howells (2010), is the spread between the WIBOR 3M and OIS 3M rates (Figure 31, panel 5). Due to the fact that the WIBOR rate refers to transactions in the market of unsecured interbank deposits and it includes expectations of future rates and the risk involved in lending to banks, the spread between the money market rate and almost risk-free OIS shows the liquidity risk and counterparty risk premium and may be treated as a measure of banks' health. If this variable is absent in the cointegrating vector, particularly in periods when the risk is at a relatively high level and when it is volatile, it may affect the estimation of the constant or a long-run multiplier.

Results of the estimation are shown in Table 11. Changes in interest rates are fully transmitted to the average interest rate on household deposits (we cannot reject the hypothesis that, in a long-run, the deposit rate adjusts fully to the money market rate). This is mainly due to deposits with the maturity of over 3 months and up to 12 months. The interest rate on the shortest deposits, up to 1 month, shows a weaker degree of adjustment (also weaker than in the past). On the other hand, the estimated long-run adjustment multiplier for interest rate on deposits over 1 month to 3 months exceeds one. Such a result was certainly due to the financial crisis – after its outbreak banks searched for liquidity with such term and, accordingly, rapidly increased interest rates (see also Figure 34). It should be expected that this multiplier will fall in the future, along with the gradual absorption of crisis disturbances (comparing to the multiplier presented in the previous report, its point estimate is lower by approximately 0.2 p.p.). The dummy variable shows that due to the financial crisis and the change in banks' approach to interest rate setting, the average weighted interest rate on household deposits was higher by approximately 0.7 p.p.; it referred, to the greatest extent, to deposits with a maturity of over 1 month to 3 months. The same factor reduced the interest rate on deposits

up to 1 month by approximately 0.26 p.p. The spread between the WIBOR 3M rate and OIS 3M was found statistically significant in the case of interest rate on deposits with the maturity of over 3 months to 6 months.

Table 11. Estimates of long-run multipliers of pass-through of money market rates to deposit and lending rates, 2005:01-2015:08, aggregated data

Interest rate	Long-run multiplier	Is long-run multiplier=1?	Loading parameter	Other cointegration elements ^{(1)/(2)}
Household deposits				
Total	0.95	yes	-0.22	0.74 ⁽¹⁾
Up to 1 month	0.73	no	-0.25	-0.264 ⁽¹⁾
From 1 to 3 months	1.185	no	-0.11	1.55 ⁽¹⁾
From 3 to 6 months	0.99	yes	-0.39	1.18 ⁽¹⁾ 0.6 ⁽²⁾
From 6 to 12 months	1.05	yes	-0.24	1.23 ⁽¹⁾
Corporate deposits				
Up to 1 month	0.81	no	-0.48	-0.2 ⁽¹⁾
Household loans				
Total	0.84	yes	-0.36	3.2 ⁽²⁾
Consumer	No long-run relation			
Housing	0.65	yes	-0.14	0.91 ⁽²⁾
For sole proprietors	1.00	yes	-0.24	1.4 ⁽¹⁾ 1.2 ⁽²⁾
Corporate loans				
Total	0.96	yes	-0.45	0.58 ⁽²⁾
Up to PLN 4 million	0.99	yes	-0.32	0.005 ⁽²⁾
Over PLN 4 million	1.00	yes	-0.52	0.4 ⁽²⁾

Notes: ⁽¹⁾ a dummy variable showing systematic impact of the financial crisis on interest rates on deposits or loans at banks; ⁽²⁾ spread between the WIBOR 3M rate and the OIS 3M rate as a proxy of liquidity risk and counterparty credit risk.

Source: Own calculations based on NBP data.

The interest rate on deposits of firms (we only show those with the maturity period of up to 1 month since they represent the majority of corporate deposits, see also Table 9), does not fully adjust to the money market rate. The long-run multiplier decreased as compared with that estimated in the previous report (1.0).

The interest rates on total household loans and on total corporate loans fully adjust to changes in money market rates. Point estimates of the multipliers of long-term adjustment of individual corporate loan types are very close to one, those for households are lower, however, formal tests show that no grounds exist to reject the hypothesis that, in the long-term, the adjustment of lending rate corresponds to the change in the money market rate. Among analysed household loans, unsecured loans for consumption purposes are special since they do not exhibit long-term relationship with the money market rate. On the other hand, such relationship exists for loans for house purchases or loans to sole proprietors. However, a significant role of the risk proxy variable and dummy variable is visible, the latter showing a systematic impact of the financial crisis. Both variables strongly increased interest rates. Their impact on the interest rate on corporate loans is also statistically significant, but, much lower. Banks clearly attributed a lower risk to corporate loans than to household loans.

The stability analysis of all estimated long-term relationships (recursive estimations) indicates serious disturbances in the period of the most acute phase of the financial crisis.

The analysis of individual banks' data confirms the conclusions based on aggregated data. Figure 37 presents estimates of long-run multipliers in the period before September 2008 and later: from September 2008 to July 2013 (the sample analysed in the previous report) and from September 2008 to March 2015. We used the pooled mean group estimator (Pesaran *et al.*, 1997), which assumes homogenous long-term reaction of all banks to changes in interest rates, and simultaneously enables diversification of their short-term reaction.²⁵

The results indicate that since mid-2013 the long-run multipliers for interest rates on deposits have decreased, in particular, in the case of household deposits over 1 to 3 months and over 3 to 6 months, i.e. in those categories where the pass-through was disturbed to the greatest extent. Currently those values are closer to, but still above one. The pass-through to the interest rate on deposits up to 1 month, both in the case of household deposits and corporate deposits is also weaker and it is not full.

Long-run multiplier for housing loan rate has not changed significantly over the last two years, however, interest rates on loans to sole proprietors and, especially, to corporates seem to adjust more strongly. In the case of interest rates on corporate loans, the most recent estimates of the long-term adjustment coefficients are very close to those obtained in the pre-crisis period. On a sample from 2008:09 to 2015:03, the hypothesis of full long-term adjustment of the interest rates cannot be rejected for all types of loans.

Figure 37. Coefficients of long-term adjustment of deposit and lending rates in three subperiods: 2005:01-2008:08, 2008:09-2013:07, 2008:09-2015:03



Notes: the pooled mean group estimator.

Source: Own calculations based on NBP data.

²⁵ Incorrect assumption of homogeneity of parameters across cross-section units leads to the loss of consistency of alternative estimators (e.g. fixed effects). Studies performed for Poland and for other countries suggest that whereas banks adjust retail interest rates to the money market rates in a similar way in the long run, the short-term adjustment in individual banks may differ (see, e.g. Stanisławska, 2015). In the presented analysis the assumption concerning the homogeneity of long-term adjustment is subject to testing.

Transmission to lending rates: money market rates and banks' financing cost

Research on euro area countries, which experienced strong disturbances in the pass-through of policy rate to lending rates in 2008-2009, indicate mainly two causes of such a situation: growth in credit risk and its perception by banks as well as growth in banks' financing costs (e.g. ECB, 2013; Illes *et al.*, 2015). Below we verify the role of the latter factor for development of lending rates in Poland (on a micro data). To that end we have approximated banks' financing costs with weighted average cost of liabilities and assessed its impact on lending rates. Employing data on individual banks participating in the interest rate statistics we estimated the models of transmission from interbank market rate to lending rates and from weighted average cost of liabilities to lending rates.

We approximated banks' financing cost on the basis of the structure of banks' liabilities (taking into account their term structure), by assigning the relevant interest rates to individual categories of liabilities. The summary of components used for determining the weighted average cost of liabilities and the average weights are showed in Table 12. The calculated by us weighted average cost of liabilities constitute only an approximation of banks' financing costs, since we did not take into account foreign-currency liabilities and data on interest rates on some categories of liabilities were not available (in such cases we tried to match other possibly closest rates, e.g. we approximated the cost of issuing banks' own debt with yields on government benchmark bonds).²⁶ Changes in the weighted average cost of liabilities arise both from changes in interest rates and from changes in the structure of banks' liabilities. It should be emphasised that our measure does not fully reflect the marginal costs of banks' financing as weights of individual interest rates are based on stock of banks' liabilities, instead of only newly acquired funds. Nevertheless, it may constitute a better proxy of banks' financing costs than the money market rate or the policy rate usually used in the interest rate pass-through models.

Figure 38 presents the difference between the weighted average cost of liabilities and the NBP reference rate and the interbank market rate (it is a median in the group of analysed banks). The spread between the weighted average cost of liabilities and the policy rate was stable in the period until the outbreak of the financial crisis, which indicates a stable relation between those two rates. At the turn of 2008 and 2009 the spread significantly increased, subsequently gradually decreasing, however, remaining above the pre-crisis level. The spread in relation to the WIBOR rate developed in a similar way. It implies that in the analysed period the reference rate and the WIBOR 3M rate did not represent a good proxy of changes in banks' financing cost, such as assumed in the interest rate pass-through models (in the theoretical model banks determine the lending rate in relation to the marginal cost of capital; in empirical studies it is assumed that this cost is well described by the policy rate or the interbank market rate). Therefore, the observed disturbances between the WIBOR rate and lending rates could have resulted from the change in relation between that rate and banks' financing cost (growth of external financing premium).²⁷

²⁶ The accurate inclusion of financing in foreign currency is not possible, *inter alia*, due to the lack of information concerning costs of hedging open foreign currency positions (if a bank acquires foreign funds in order to grant loans denominated in PLN). Nevertheless, taking into account also liabilities in foreign currency (and ignoring the hedging costs) leads to similar results as presented in this section.

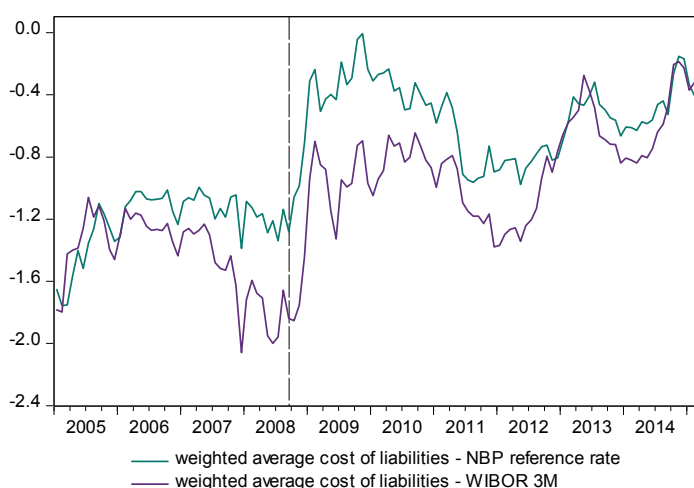
²⁷ Transmission of banks' external financing premium to lending rates is indicated, e.g. by Disyatat (2010).

Table 12. Components of the weighted average cost of liabilities

Category of liabilities	Weight	Assigned interest rate
Liabilities to non-financial sector	0.73	
▪ Household deposits	0.53	Interest rate on new household deposits ⁽¹⁾
▪ Corporate deposits	0.20	Interest rate on new corporate deposits ⁽¹⁾
Liabilities to the general government sector	0.08	
▪ Deposits of the general government sector	0.08	Interest rate on new corporate deposits ⁽¹⁾⁽²⁾
Liabilities to financial sector	0.18	
▪ Deposits with various maturity terms	0.08	WIBID
▪ Loans from other monetary financial institutions	0.004	WIBOR 1Y
▪ Liabilities due to repo/SBB	0.04	WIBOR O/N for operations up to 1 week, interest rate on OIS contracts for longer terms
▪ Liabilities due to issuing own debt	0.05	WIBOR 6M for issues up to 1 year, yield on Polish benchmark bonds for longer terms
Liabilities to central bank	0.01	
▪ Liabilities due to open market operations		Reference rate
▪ Lombard loan		Lombard rate
▪ Refinancing loan		Refinancing loan rate

Notes: ⁽¹⁾ Excluding current deposits for which interest rate on outstanding amounts is employed. ⁽²⁾ Due to the lack of information concerning interest rate on deposits of the general government sector, we treat this sector as enterprises.

Source: Own calculations based on NBP data and Thomson Reuters.

Figure 38. Spread between weighted average cost of liabilities and the NBP reference rate and the WIBOR 3M rate

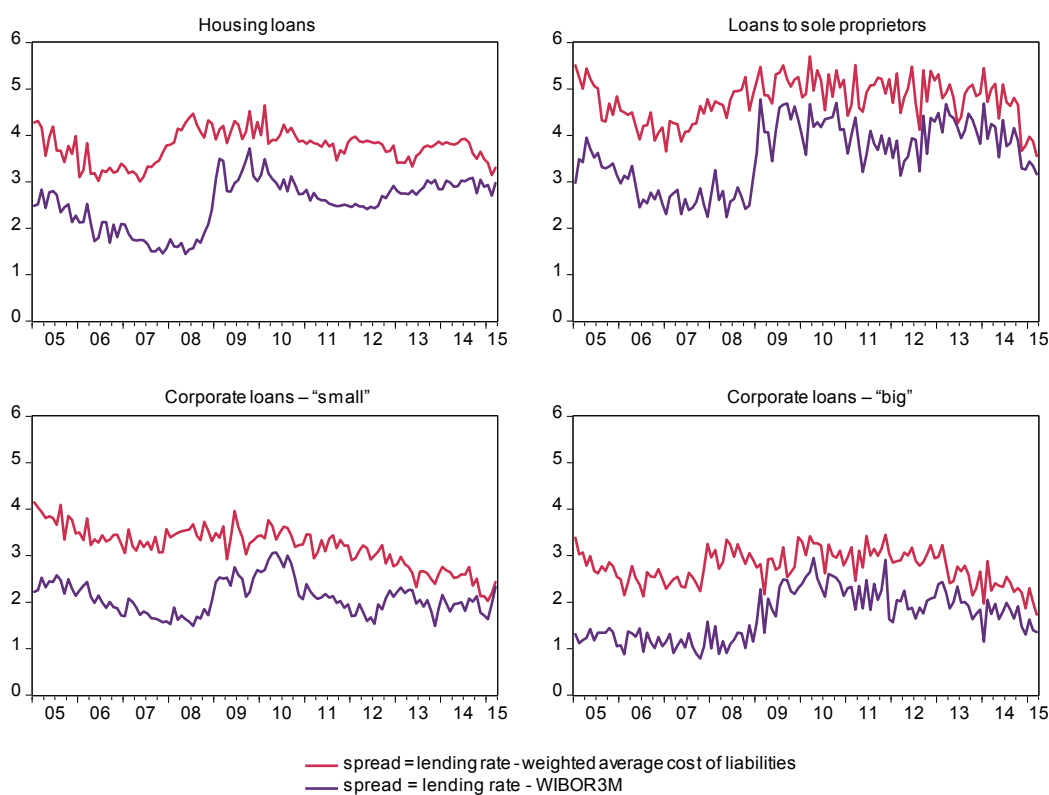
Note: The lines present a median in the group of banks included in the study. September 2008 has been marked with the vertical dashed line.

Source: Own calculations based on NBP data, Thomson Reuters.

This conclusion is confirmed by the comparison of the lending rate spreads determined in relation to WIBOR 3M and to the weighted average cost of liabilities (Figure 39). In the first case we observe the permanent shift in the level of spreads since the beginning of 2009 (except for small corporate loans, for which the change was transitory), while in the second case the spreads are more stable over time.

We conducted the formal analysis of interest rate transmission on individual banks' data, with the use of heterogeneous panel models (the pooled mean group estimator). We estimated two versions of the pass-through models: one describing the transmission of the interbank market rate (WIBOR 3M), and the other one – of the weighted average cost of capital.²⁸

Figure 39. Spread between the interest rate on retail loans and weighted average cost of liabilities or the interbank market rate



Note: The lines present a median in the group of banks included in the study.

Source: Own calculations based on NBP data, Thomson Reuters.

The interest rate on housing loans, loans granted to sole proprietors and large-amount loans granted to firms does not fully adjust to the money market rate – the coefficient of long-term adjustment ranges from 0.89 to 0.92 and it is statistically significantly different than unity (Table 13). Only in the case of interest rate on small loans (up to PLN 4 million) to firms the transmission is complete (the long-term adjustment coefficient amounts to 1.01). In models describing the pass-through of weighted average cost of liabilities to the lending rates the estimates of long-term adjustment coefficients are higher than in the case of models with the WIBOR

²⁸ The tests have confirmed that the interest rates on retail loans (excluding consumer loans) cointegrate both with the WIBOR 3M rate and the weighted average cost of liabilities.

rate – they range from 1.04 to 1.25. In the case of housing loans, the long-term adjustment to the weighted average cost of liabilities is full, and for other interest rates it is significantly higher than one. The long-term adjustment stronger than unity is not consistent with intuition since it would mean that in the period of decreasing interest rates banks reduced interest rates on the granted loans by more than their financing cost have declined. However, such high estimates of the long-run multiplier may result from the failure of weighted average cost of liabilities determined by us, which does not fully capture the marginal cost of capital acquisition by banks.

Table 13 also shows two criteria for model comparison: fit to data in the sample (log likelihood) and the root mean square error (RMSE) of the forecast of the retail interest rate level in the period from September 2008 (based on estimates of the model from an earlier period). Models with the weighted average cost of liabilities seem to fit data to lesser degree than models with interbank market rate. Nevertheless, they provide more accurate forecasts (in RMSE categories) of interest rates for housing loans and loans granted to individual entrepreneurs, i.e. those loan categories for which the biggest changes in spreads against WIBOR occurred in the period after the outbreak of the financial crisis. In the case of “big” loans granted to firms forecast errors are very similar, whereas in the case of interest rates on “small” loans granted to firms, the model with the WIBOR rate provides better forecasts, however, it is affected by one bank (see also: Figure 40).²⁹

Table 13. Estimates of error correction models of pass-through of the WIBOR 3M rate and average weighted cost of liabilities to lending rates, 2005:01-2015:03 (individual data)

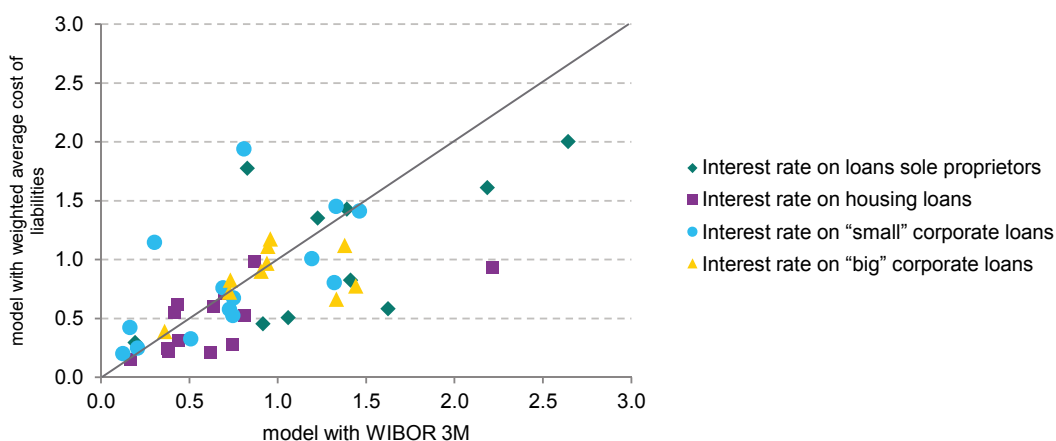
Interest rate	Long-run multiplier	Is long-run multiplier=1?	Immediate reaction	Loading parameter	Log-likelihood	RMSE ⁽¹⁾
Interest rate on housing loans						
▪ WIBOR 3M	0.92 (0.03)	no	0.33 (0.15)	-0.30 (0.08)	-72.01	0.88
▪ weighted average cost of liabilities	1.04 (0.06)	yes	0.28 (0.11)	-0.23 (0.06)	-152.89	0.53
Interest rate on loans to individual entrepreneurs						
▪ WIBOR 3M	0.89 (0.03)	no	-0.22 (0.19) ⁽³⁾	-0.45 (0.07)	-1265.12	1.50
▪ weighted average cost of liabilities	1.25 (0.04)	no	-0.11 (0.23) ⁽³⁾	-0.43 (0.07)	-1305.38	1.21
Interest rate on small loans to firms (with the value up to PLN 4 million)⁽²⁾						
▪ WIBOR 3M	1.01 (0.02)	yes	0.11 (0.14)	-0.42 (0.07)	-391.09	0.85
▪ weighted average cost of liabilities	1.16 (0.04)	no	0.17 (0.12)	-0.37 (0.06)	-600.90	0.98
Interest rate on big loans to firms (with the value over PLN 4 million)						
▪ WIBOR 3M	0.92 (0.02)	no	0.21 (0.25)	-0.66 (0.07)	-1043.19	1.01
▪ weighted average cost of liabilities	1.18 (0.03)	no	0.33 (0.22)	-0.62 (0.06)	-1089.74	0.96

Notes: Standard errors in parenthesis. Columns: “immediate reaction” and “loading parameter” show the average estimates of those parameters in the group of analysed banks. ⁽¹⁾ RMSE of a one-period ahead forecasts from 2008:09 to 2015:03 based on model estimates on a sample 2005:01 – 2008:08. ⁽²⁾ The hypothesis of homogenous long-term adjustment is on the verge of rejection (the p value equals to 0.05 in the model with WIBOR and 0.04 in the model with the weighted average cost of capital). The alternative group estimator (mean group) of long-term reaction, describing the average reaction in the group of banks, suggests that the adjustment to the WIBOR rate equals to 0.85 (standard error = 0.07), and the adjustment to the weighted average cost of liabilities – 0.90 (standard error = 0.13). In the first case, the hypothesis on completeness of the long-term adjustment is at the edge of rejection (p value equal to 0.04), and in the second case – we may accept it. ⁽³⁾ The estimation of the average immediate reaction has an incorrect sign, but it is also statistically insignificant. Source: own calculations.

²⁹ If we ignore this bank, forecasts derived from the model with the weighted average cost of capital demonstrate a slightly lower RMSE than the one with WIBOR (RMSE amounts to 0.84 for the model with the WIBOR rate and 0.78 for the model with the weighted average cost of liabilities).

Summing up, the presented above results suggest that the growth of spreads between the interest rate on retail loans and the money market rate results, at least partly, from the growth of premium of banks' external financing. This disturbance resulted mainly from the growth of interest rates on retail deposits which constitute the most important source of banks' financing.

Figure 40. RMSE statistics of lending rate forecasts (for individual banks) from models with the money market rate and weighted average cost of liabilities for the period 2008:09-2015:03



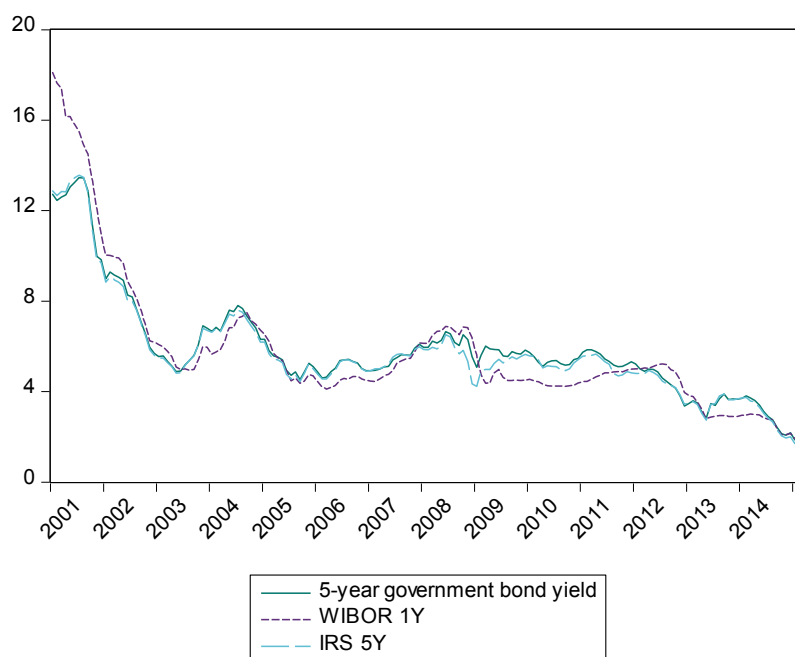
Note: Each point presents RMSE of forecasts for individual bank from two models. The 45° line was marked grey.

Source: own calculations.

3.1.3. Transmission to government bond yields

One of the basic factors influencing yields of government bonds is credit risk. Indeed, comparing yields on, for example, German and Greek government bonds over several recent years, the credit risk explains almost the entire difference. However, comparing yields between countries with various currencies, or within a single country for a certain period, interest rates in the interbank market should also be taken into account. This is because one of the financing methods of, for example, a 5-year government bond is to take out a 3-month loan in the interbank market and refinancing it until the sale or redemption of the bonds. Therefore, a rise in the interest rate causing an increase in the financing cost, reduces the prices and increases the yields of bonds. Arbitrage should maintain yields close to average interest rates expected to the maturity of bonds. Figure 41 showing WIBOR 1Y, IRS 5Y (interest rate swap, the rate illustrating the average WIBOR 6M expected over the next 5 years) and yields of 5-year government bonds, seems to confirm that for Poland.

In this part of the report we investigate whether a long-term relationship exists between interest rates in the interbank market and yields on government bonds. We check the occurrence of cointegration between the WIBOR 1Y rate, illustrating the current monetary policy and MPC communication, and yields on 2-, 5- and 10-year government bonds, using the Engle-Granger procedure (see, e.g. Welfe, 2013). We also use IRS rates with the corresponding periods to maturity (1Y, 2Y or 5Y) instead of the WIBOR rate. Our calculations are based on monthly data starting in January 2001 and ending in June 2015.

Figure 41. 5-year government bond yield, WIBOR 1Y and IRS 5Y

Source: Thomson Reuters.

Using the ADF test we do not identify any grounds to reject a unit root in the case of all analysed variables, except three, i.e. yields of 2-year government bonds as well as WIBOR 1Y and IRS 2Y rates. On the other hand, we reject the stationary features using the KPSS test. Therefore, we treat all variables as $I(1)$. Accordingly, we estimate cointegrating regressions (using the dynamic OLS estimator), with levels of yields of government bonds acting as explained variables and WIBOR and IRS rates as explanatory variables. Results are presented in Table 14, rows 4-5.

Subsequently, we test the hypothesis concerning the occurrence of the unit root in residuals, rejecting it in all cases, although for the relation between the IRS rate and the yield of 10-year bonds only at the 10-per cent level of significance. Therefore we conclude that a long-term relationship exists between interest rates in the interbank market and yields of government bonds.

Using the Wald test, we have checked whether long-run multipliers are equal to 1, which would mean full transmission. However, due to the fact that periods to maturity of the WIBOR 1Y rate and the analysed bonds do not overlap, the transmission does not necessarily have to be full. For example, WIBOR 1Y covers 20 per cent of the period to maturity of a 5-year bond, therefore, the coefficient should be at least equal to 0.2. Therefore, we additionally test whether the coefficients are equal to 0.5, 0.2 and 0.1 for 2-, 5- and 10-year bonds, respectively. In each case we reject a zero hypothesis (p values in the Wald test amount to 0.00). Long-run multipliers in models with the WIBOR rate decrease parallel to the extending length of the period to maturity of bonds. In models with the IRS rates the estimated coefficients are closer to 1. At a 5-per cent level of significance the Wald test rejects full transmission in all cases except one – for the relationship between the IRS 5Y and the yield of 5-year bonds. At a 1-per cent level of significance it is impossible to reject full transmission also for models with the yield of 2-year bonds.

At the end, we estimate regressions with the first differences in the yield of government bonds as explained variables, and the first differences in WIBOR and IRS rates, and the delayed levels of the error correction terms (ECT, i.e. residuals of corresponding cointegrating regressions), as explanatory variables. The results are contained in Table 14 (rows 5-7).³⁰

Table 14. Estimation results – error correction models for yields on Treasury bonds

	Yield of 2-year Treasury bonds		Yield of 5-year Treasury bonds		Yield of 10-year Treasury bonds	
Model with the rate:	WIBOR 1Y	IRS 2Y	WIBOR 1Y	IRS 5Y	WIBOR 1Y	IRS 10Y
Constant	0.28** (0.12)	-0.06 (0.06)	1.33*** (0.23)	0.22*** (0.07)	2.40*** (0.27)	0.62*** (0.11)
Long-run multiplier	0.95*** (0.02)	1.02*** (0.01)	0.80*** (0.04)	0.98*** (0.01)	0.63*** (0.05)	0.94*** (0.02)
Immediate reaction	0.86*** (0.09)	0.96*** (0.03)	0.67*** (0.11)	0.94*** (0.03)	0.52*** (0.09)	0.93*** (0.02)
Loading parameter	-0.10** (0.04)	-0.09 (0.05)	-0.12** (0.05)	-0.10** (0.06)	-0.09* (0.05)	-0.05** (0.03)
Are interest rates cointegrated? [Value p of ADF test]	yes** [0.04]	yes** [0.04]	yes*** [0.00]	yes** [0.02]	yes*** [0.00]	yes* [0.10]
Is long-run multiplier=1? [Value p of Wald test]	yes* [0.02]	yes* [0.02]	no [0.00]	yes*** [0.15]	no [0.00]	no [0.00]
R² – cointegrating regression	0.98	0.99	0.94	0.99	0.89	0.98
Non-centred R² – error correction model	0.68	0.91	0.47	0.92	0.38	0.90

Notes: In parenthesis, standard errors have been provided, robust to heteroscedasticity and autocorrelation, whereas in square brackets p value in the ADF test has been provided (in the case of cointegration testing) or Wald test (in the test on long-run adjustment completeness). *, ** and *** means: for estimates of parameters – statistical significance; for decisions in the ADF test – rejecting the hypothesis on the lack of cointegrating relation at the 10-, 5- and 1-per cent significance level, respectively; for decisions in the Wald test – lack of grounds for rejecting the hypothesis that the long-run multiplier=1, at the 10-, 5- and 1-per cent significance level, respectively.

Source: own calculations.

Interestingly, components of error correction are highly correlated with the share of non-residents in the domestic market of government bonds (-0.53 for 5-year bonds) and, which is more predictable, with CDS spreads (0.17). Components of error correction from regression with the IRS rates are more highly correlated with CDS spreads – 0.67 against -0.44. It probably means that factors associated with demand and supply play a significant role in the government bond market in Poland (the support of such hypothesis has been provided by a recent study by IMF, 2014). Capital inflows are compensated by spreads, which is transmitted to IRS rates. A significant part of other deviations against the long-term relation with interest rates in the interbank market may be explained by changes in the credit risk.

³⁰ For comparability with the literature, we calculated the speed of transmission, which for models 1-6 amounts to 0.91, 0.64, 1.15, 0.41, 1.23 and 0.17 of the month, respectively, however, as in the case of similar calculations for the interbank market, it has a limited interpretation capacity. Half-life periods amount to: 6.55, 7.51, 5.66, 6.78, 7.50 and 13.32 months, respectively.

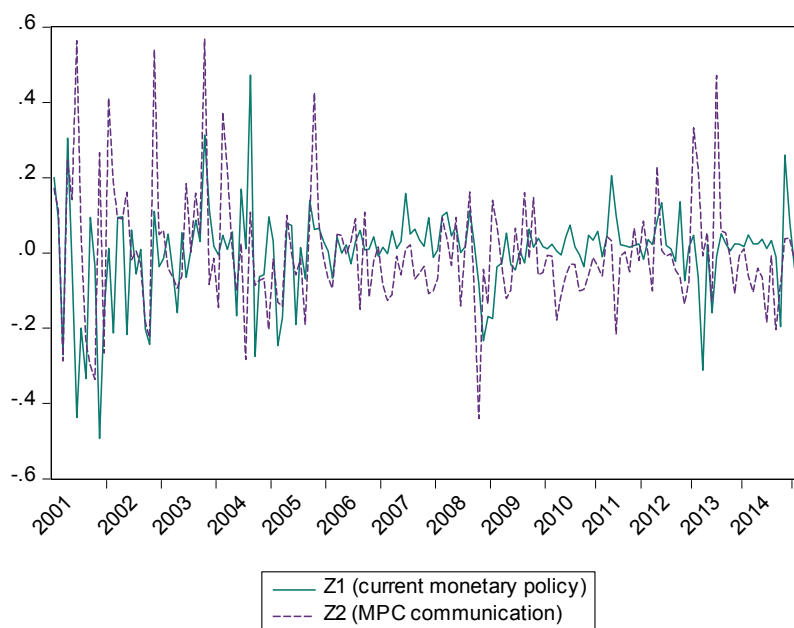
3.1.4. Transmission to prices of financial assets – event study

In this section, based on Kapuściński (2015), we show the impact of the current monetary policy and MPC communication (forward guidance or implicit signalling of future monetary policy) on prices of financial assets. We have taken into account share prices, yields of government bonds and exchange rate. The calculations are based on a sample starting in January 2001 and ending in June 2015.

In accordance with the method proposed by Gurkaynak, Sack and Swanson (2005), hereinafter referred to as GSS, at first, we calculated first differences of variables illustrating the interest rate path expected over the next year, in 2-day windows. We used changes in WIBOR 1M, FRA 1x2, 2x3, 3x6, 6x9 and 9x12 rates between days before and days after decisions of the MPC concerning the level of the reference rate. Subsequently, they were “compressed” with the use of the principal component analysis. Applying the method of minimum average partial correlation, we found the relevant number of factors is two.

Secondly, we performed the rotation of factors, so that the first one (hereinafter marked as Z_1) corresponded with the current monetary policy and the second one (Z_2) – with MPC communication. The first factor after rotation was normalised so that it changes proportionally to the WIBOR 1M rate, accordingly, it may be interpreted as an unexpected component of change in the current interest rate. On the other hand, after the change in the scale of the second factor, its unit change has the same impact on rates expected in 9-12 months as the unit change of the first factor, i.e. 0.68 p.p. Both factors are presented in Figure 42.

Figure 42. Factors after rotation



Source: own calculations.

Third, we used the factors as explanatory variables in a regression analysis. In one group of models, foreign interest rates were additionally introduced (OIS 1Y for the US dollar and for euro) as well as the measure of the global risk aversion (VIX^{31}), as control variables. Due to the fact that data on OIS 1Y for the US dollar were

³¹ Implied volatility of S&P 500 index.

only available from January 2004, models with control variables were estimated on a shorter sample. The set of explanatory variables comprised the first differences or percentage changes in 2-day windows for the index of share prices (WIG 20), yield of 2-, 5- and 10-year government bonds and the exchange rate (EUR/PLN since Poland's accession to the European Union, earlier - EUR/USD; growth means depreciation of zloty). Results are presented in Table 15.

According to the estimates, both current monetary policy and MPC communication is important for the yields on government bonds. They increase after a current or signalled future tightening of the monetary policy (or decrease after easing – the models are linear). It confirms the results of Section 3.1.3, obtained using the data of a lower frequency and without decomposing of the monetary policy into current measures and MPC communication.

MPC communication is more significant than the current monetary policy for the stock market, probably mainly due to the fact that its impact appears earlier, as GSS indicate. Share prices fall when the MPC signals higher future interest rates. The response to an increase in the current interest rate is not distinguishable from zero.

MPC communication also affects the exchange rate, however, in an unexpected way or contrary to the uncovered interest rate parity and the approach taking into account carry trade. The exchange rate becomes weaker after MPC announcements signalling more restrictive future monetary policy. One of the methods to explain this result is the occurrence of carry trade in shares, instead of money market instruments (Cenedese *et al.*, 2015). After an increase in the current interest rate, the exchange rate does not change in significant manner.

Table 15. Estimation results – linear regression models for prices of financial assets

	Index of share prices		Yield of 2-Year government bonds		Yield of 5-Year Treasury bonds		Yield of 10-Year Treasury bonds		Exchange rate	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Constant	0.20 (0.17)	0.11 (0.18)	-0.01 (0.01)	0.00 (0.01)	-0.02*** (0.01)	-0.01 (0.01)	-0.01 (0.01)	0.00 (0.01)	-0.13** (0.06)	0.04 (0.07)
Z₁ (current monetary policy)	0.45 (0.95)	-0.50 (1.35)	0.44*** (0.05)	0.52*** (0.05)	0.38*** (0.06)	0.40*** (0.05)	0.26*** (0.07)	0.20*** (0.07)	0.35 (0.46)	0.23 (0.76)
Z₂ (MPC commun.)	-3.91*** (1.33)	-5.11*** (1.87)	0.41*** (0.07)	0.49*** (0.05)	0.60*** (0.10)	0.70*** (0.13)	0.38*** (0.06)	0.42*** (0.06)	1.61*** (0.34)	1.81*** (0.51)
OIS 1Y USD		0.17 (3.03)		-0.02 (0.09)		0.06 (0.14)		0.04 (0.08)		1.74 (1.25)
OIS 1Y EUR		-3.89 (4.17)		0.12 (0.11)		0.27 (0.26)		0.08 (0.12)		-1.71 (1.79)
VIX		-0.39*** (0.13)		0.00 (0.00)		0.01 (0.01)		0.00 (0.00)		0.19*** (0.04)
R²	0.07	0.21	0.51	0.68	0.54	0.59	0.48	0.48	0.09	0.25

Notes: In parenthesis, standard errors have been provided, robust to heteroscedasticity. *, ** and *** means statistical significance, at 10-, 5- and 1-per cent significance level, respectively.

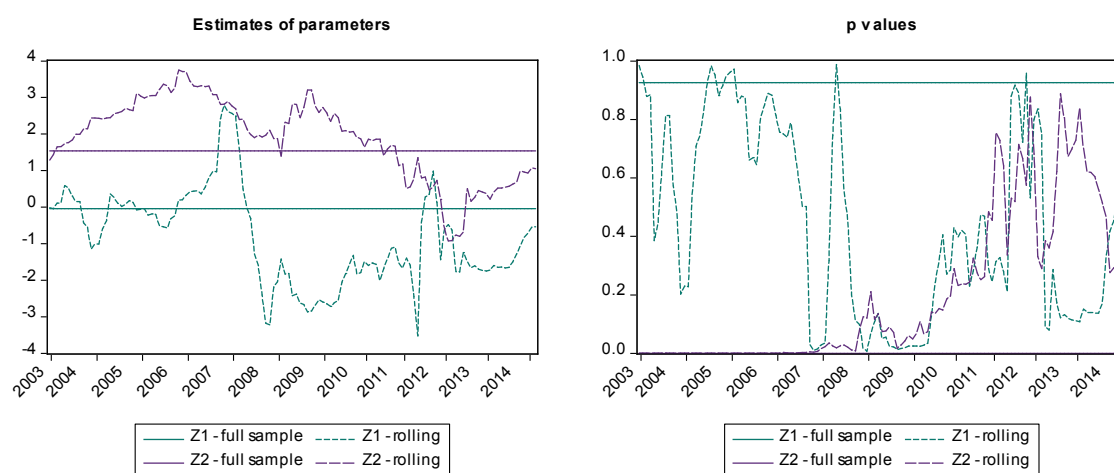
Source: own calculations.

In addition, rolling regressions (Figure 43) indicate that since mid-2006 the positive relation between the exchange rate and the measure of MPC communication has been declining. Since the global crisis, it is not statistically significant. Over the majority of the sample the exchange rate strengthened or did not change in

the statistically significant manner after an increase of the current interest rate. The remaining coefficients were similar at the beginning and at the end of the sample, whereas during the global financial crisis and crisis in the euro area a considerable instability of estimates occurred.

Results indicate that if the interest rate was at a level close to zero, and additional monetary policy easing was necessary; the MPC could use forward guidance for that purpose.³²

Figure 43. Rolling estimates of parameters and p values (Student's t test) from the model for the exchange rate



Source: own calculations.

Box 3. Impact of forward guidance on financial markets

In section 3.1.4 the study of the impact of the current monetary policy and MPC communication (including forward guidance) on prices of financial assets is described. In this box we describe the reaction of financial markets to forward guidance – direct signalling of the future monetary policy by the MPC.

The MPC used forward guidance from September 2013 to June 2014:

- In the information after the meeting on 3-4 September 2013 it was stated that *“The Council evaluates that NBP interest rates should be maintained at an unchanged level at least until the end of this year.”* This passage was also included in the information after the next meeting (October 2012).
- In the information after the meeting on 5-6 November 2014 the phrase *“until the end of this year”* was replaced by *“until the end of the first half of 2014”*. This fragment was also left in the information after meetings held in January and February 2014.
- In the information after the meeting held on 4-5 March 2014, instead of the phrase *“until the end of the first half of 2014”*, the phrase: *“until the end of the third quarter of this year”* was used. This fragment was also included in the information after meetings held between April and June 2014. It was subsequently removed, without replacing it by other direct reference to the future monetary policy.

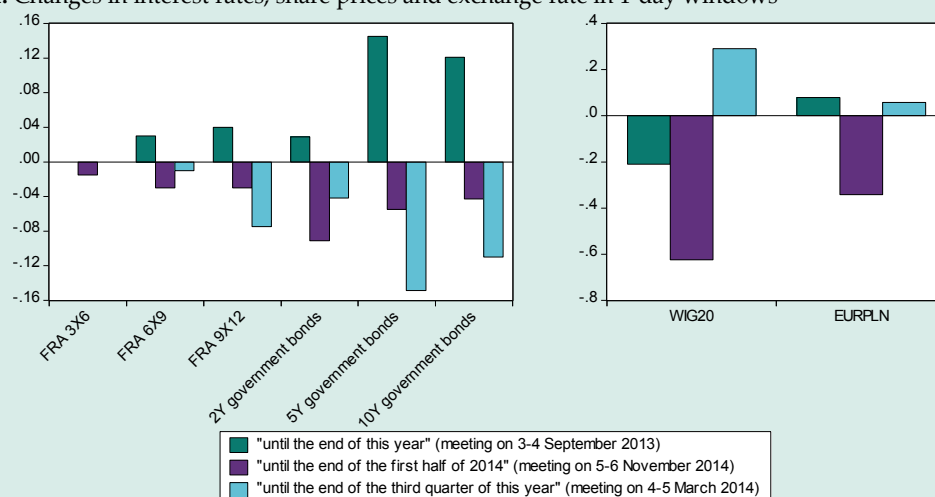
To assess the impact of forward guidance on financial markets, we may, firstly, use estimates of the Z_2 factor from section 3.1.4, as a quantitative measure of MPC communication. Chronologically, the factor amounted to 0.05, -0.11 and -0.10, which means that the introduction and the changes in the forward guidance constituted the equivalent of, respectively: an increase of 0.05 p.p. in the rates, and reductions of 0.11 and 0.10 p.p. (more precisely: the impact on

³² However, it should be stressed that hitting the zero restriction for nominal interest rates remains an event of low probability for Poland (Brzoza-Brzezina *et al.*, 2015).

FRA 9x12 was the same as an unexpected change in WIBOR 1M by the same values). The positive value for the meeting of September 2013 is interesting, probably resulting from the short period for which absence of interest rate changes was announced (1 quarter), which could have been interpreted as an announcement of increases coming sooner. Moreover, at a press conference after the previous meeting, the President of NBP assessed that interest rates should remain unchanged at least until the end of 2014; therefore, the appearance of the discussed passage did not add much to the information for financial markets (the value of the factor is lower than the standard deviation of the last 5 years of the sample).

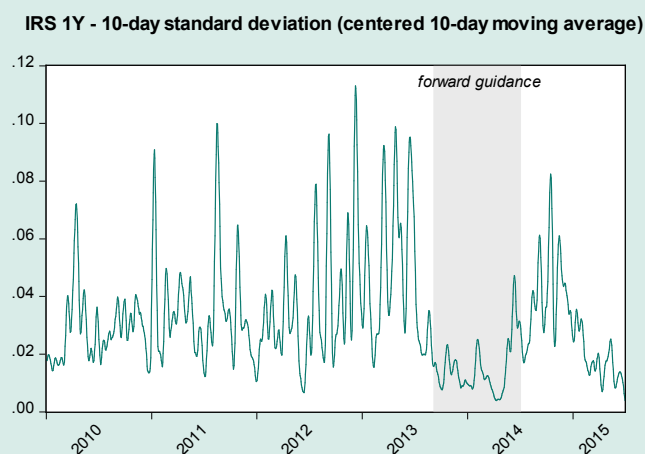
Secondly, changes can be shown in FRA rates (3x6, 6x9 and 9x12), yields of government bonds (2-, 5- and 10-year) as well as share prices and the exchange rate in 2-day windows around the meetings at which forward guidance was introduced or changed (Figure R3.1). The changes in FRA rates and bond yields confirm that the introduction of the forward guidance put an upward, while its changes, – downward pressure on the expected path of the rates. The response of share prices and the exchange rate was minor (once again, below the standard deviation) and non-systematic. It probably means that for the variability of the last two factors around the studied meetings, other factors were essential.

Figure R3.1. Changes in interest rates, share prices and exchange rate in 1-day windows



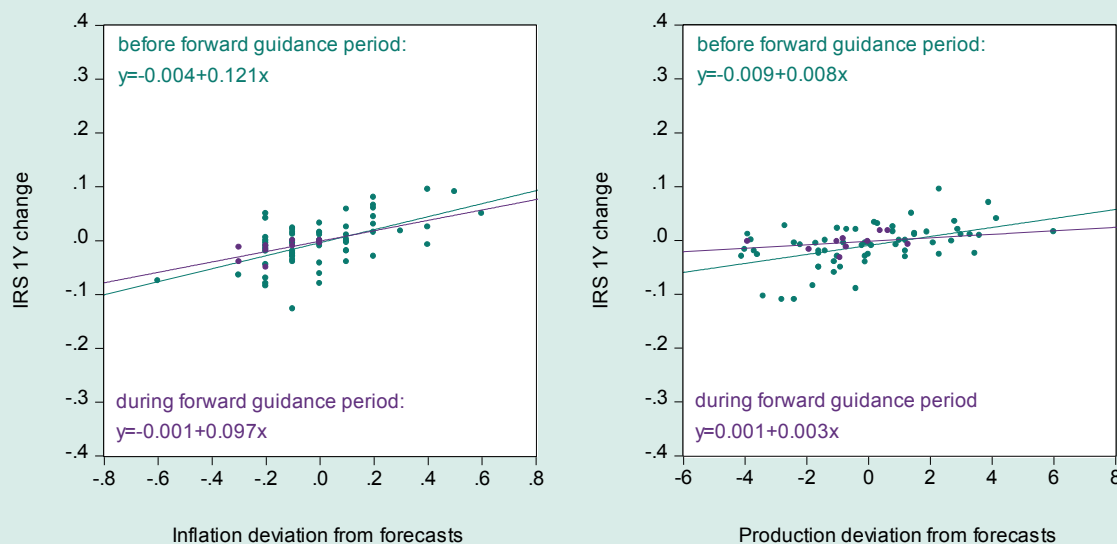
Third, in the forward guidance period a significant decline in volatility of the IRS 1Y rate took place, illustrating expectations concerning the interest rate path over the following year (Figure R3.2). It indicates that direct signalling of future monetary policy contributed to stabilising the expectations related to the rates (this effect was also visible in questionnaire surveys concerning expectation measures – the decline in dispersion of interest rate forecasts by analysts occurred – see: NBP, 2014).

Figure R3.2. Volatility of IRS 1Y rate



Fourth, the sensitivity of the IRS 1Y rate to deviations in inflation and industrial production from the forecasts published prior to the forward guidance period (due to data availability, a period from July 2008 to August 2013 was selected) and during its operation (Figure R3.3) can be compared. In both cases, the decrease in sensitivity took place, which is indicated by a lower slope of the regression line. This confirms that forward guidance w stabilised expectations about future interest rates effectively. Due to the fact that this policy was used over a short period of time, this latest finding should be treated with caution.

Figure R3.3. Sensitivity of the IRS 1Y rate to deviations of data against forecasts



3.1.5. Reactions of loans to monetary policy shocks

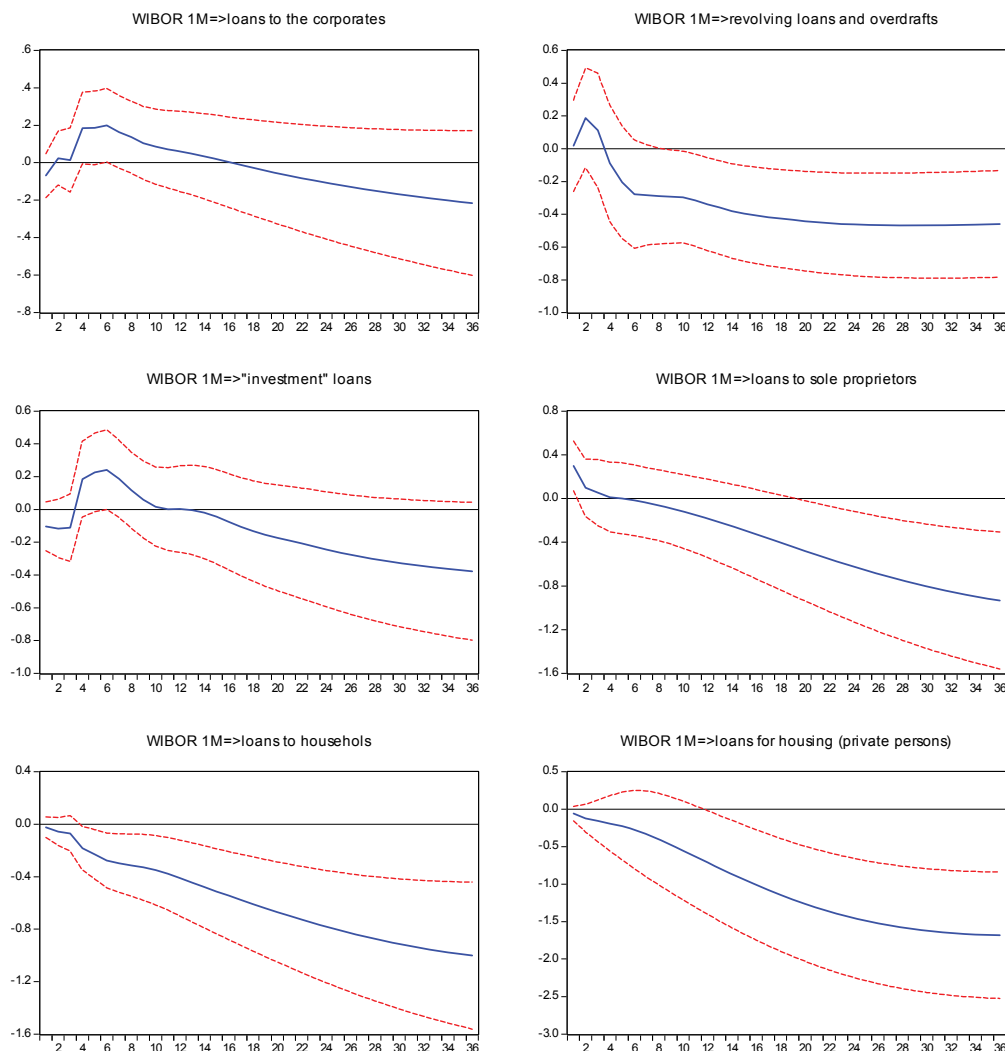
We obtain the reaction of zloty-denominated loans to the interest rate shock from monthly (S)VAR models in which we use Cholesky decomposition. The sample covers the period from January 2001 to June 2015. We use the following set of variables: industrial production, CPI, loans denominated in PLN, WIBOR 1M interest rate, nominal effective exchange rate. All variables but the interest rate are in log levels. Exogenous variables include foreign demand, foreign interest rate, dummy variables eliminating outliers (in the majority of cases, they include rapid, short-term changes in lending associated with privatisation – incurring a credit in connection with subscription for shares and fast repayment of the credit after reduction of orders).

Due to the fact that in the Cholesky decomposition results may depend on the ordering of the variables, two orderings have been checked: the first one, with credit placed third, i.e. after industrial output and prices, and the second one, where it is moved to the last place. If credit is placed after output and prices and before the interest rate, it means that it reacts to interest rate shocks with a lag, but, on the other hand, it also means that loans can be treated as a variable in the central bank reaction function. In the second variant, loans are treated as a fast reacting variable, which may be affected by the interest rate and the exchange rate without any lag. In most cases, the differences turned out insignificant. Figure 44 presents the results for the second variant.

Comparing to the results obtained in the previous report, corporate loans react slower. Following the rise in interest rate they may even continue to grow over a certain period of time – this may involve a rise in debt to finance working capital and inventory. A decline and slow adjustment to new conditions starts only after several months. On the other hand, the response of household loans is close to those previously observed.

A strong response of loans to sole proprietors, whom higher risk is usually attributed, may confirm the operation of the credit channel.

Figure 44. Impulse response functions of loans in PLN to firms and households (in nominal terms) to a contractionary interest rate shock

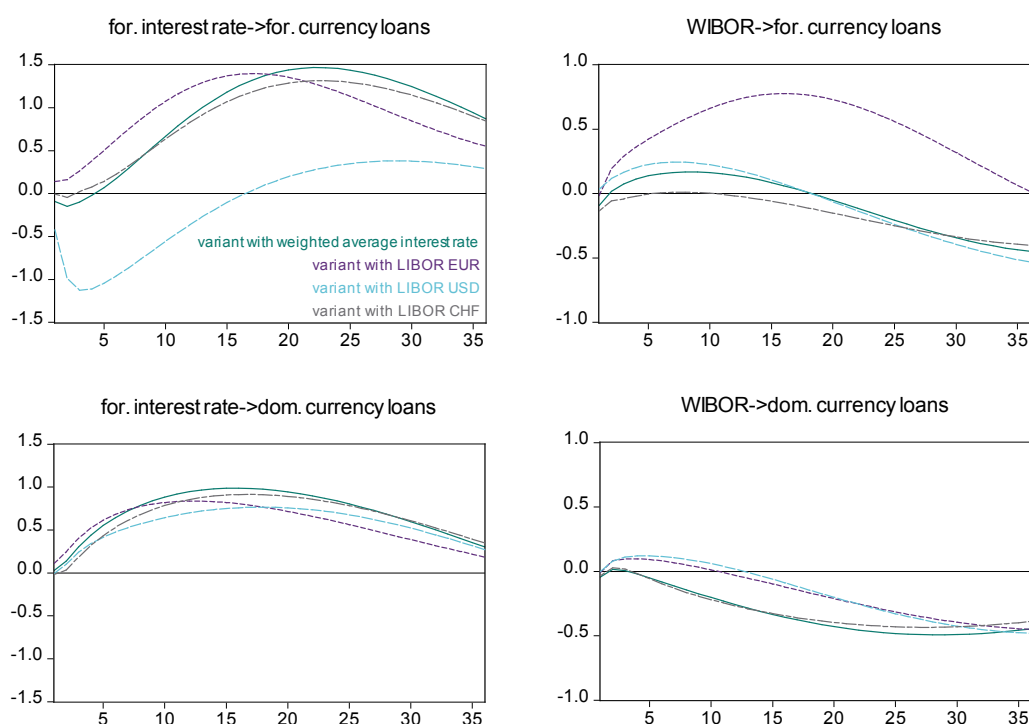


Source: own calculations.

In addition, the impact of the monetary policy on foreign currency loans to non-financial enterprises was analysed. Due to the fact that following the amendments to Recommendation S, access to housing loans denominated in foreign currency is limited, changes in the exchange rate and loan repayments mostly affect the status of this variable, in this report no analogical analysis has been performed for the household sector. As compared with the basic specification, certain changes were introduced. A foreign interest rate has been added as the first ("most exogenous") variable in Cholesky decomposition. Due to the lack of data concerning the detailed foreign currency structure of loans to non-financial enterprises over time, four variants for robustness of results were checked. In the first one, the foreign interest rate was calculated as a mean of LIBOR rates for euro, US dollar and Swiss franc, weighted by the foreign currency structure of receivables from the non-financial sector. Due to the fact that this sector comprises households, receivables denominated in franc play a significant role in foreign currency receivables. Questionnaire surveys

(Puchalska and Tymoczko, 2013) indicate that enterprises currently prefer euro, whereas earlier they preferred the dollar. Therefore, in the consecutive three variants LIBOR EUR, USD and CHF was introduced separately. REER was replaced, respectively, by effective exchange rate, as in calculations of the average foreign interest rate and EUR/PLN, USD/PLN and CHF/PLN rates. The same rates were used for clearing of foreign currency loans from effects of changes in the exchange rate. For the purpose of better capturing of potential substitution effect, besides foreign currency loans, PLN denominated loans were used in the models. In the alternative specification (also in four variants), interest rates (domestic and foreign) were replaced with a spread between them. Figure 45 and Figure 46 show reactions of loans to impulses of interest rates and spread, respectively.

Figure 45. Response functions of loans to impulses of the foreign interest rate and the WIBOR rate

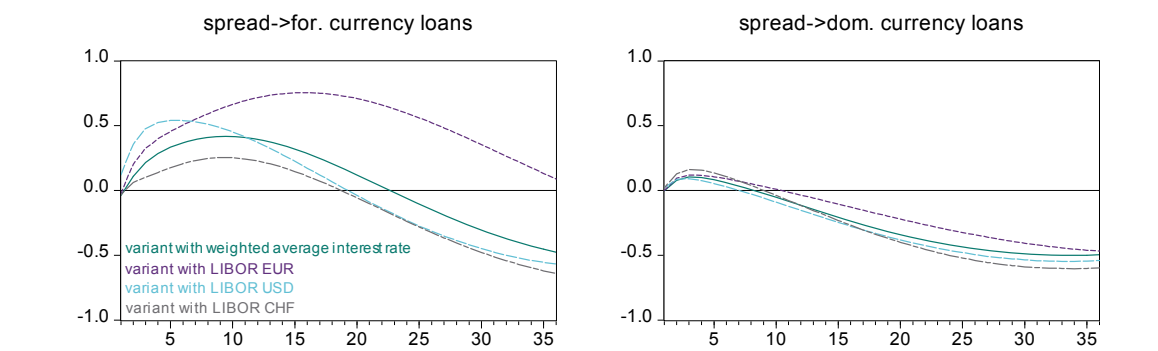


Source: own calculations.

The reaction of foreign currency loans to the impulse of the domestic interest rate is significant and positive only in the variant with the LIBOR rate for euro (and the EUR/PLN rate and loans cleared by this rate). The reaction of PLN denominated loans is similar as in the models described above. Following an increase of the foreign interest rate, growth in foreign currency and PLN denominated loans takes place, excluding the variant with the LIBOR rate for US dollar, indicating the decline of foreign currency loans. Their growth in the remaining cases is not consistent with the intuition; however, it may be explained by rate appreciation after impulses of the average weighted foreign interest rate as well as LIBOR EUR and CHF rates, excluding LIBOR USD. Bruno and Shin (2014) indicate that rate appreciation results in foreign capital inflow to the banking sector, which probably fosters the growth in foreign currency loans.³³

³³ The positive relation between the foreign interest rate and lending is also indicated by Denderski and Paczos (2015) in the study for countries of Central and Eastern Europe at banks' level.

Figure 46. Response functions of loans to the impulse of spread between the WIBOR rate and the foreign interest rate



Source: own calculations.

On the other hand, after the spread impulse foreign currency loans increase in variants with the average foreign rate and the LIBOR rate for euro, whereas zloty-denominated loans decline in each case. In other words, the results suggest a certain substitution effect between PLN denominated and foreign currency loans, limiting the effectiveness of the monetary policy, whereas the key foreign interest rate is that for the euro area.

3.2. Exchange rate channel

3.2.1. Impact of interest rate disparity on exchange rate

Standard exchange rate models, underpinned by a concept of uncovered interest rate parity with a time-varying or random risk premium, assume existence of a direct relation between monetary policy and a spot rate. In these models there is no feedback between the exchange rate, the real sector and the interest rate. Risk premium dependent on deviations of fundamental variables from their steady states has been introduced in Wadhvani (1999). Put it another way, in contrast to the time dependent risk premium of the standard models, in Wadhvani (1999) there is a direct feedback from the exchange rate to the real sector.

A model of uncovered interest rate parity with a floating risk premium has been estimated for Poland since 2001 for the nominal and real effective exchange rate (NEER/REER) of zloty.³⁴ Over 1998-2015 variables representing risk premium have undergone several changes. Anticipated output gap, representing both approximation of the risk premium and the evaluation of economic fundamentals, statistically significant in 2005-2013, since 2013 has been replaced by current output gap. Two factors might have been the underlying reason: on the one hand, stabilisation of the economy and, on the other hand – minor albeit frequent changes in economic forecasts. Earlier, investors paid more attention to a selection of categories, in particular, macroeconomic variables which deviated significantly from their long-term averages. In 2000-2003 the risk premium was well approximated by a share of trade balance in GDP or a ratio of current account balance to GDP – however, the impact of those variables on the exchange rate was highly volatile on a quarter to quarter basis. Over 2001-2004 interest rate term structure, reflecting the expected changes in the reference rate, was

³⁴ They constituted a block in small macroeconomic models used for forecasting inflation and GDP or for analyses of the monetary transmission.

used as the measure of risk premium³⁵ – however, its impact on the exchange rate was unstable. In the years 2002-2004 the risk premium was well approximated by a share of external or domestic financing in the total financing of the state budget – the estimated impact of those variables on the exchange rate was quite stable. However, estimations for 1998-2011 showed nonlinearities in the exchange rate responses to changes in interest rate disparity across the business cycle: in the prosperity the response was weaker than in the slump. Similarly, the impact of the risk premium on the exchange rate was lower during prosperity and it was growing with deteriorating economic situation. During the recent financial crisis, behaviour of the risk premium was under pressure of investors overestimating short-term risk of investing in zloty.

Current results obtained from QMOTR 2 model (for details see Appendix 1), only partially confirm these observations. In the model of the nominal effective exchange rate of zloty, changes in the current exchange rate are heavily affected by expectations of its future changes. The coefficient of the forward-looking term amounts to 0.87 and it does not change significantly across the business cycle – this may confirm that investors believe in stability of the Polish economy after the financial crisis. The interest rate disparity, i.e. a difference between WIBOR 3M and EURIBOR 3M rates, in the exchange rate equation, where the risk premium is determined by the output gap, is significant and stable across the business cycle. Its coefficient is not significantly different from unity and amounts to 0.97 for the whole estimation period, and varies in the cycle from 0.96 to 0.99. The weight of the change in the domestic interest rate is over two-fold bigger than that of the foreign interest rate and it does not vary significantly over the business cycle (Table 16). This determines the exchange rate response to the interest rate: an increase in the domestic interest rate by 1 p.p. causes appreciation of the exchange rate by 1.03% in the second quarter after the shock, whereas the same growth in the foreign interest rate leads to a depreciation of zloty, maximum by 0.26% (Figure 47). Such a difference in the strength of the impact arises from two factors: a shallow capital market and – assuming a constant level of the risk premium – a lower probability of depreciation than appreciation, owing to continuous capital inflows from the EU funds. Assuming that domestic and foreign interest rate increase simultaneously by 1 p.p., it will result in negative values of the disparity, causing depreciation of the exchange rate, maximum in the second quarter after the shock and equal to 0.77% (Figure 48). Furthermore, the high degree of forward-lookingness of the exchange rate causes the anticipatory response of the exchange rate to changes in the disparity. This response is procyclical. It is the weakest, amounting to 0.8%, when the output gap is below a threshold estimated at 0.2% of the potential GDP. In prosperity (output gap over 0.2%) and recovery (growing output gap), the response is estimated at 1.12%. Such asymmetry suggests that investors are currently more optimistic in terms of risk assessment than shortly after the financial crisis (more details on cyclical features of the transmission mechanism are presented in section 2.3 of the report).

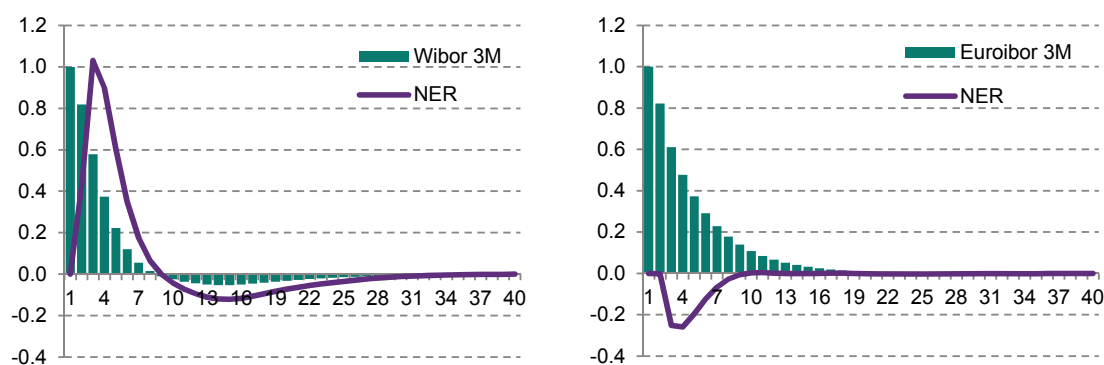
The shock of the risk premium, approximated by the output gap, by 1 p.p. results in average appreciation of the exchange rate by 1.34%, which also varies over the business cycle. However, at present, to explain the exchange rate, current business conditions are more important than expectations of a future economic situation. In recovery and prosperity, a shock leading to an increase in the output gap by 1 p.p. results in the appreciation of the exchange rate by 0.96% and 4%, respectively (Figure 49). In turn, a decline by 1 p.p. in the output gap in recession and slump triggers a depreciation of zloty by 2.7% and 0.91% respectively, Figure 50. A relatively limited appreciation in recover is associated with the fact that its first phase unfolds under slow or negative GDP growth until the output gap reaches the level equal to the threshold (0.2% of potential GDP). Then, one might expect depreciation of zloty rather than appreciation, yet, investors launch first investments

³⁵ The term structure of interest rates was represented by the difference between WIBOR 3M and WIBOR 1M rates. The growing difference increased anticipation of the successive cuts of the interest rate (from 2001 until the end of 2003 the reference rate decreased from 18% to 5.25%). The growing probability of reference rate reduction increased demand for zloty, resulting in its appreciation despite the decreasing disparity of interest rates.

already in this phase, in anticipation of improved business conditions and the associated higher future returns. With better business conditions, investors' optimism rises, which translates into a continuous growth of appreciation rate (up to 4%). The decline in GDP growth results in a decline in investments, weakening the appreciation rate to 0.96%. After exceeding the threshold level of the output gap (below 0.2% of potential GDP), investors start to withdraw from the market, what leads to increased depreciation rate, maximum to 2.7%. GDP stabilisation in slump reduces depreciation to 0.91% and from that moment, the first recovery phase starts.

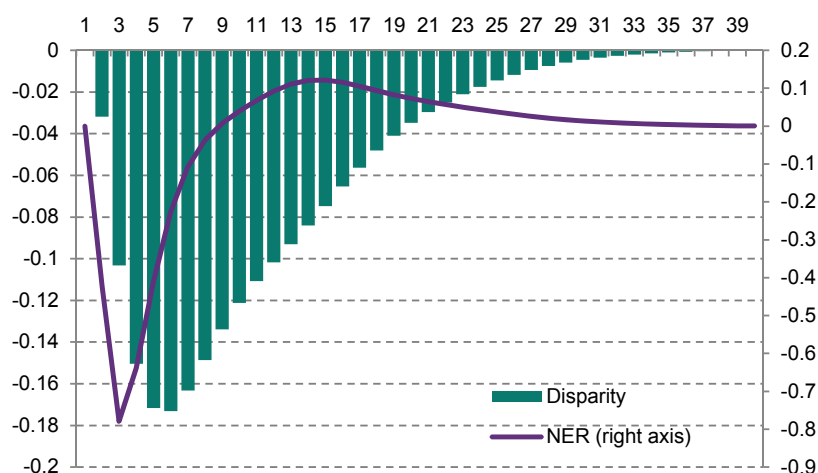
The weight of the output gap in explaining changes in the exchange rate ranges from 33% in recession to 41% in recovery (Table 16). In the similar way, the weight of factors typically named as "other" also changes over the business cycle. This group comprises mainly disturbances of the foreign demand, acting in the opposite direction to the aforementioned output gap shocks and increasing foreign investors' interest in the Polish market in slump and decreasing it in prosperity. The weight of those factors is comparable to this of the output gap and varies from 26% during prosperity in the euro area to 33% in the slump.

Figure 47. Impact of growth in domestic and external interest rate by 1 p.p. on nominal effective exchange rate of zloty (NER); increase = appreciation



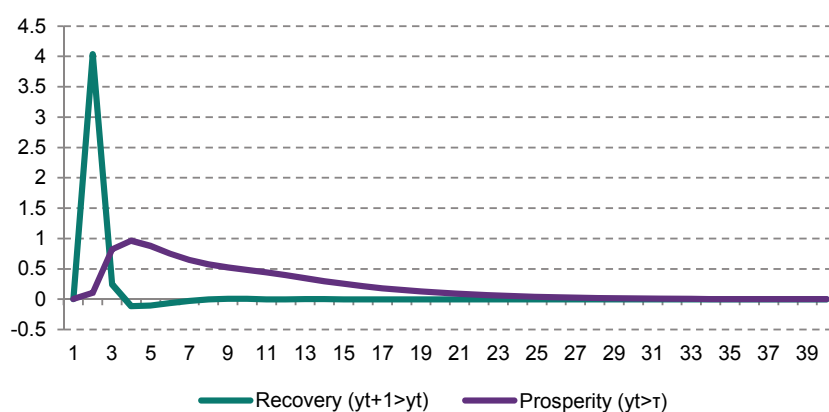
Source: own calculations.

Figure 48. Response of the nominal effective exchange rate (NER) of zloty to changes in interest rate disparity (increase = appreciation)



Source: own calculations.

Figure 49. Response of the nominal effective exchange rate of zloty (NER) to output gap growth by 1 p.p. in the recovery and in the prosperity ($\tau \geq 0.2$)



Source: own calculations.

Figure 50. Response of the nominal effective exchange rate of zloty (NER) to output gap decline by 1 p.p. in the recession and in the slump ($\tau < 0.2$)



Source: own calculations.

Table 16. Decomposition of variance of the nominal effective exchange rate of zloty (NER), in %

NER decomposition in:	WIBOR 3M	EURIBOR 3M	Output gap	Net exports	Other
Period: 2000 – II Q 2015	9.5	4.2	36.3	18.8	31.2
Recession	8.7	4	33.1	20.4	33.8
Recovery	9.8	4.5	41.1	18	26.6
Slump	8.5	4.2	34.8	19.8	32.7
Prosperity	9.7	4.4	41.3	18.5	26.1

Source: own calculations.

3.2.2. Impact of exchange rate on aggregate demand

Changes in the exchange rate, influencing the relative prices, affect competitiveness of domestically produced goods in foreign markets and imported goods in the domestic market, leading to changes in volumes of exports and imports and, by the same token, to changes in aggregate demand.

To estimate the impact of the exchange rate on the aggregate demand, we have used QMOTR 2 model. The response of the output gap to appreciation of the nominal effective exchange rate of zloty by 1% varies from -0.04 p.p. in the first quarter after the exchange rate disturbance to 0.03 p.p. in the fourth quarter (Figure 51). The oscillations stop after 12 quarters, generating a cumulated effect close to zero. Such fluctuations arise from different timing of response of export and import volumes to the exchange rate. During the first two quarters price effects prevail, i.e. after appreciation of the exchange rate, domestic prices of imported goods fall³⁶ and price competitiveness of domestically produced goods in foreign markets deteriorates. This increases import volume rate of growth and reduces export volume rate of growth. With the Marshall-Lerner condition³⁷ being met, net exports deteriorate, reducing the output gap and the GDP growth rate. In the next two quarters the decreasing rate of growth in export volume reduces import volume growth (due to the high import elasticity of exports), which transforms into improvement of net exports, and increases the output gap and GDP growth. Moreover, a positive effect of net exports is strengthened by a response of the nominal interest rate to changes in the exchange rate: exchange rate semi-elasticity of the interest rate is negative and amounts to -0.03,³⁸ which in the case of currency appreciation results in the decline of the interest rate, followed by an increase in GDP growth. The described responses correspond to the decline in the GDP growth rate by 0.04 p.p. in the first quarter after the shock and its increase in the third quarter by 0.02 p.p. (Figure 52).

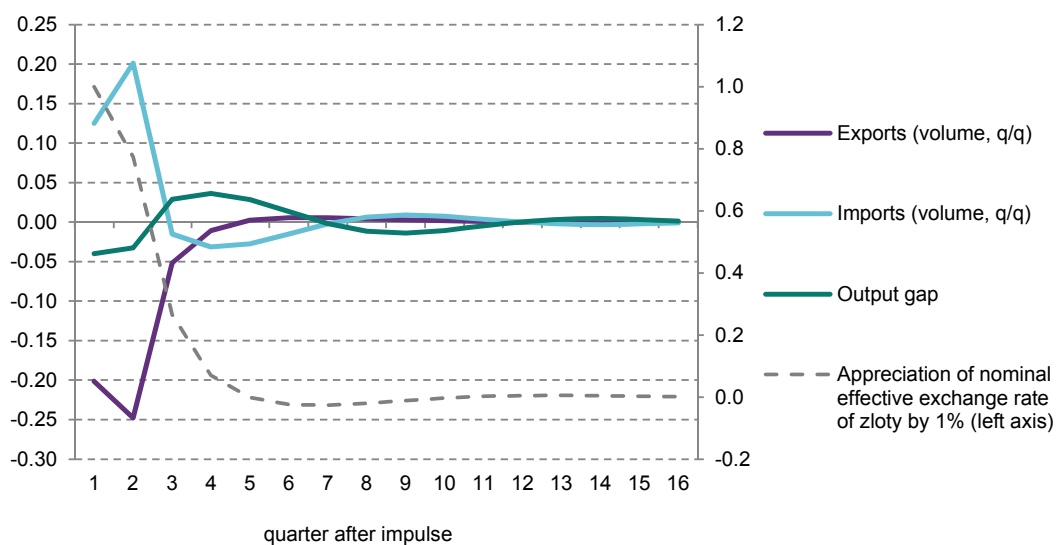
The decomposition of variance of the output gap, and volume of exports and imports (Table 17) also indicates minor weight of the exchange rate in explaining changes of these categories, amounting, respectively, to 0.8%, 7.8% and 6%.

³⁶ During the first two quarters 91% of exchange rate change effects is absorbed.

³⁷ Marshall-Lerner condition states that if the sum of price elasticity of domestic demand for imports (ϵ_m) and foreign demand for exports (ϵ_x) is higher than one, the depreciation of domestic currency leads to improvement of the trade balance.

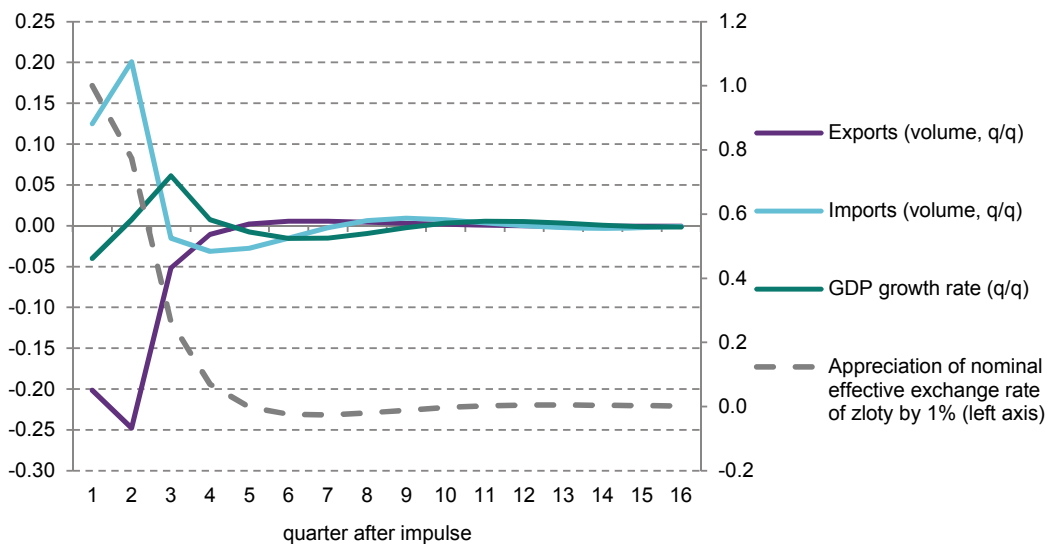
³⁸ Semi-elasticity is equal to -0.03 for the entire estimation period (2000 Q1 - 2015 Q2). In various phases of the business cycle it ranges from -0.01 in recession to -0.11 in prosperity.

Figure 51. Impact of 1% appreciation of the nominal effective exchange rate of zloty on the output gap, growth rate of exports and import volume (quarterly growth, annualised)



Source: own calculations.

Figure 52. Impact of a 1% appreciation of the nominal effective exchange rate of zloty on GDP growth, exports and import volume (quarterly growth, annualised)



Source: own calculations.

Table 17. Decomposition of variance of output gap, volume of exports and volume of imports (in %)

Variance	Supply	Domestic demand	Net exports	External factors	Exchange rate
Output gap	31.5	20.5	7.9	39.3	0.8
Volume of exports	5.5	5.0	13.6	68.1	7.8
Volume of imports	21.0	26.1	18.7	28.2	6.0

Source: own calculations.

Exchange rate plays only a minor role among factors determining growth of exports – currently its share amounts to 7.8%, whereas in the pre-accession period it was about 30%.³⁹ This is due to changes in intercorporate relations and trade within global value chains (GVC). International enterprises realize settlements within a capital group, treating production in a subsidiary company as a part of production of their own group. They offset changes in the exchange rate by altering either import prices or import contribution. The manufactured products are exported within the GVC. At the same time, under the influence of direct foreign investment, export offer is being modernized, mainly in processed goods trading, contributing to the decline in the role of export price competitiveness (e.g. Marczewski *et al.*, 2014). This rationale for a limited role of the exchange rate suggests, by the same token, a consistently high weight of external factors (68%) to stimulate exports.⁴⁰

A limited role of exchange rate in explaining import volume growth is justified in a similar way.⁴¹ For the growth of imports, domestic factors have major importance (46.1%), including: 26.1% is the domestic demand (change in the output gap by 1 p.p. results in the growth of import volume by 1.13%) and 21% are factors associated with the supply (including quality) of products and their price. At the same time, a relatively high weight of external factors (28.2%) is due to that part of imports of intermediate goods which is required for the output generated by international corporations located in Poland and sold abroad, including transactions within global value chains.⁴²

3.2.3. Pass-through effect

In the previous report (Kapuściński *et al.*, 2014) we have shown a significant decline of the exchange rate pass-through effect – from 0.21 in 2008 to 0.18 in 2010 and 0.06 in 2013. A key question from the point of view of the transmission mechanism was the issue whether the rapid drop of this effect was structural (permanent) or cyclical (transitory). The current estimates of the exchange rate pass-through (P-T) effect to consumer prices, comprising years 2000(2002)-2015 (Q2), performed with the use of various methods and models

³⁹ The quoted 30% level is the rate weight in explaining exports volume growth, adjusted by the change in the calculation method, equal to 39.9% in 1998 and referred to in Kapuściński *et al.* (2014). If the previous calculation method was applied, the current rate weight would amount to approximately 20%.

⁴⁰ External factors include: potential GDP, output gap, prices and real interest rate in the euro area.

⁴¹ Impact of the exchange rate on the real sector in the business cycle is presented in section 2.3.4.

⁴² The above explanation is empirically confirmed in the study by Kelm (2016). It shows that in Poland, exports and imports within global value chains practically do not respond to changes in the exchange rate.

(SVAR, QMOTR) confirm the low level of the pass-through: 0.07-0.08 (Table 18).⁴³ Therefore, we maintain the argument of the structural nature of pass-through evolution. This is associated with changes in the production process caused by internationalisation, expressed by a growing share of international enterprises in industrial production and services. Another reason is the stabilising policy of NBP, conducting direct inflation targeting policy.

Besides the structural fall, exchange rate pass-through may, nonetheless, somewhat vary across the business cycle (see section 2.3.4). In prosperity, understood as a period during which the output gap exceeds 0.2% of potential GDP, the Phillips curve becomes more convex, which means that companies tend to increase rather than to reduce prices and the pass-through effect reaches a peak of 0.135. In slump (threshold ≤ 0.2) the Phillips curve becomes concave and companies refrain from price rises, they tend rather to reduce them, the pass-through effect equals 0.023. The difference in the level of pass-through between recovery and recession is much smaller, and the respective figures amount to 0.084 and 0.059 (Table 19). Slight increase of the pass-through effect for consumer prices, in relation to the results presented in the previous report (Kapuściński *et al.*, 2014), is associated with the predominance of the recovery phase over the last two years, and since the beginning of 2015 – with approaching the prosperity threshold with an increased pass-through.

Table 18. Pass-through effect

Pass-through effect	after 2 quarters		after 4 quarters		after 8 quarters	
	estimation 2000-2013	estimation 2002-2015	estimation 2000-2013	estimation 2002-2015	estimation 2000-2013	estimation 2002-2015
Import prices (PM)	0.67	0.78	0.70	0.86	0.74	0.86
Producer prices (PPI)	0.21	0.32	0.23	0.36	0.25	0.36
Consumer prices (CPI)	0.02	0.05	0.04	0.07	0.06	0.07

Source: own calculations.

Table 19. Asymmetry of the pass-through effect over business cycle, approximated by the output gap (y)

Pass-through effect in:	1998-2008 (Single equation model, Przystupa, Wróbel (2011))	2000 - 2015 Q2 (QMOTR)
Average over business cycle	0.210	0.076
Recession ($y_{t+1} \leq y_t$)	0.091	0.059
Recovery ($y_{t+1} > y_t$)	0.274	0.084
Slump ($y_t \leq \tau$), threshold = $\tau = 0.2$	($\tau = 0.24$) 0.179	0.023
Prosperity ($y_t > \tau$), threshold = $\tau = 0.2$	($\tau = 0.24$) 0.192	0.135

Source: own calculations.

⁴³ Textbooks define exchange rate pass-through effect into domestic prices as a response of import prices expressed in domestic currency to the changes in the exchange rate between the exporting and the importing country. Under perfect competition this ratio should equal unity. Gagnon and Ihrig (2004) demonstrated that if producers have confidence in a monetary policy actively stabilising inflation, they are less inclined to change consumer prices in response to a change in the exchange rate. Analysing the pass-through effect in developed countries in 1971-2004 they estimated that the stabilisation of inflation in the middle of the 1980s led to a decline in the pass-through effect from 0.16 in 1971-1983 to 0.5 in 1984-2004. In countries where a direct inflation targeting regime was implemented in the 1990s, the decline was even larger: from 0.18 to 0.03. The pass-through effect obtained for the developed countries in 1971-1983 is close to the current pass-through level in Poland and in other countries of Central and Eastern Europe.

At the same time, the response of prices to the exchange rate has become faster. For consumer prices 39% of the price change takes place during the first quarter after the exchange rate shock (Table 20). The corresponding figures for producer and import prices are 74% and 77%, respectively. Practically, the overall effect shows up during four quarters. It seems that, in particular in the case of production and import prices, acceleration of pass-through is correlated with a decrease of commodity prices in the world market, which means higher profits due to the decline in prices than losses from changes in the exchange rate. A side effect of this phenomenon is more than proportional (in relation to business cycle effects) growth in the pass-through effect.⁴⁴ The aforementioned changes in production processes, in this case associated with minimisation of production costs by limiting the quantity of stocks held, additionally accelerate price response.

Table 20. Time decomposition of the pass-through effect

Time decomposition of the pass-through effect (total P-T=100) for ↓	Quarter after the exchange rate shock				
	1	2	3	4	5-8
Import prices (PM)	77 (48)	14 (41)	7 (5)	2 (3)	0 (3)
Producer Prices (PPI)	74 (55)	16 (27)	6 (7)	3 (6)	1 (5)
Consumer prices (CPI)	39 (10)	36 (38)	21 (29)	3 (11)	1 (12)

Note: In parentheses the values consistent with 2013 estimates are provided.

Source: own calculations.

The results of the pass-through effect estimations and their suggested interpretation show that neither stability of this effect during time nor its consistency at all stages of pass-through or in various phases of the business cycle may be assumed. Moreover, it is worth noting that in analyses of the exchange rate pass-through, identification of causes of both exchange rate and prices changes in the world market is as significant as the cyclical variability of the pass-through effect (Forbes *et al.*, 2015).

3.3. Credit channel

This chapter contains a comprehensive analysis of the operation of the credit channel. It consists of three sections. In two first sections we use aggregated data, and in the third section – individual data. In the first section (1.1.1) we use vector autoregressive models with sign restrictions and identify three orthogonal shocks:

(i) loan demand, (ii) loan supply; and (iii) monetary policy (interest rate). We analyse macroeconomic effects of loan demand and supply shocks, compare them to the monetary policy shock and verify earlier results concerning monetary policy impact on the real sector, inflation and zloty denominated loans. Loan supply and demand shocks obtained in this part can be classified as those generated as a result of change in banks' preferences to loan granting, for example, in connection with the change of risk attitude or risk perception (risk-taking channel).

In the next section (3.3.2) we present estimates of the long-term supply and demand functions of total loans denominated in zloty as well as corporate and household loans, with the use of vector error correction

⁴⁴ From January 2014 to September 2015 the nominal effective zloty exchange rate depreciated by 0.3%, whereas producer prices dropped by 4%, mainly due to the decline of commodity prices in the global market (a change neither dependent on domestic structural factors nor on the business cycle), increasing the pass-through effect of exchange rate changes to production prices in this period to almost 0.4.

models. Whereas earlier we try to confirm the operation of the credit channel identifying supply and demand shocks based on theory, in the second section, we select theory-based factors affecting loan demand and supply in the long term. We check whether after disturbances demand and supply functions return to their long-term equilibrium. Disentangling non-observable demand and supply functions may confirm operation of the credit channel.

Finally, in the last section (3.3.3), we analyse bank lending channel – we report how monetary policy affects banks' balance sheets and how these, in turn, affect the supply of bank loans. It is an approach suggested by Disyatat (2010). In this case, the analysis refers to loans denominated in zloty and foreign currency. We show that banks' balance sheets influence loan supply significantly. Moreover, monetary policy shocks have a statistically significant impact on balance sheets; however, their share in the variance of variables used to proxy of banks' balance sheets strength is not high.

3.3.1. Loan demand and supply shocks (SVAR model with sign restrictions)

In the context of the recent financial crisis and its impact on lending activity of the banking sector it is crucial to disentangle unobservable loan demand and supply functions. The amount of loans currently observed is a product of shifts in their supply and demand, thus after a monetary policy shock it is not clear whether the reaction of lending was mostly due to the operation of the interest rate channel or the credit channel, or their interaction. Until the outbreak of the financial crisis, empirical studies were bringing mixed evidence on the existence of the credit channel.

Following Peersman (2012), we analyse the loan demand and supply functions identifying three structural shocks: a monetary policy shock, a loan demand shock and a loan supply shock. To that end, we have introduced the following restrictions:

- a contractionary monetary policy shock should lead to an immediate rise in the WIBOR 1M (which is a proxy for the central bank policy rate) and banks' lending rate, as well as a decline in the volume of loans and consumer prices in the third, fourth and fifth month after the shock (the last restriction is aimed at maintaining coherence with models described in section 2.1);
- a loan demand shock is identified through reference to the shift of loan demand curve to the right, thus, it is associated with a simultaneous growth in the volume of loans and the lending rate. It may result, e.g. from a change of borrowers' preferences;
- a loan supply shock is associated both with the shift of the loan supply curve to the right and the immediate rise of credit multiplier (defined as the ratio of loans to the monetary base ($M0$)). The first component entails the assumption that the loan supply shock increases loans and reduces banks' lending rate. A positive credit multiplier warranties that a loan supply shock increases bank lending, irrespective of the prevailing monetary policy stance. It may result from a lower risk aversion of banks, or easier securitization of their loans, etc. Moreover, we have assumed that the WIBOR 1M interest rate rises immediately in response to the loan supply shock;
- in addition, we have introduced several zero restrictions to the model: neither industrial production nor prices respond immediately to of loan demand and supply shocks;

- finally, for the sake of comparability with the results shown in section 2.1, we have introduced restrictions on signs of coefficients in the monetary policy rule (i.e. the coefficient on the output gap and inflation must not be negative).

Figure 53, Figure 54 and Figure 55 present the obtained impulse response functions of all variables to three shocks identified according to the aforementioned assumptions.

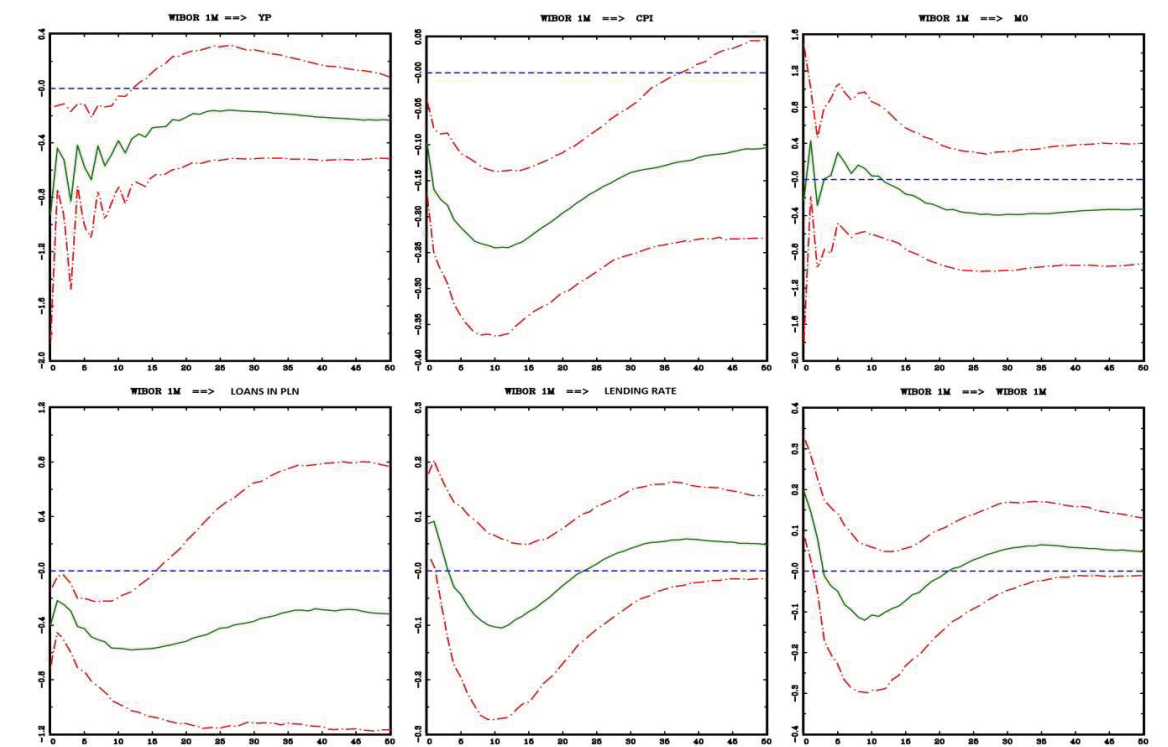
Impulse response functions to the monetary policy shock are very close to those presented in section 2.1. This is satisfactory considering the fact that the current model contains one variable more, that it does not contain the exchange rate and that three shocks are identified simultaneously. It confirms the universality of results obtained in section 2.1 for the model with sign restrictions.

Loan demand shock does not affect industrial production. Even if prices rise (taking into consideration the median response), this effect is not statistically significant. The interest rate goes up, yet this increase is on the border of statistical significance. Only the behaviour of the lending rate and loans is unambiguous: both increase after the loan demand shock. Therefore, it can be summed up that a loan demand shock often exhibited neutrality in relation to production and prices, whereas the ambiguous behaviour of the WIBOR 1M rate was the natural consequence thereof.

Results related to the loan supply shock are less ambiguous.⁴⁵ It results in a rise in output, consumer prices and the WIBOR rate. The latter increases sharply, by 30 basis points after approximately 7 months (with the effect boosted by imposed sign restrictions in the monetary policy rule). Due to the fact that output, consumer prices and loans decline, monetary policy becomes looser. However, the initial strong impact of the WIBOR 1M rate and, consequently, the increase in the lending rate, causes that the monetary policy easing does not prevent the economic slowdown after 18 months after the shock. It is worth noting that credit grows despite a significant decline of M0.

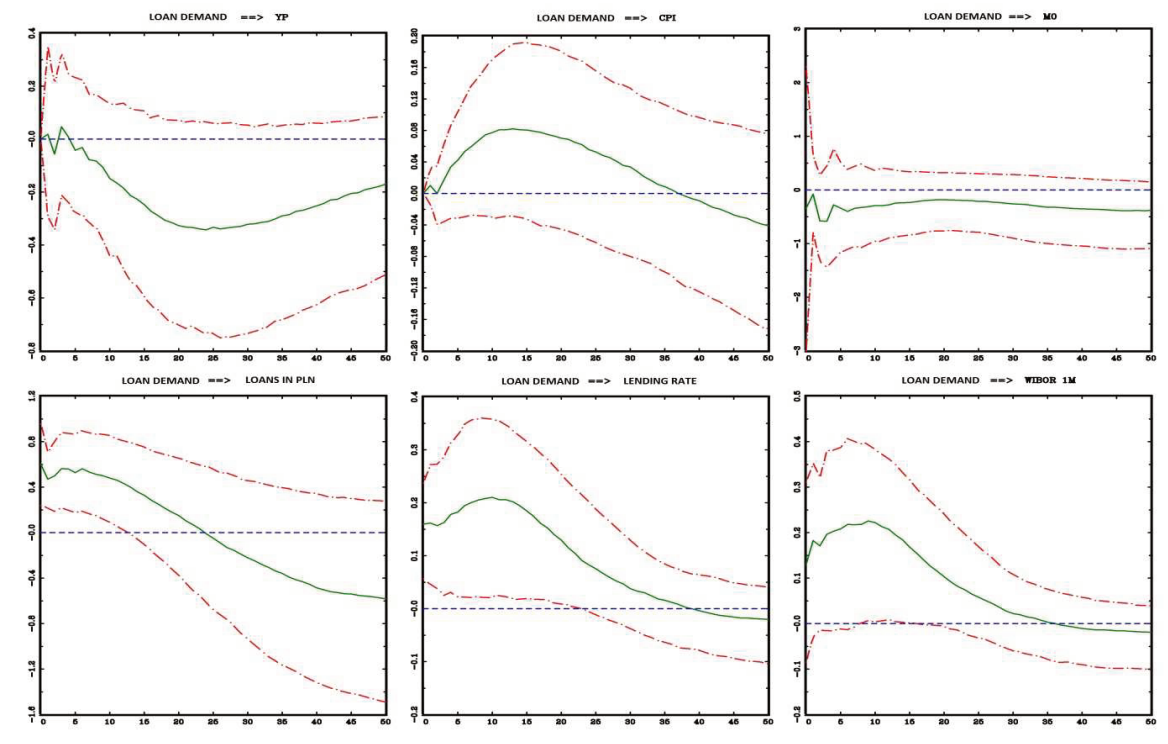
⁴⁵ The obtained loan supply shock is highly correlated with the measure of credit standards (see: data from Senior Loan Officer Opinion Survey; <http://www.nbp.pl/homen.aspx?f=/en/systemfinansowy/kredytowy.html>)

Figure 53. Impulse response functions to a contractionary monetary policy shock



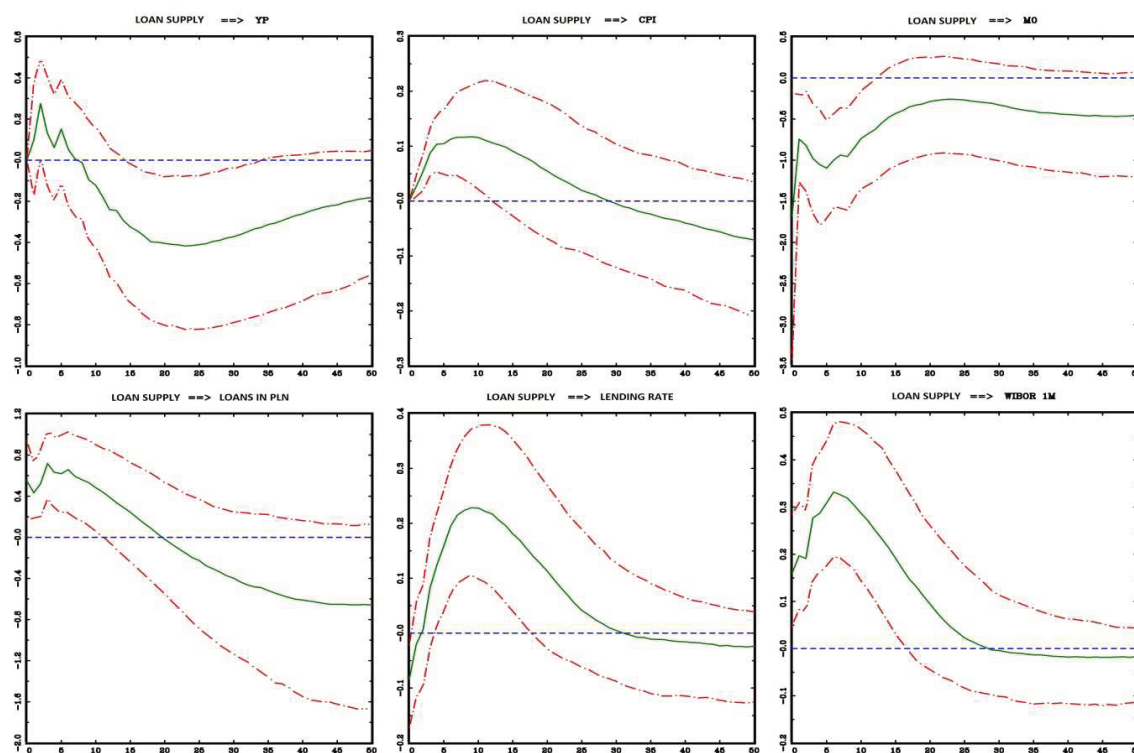
Source: own calculations.

Figure 54. Impulse response functions to a loan demand shock



Source: own calculations.

Figure 55. Impulse response functions to a loan supply shock



Source: own calculations.

Variance decomposition shows that within one year, the exogenous loan supply shock has the biggest share in explaining the error variance of loan forecast. We estimate it at 17%, with a 68-per cent error band contained between 3.5% and 43%. Interestingly, within four years, the share of this shock in explaining the loan forecast error variance declines even by a half, to 8% (68-per cent error band is contained between 2.5% and 18%). This indicates that the impact of loan supply shock on the volume of loans is short-lived, which is, consistent with the conclusions from IRFs. A similar picture emerges for the exogenous loan demand shock, although its “explanatory power” of the loan forecast error variance is slightly smaller. In particular, within one year, this shock explains approximately 14.5% of the loan forecast error variance (68-per cent error band for this estimate is contained between 2.5% and 37%). As in the case of the supply shock, within four years, the share of the loan demand shock in explaining the loan forecast error variance declines by a half, to 7.5% (68-per cent error bands from 2% to 18%).

Due to the fact that together with the loan supply and demand shocks we have identified the monetary policy shock, it is natural to compare impulse response functions with those presented in section 2.1. The results are consistent. In the current model, the share of the exogenous monetary policy shock in explaining the forecast error variance of industrial production one year amounts to 15% (68-per cent error band: 3.5%-42%), whereas within four years – 12.5% (68-per cent error band: 3.7%-29%).⁴⁶ Our last observation is a noteworthy share of the loan supply shock in explaining the forecast error variance for the WIBOR 1M rate. Within one year it amounts to 19%, falling only slightly within four years, to 16.5%. It confirms the earlier observation that the monetary authorities tended to counteract reliably the loan supply shocks.

⁴⁶ As a reminder, analogical results from section 2.1 indicated a 10-per cent share of the monetary policy shock in explaining the forecast error variance of the production (both within the horizon of one year and four years).

A question arises whether our results are sensitive to the chosen sample, and especially, whether the global financial crisis has had an impact on credit channel operation. Thus, we have re-estimated the model on a sample covering solely the post-crisis period. The results differ from those reported above. Namely, demand and supply shocks do not dominate any more, whereas the role of monetary policy shocks increases. Within one year, the share of a loan supply shock in explaining the loan forecast error variance drops over three-fold to 5.5% (68-per cent of error band is contained between 2% and 13.5%). It is a considerable change taking into account that the share of this shock obtained from the model estimated on the whole sample amounted to 17%, i.e. a value which is now outside the error band. In the case of the loan demand shock, its share in explaining the variance of the loan forecast error within one year declines by a half. Currently we estimate this share at 7% (68-per cent error band: 2%-22%). However, as we have already mentioned, the biggest differences refer to the monetary policy shock which has become the main determinant of loans. Within four years, the share of the exogenous monetary policy shock in explaining the variance of the forecast error of loans currently amounts to 28% (68-per cent error band is contained between 8.5% and 54%), whereas the estimation on the whole sample amounted to only 11%. Within four years, the share of the monetary policy shock now amounts to 17% (68-per cent error band: 3%-45%), whereas this obtained for the whole sample amounts to 7%. Interestingly, the share of the loan supply shock in explaining the variance of the forecast error of the WIBOR 1M rate within one year dropped from 19% (for the whole sample) to 11% (for the post-crisis sample). All in all, we obtain a consistent picture suggesting that since the financial crisis monetary policy has influenced loans more than it has responded itself to loans.

We have compared variance decompositions obtained for the industrial output in the same way. Although the share of loan supply and demand shocks in explaining the forecast error variance of industrial output is minor, it is worth observing that in the short sample it increases over three-fold within one year, but stays the same within four years. In the whole sample, the share of both loan supply shocks and loan demand shocks in explaining the forecast error variance of industrial production amounts to approximately 2.5% (upper limit of the 68-per cent error band does not exceed 6%), in the short one the share of the loan supply shock increases to 8.5% (68-per cent error band: 3.5%-18%). The share of the loan demand shock increases to 9% (68-per cent error band: 3.5%-19%). At the same time, it should be stressed that estimates obtained on the post-crisis sample are not lay within the 68% error band for estimates derived from the whole sample.⁴⁷

3.3.2. Demand and supply function of zloty-denominated loans (error correction models)

In order to identify a *long-term* function of loan supply using data related to its volume, we have built a vector error correction model, where, basing on the theory of credit channel, we have introduced variables determining loan supply and loan demand. A set of excluding restrictions makes it possible to disentangle loan supply and loan demand functions.

⁴⁷ In a similar study for the euro area, Peersman (2012) obtained quite divergent results as compared to ours. According to Peersman, the aggregated share of loan supply and demand shocks in explaining the forecast error variance of production and prices often exceeds 50%. Although our study confirms that after the outbreak of the crisis this share has significantly increased, the cumulative share of those two shocks does not exceed 20% (in relation to both prices and production). This can be explained by two facts: differences related to the role of loan between developed economies (e.g. the euro area) and Poland, as well as the methodological error. In our opinion, the last factor plays quite a significant role. The method used by Peersman has no fundamental justification. Arias *et al.* (2014) showed it in quite a persuasive way. In particular, comparing the results of the study by Beaudry *et al.* (2011), using the same methodology as Peersman (2012), to the results obtained based on their own methodology, they found that most of the variance decompositions regularly decreased by two- or even three-fold. At the same time, it should be stressed that our estimates rely on the methodology based on Arias *et al.* (2014), however, with numerous differences. It turns out that the methodology presented by Arias *et al.* (2014) is also vitiated by a serious error which was indicated and corrected in the work by one of the co-authors of this report, see Kocięcki (2016).

The variables of the model include: household loans and corporate loans denominated in zloty in real terms,⁴⁸ the level of economic activity (GDP), the interest rate at which banks are refinanced (proxied by the WIBOR 3M rate), interest rate on loans, inflation in y/y terms⁴⁹ and the capital buffer. We assume that loan supply depends positively on the loan rate and negatively – on the WIBOR rate. We expect that the coefficient derived for both rates will be equal in terms of absolute value. Consequently, loan supply should depend positively on the spread between the interest rate on the loan and banks' refinancing rate (banks are more inclined to grant a loan when its interest rate rises, and less inclined – if the interest rate at which they borrow funds in the interbank market and/or from the central bank increases). In the model, capital buffers understood as a difference between the solvency ratio⁵⁰ and the minimum required level of capital enabling payment of the dividend, represent the factor determining loan supply. The capital requirements are raised if the share of non-performing loans increases in banks' assets. Results for the UK, obtained on individual data, show that an increase of capital requirement has an impact on the capital maintained by banks: after an increase of capital requirements banks gradually rebuild buffers. As a result, banks cut loan growth for commercial real estate, other corporates and household secured lending. This effect can be relatively persistent – in the UK it disappears only after approximately 3 years (Bridges *et al.*, 2014). Our results show a negative impact of the growth in buffers on loan supply, household loans react stronger than credits to firms, probably due to the higher risk attributed to household loans.

Besides identifying the loan supply function we also perform an identification of the loan demand function. We expect that the demand for loans depends on GDP positively (variable of the scale) and negatively – on the lending interest rate, whereas it does not depend on the rate at which banks are refinanced, or on the solvency ratio. We assume that the inflation rate may have an impact on the behaviour of lenders and borrowers – thus, both on the loan demand function and on the loan supply function. However, we do not determine in advance whether its impact is positive or negative, since the theory does not provide an explicit answer in this case. For example, in the model of Cukierman and Hercovitz (1989) loan demand is positively related to inflation. In that model, firms make use of money and bank loans to pay for working capital. High inflation penalizes money holdings by firms and makes bank loans more attractive. Thus, cash or deposits on a current account bearing low interest rate decline whereas loans grow. By contrast, De Gregorio and Sturzenegger (1997) build a model where the demand for bank credit falls with inflation since higher inflation is related to lower productivity levels, which, in turn, reduces labour demand. Results of empirical studies also do not provide an explicit answer.

We have analysed total loans denominated in zloty, household loans and credits granted to firms. In order to obtain a normal distribution of residuals (or at least a distribution which would not be excessively skewed), we used dummy variables (inter alia, in order to eliminate the problem of year 2000 from the interest rate series and inflation growth in 2004, in connection with Poland's EU accession). Searching for cointegrating

⁴⁸ In order to obtain real values, a weighted average of consumption and investment deflator was used: the weights constituted shares of loans denominated in PLN granted to private individuals and to enterprises in total lending, variable over time.

⁴⁹ The ADF test suggests that inflation y/y is a series containing a single root – the ADF test value without trend: -1.8 (probability 0.38); with a trend and constant: -2.02 (probability 0.58).

⁵⁰ Since the beginning of 2014 the CRD IV/CRR package is binding. The package has fully replaced the regulations applicable so far: Directive 2006/48/EC of the European Parliament and of the Council of 14 June 2006 *relating to the taking up and pursuit of the business of credit institutions* and Directive 2006/49/EC of the European Parliament and of the Council of 14 June 2006 *on the capital adequacy of investment firms and credit institutions*. The purpose of the new provisions is to strengthen the regulations related to the banking sector and investment firms; the regulations constitute the next step towards creating a safer and more transparent financial system. They take into account the proposal of the Basel Committee on Banking Supervision, referred to as Basel III. Definitions of some indicators have changed; the solvency ratio is no more calculated and it has been replaced by the "required total capital". Until 2015 Q2 we used the solvency ratio, and subsequently – the required total capital ratio.

relations, we have assumed a deterministic trend in the data. The number of lags has been determined with the Schwarz information criterion, taking into account auto-correlation and distribution of residuals.

We have obtained three cointegrating relations for each type of loan. We have imposed the aforementioned restrictions on the cointegrating relations. They have been formally tested and not rejected. The most important results are presented in Table 21.

The total loan demand depends closely on the GDP level; according to our estimates, the elasticity is approximately 2.6. In mature economies it is usually lower. Fase (1995) and Kakes (2000) obtained a similarly high output elasticity of loan demand for the Netherlands. In our case, the high elasticity of loan demand in relation to GDP results from a very high income elasticity of demand from households. The elasticity of corporate loan demand (approximately 1.3) is close to the values obtained for the euro area countries. Such high income elasticity of households' demand may possibly be due to the catching up effect. In the period covered by the sample, Polish households started to increase their indebtedness from a relatively low level (the ratio of household loans denominated in the zloty to the disposable income increased from about 46% at the end of 2000 to approximately 157% in mid-2015).

Taking into account the mean value of the lending rate (8.98%) and the estimated coefficient of semi-elasticity of demand for total loans, we obtain the interest rate elasticity of demand equal to about -0.4.⁵¹ In the supply function attention should be paid to semi-elasticity against the buffer (whose average value in the sample amounts to 4.58%): for total loans it is equal to -0.78, whereas in the case of loans to firms, it is lower by a half as compared to households. It confirms our earlier observations that banks attribute a significantly higher risk to household loans than to corporate loans.

With higher inflation, loan demand increases, whereas its supply falls, probably due to the growing uncertainty related to the future interest rate. Taking into account the mean value of annual inflation rate in the sample (about 3.2%), the elasticity of demand and supply is close to the absolute value and amounts to approximately 0.26 and -0.19, respectively.

In the case of disturbances in the total loan demand function, the return to equilibrium is very slow – within a quarter between 6% and 9% of disequilibrium in the demand and supply functions is eliminated; this pace is similar for all loan types.

⁵¹ In the study of Hülsewig *et. al.* (2005) concerning the German economy the corresponding elasticity amounted to about -0.7. Other empirical works show it in a range from -0.2 to -1.1 (see: Kakes, 2000).

Table 21. Estimated coefficients of PLN denominated loan demand and supply function, 1999:Q2-2015:Q1

Function	GDP	Lending interest rate	WIBOR rate	Inflation	Buffer	α
Total loans in PLN						
Loan demand	2.68 (22.12)	-0.05 (5.99)	x	0.08 (7.8)	x	-0.09 (3.95)
Loan supply	x	0.30 (13.07)	-0.30 (13.07)	-0.06 (5.98)	-0.17 (12.8)	-0.08 (5.01)
Corporate loans in PLN*						
Loan demand	1.31 (7.78)	-0.074 (7.77)	x	0.07 (8.29)	x	-0.09 (3.23)
Loan supply	x	0.13 (8.38)	-0.13 (8.38)	-0.04 (6.0)	-0.12 (14.4)	-0.13 (4.21)
Household loans in PLN						
Loan demand	3.48 (22.7)	-0.07 (5.74)	x	0.11 (7.91)	x	-0.07 (2.57)
Loan supply	x	0.39 (11.8)	-0.39 (11.8)	-0.07 (4.85)	-0.23 (12.32)	-0.06 (3.86)

Note: in parenthesis, the absolute values of *t*-statistics are reported; α parameter shows the speed of adjustment toward equilibrium after shock to loan demand or supply function. In the case of corporate loans, a sample 1999:Q1-2015:Q1 was used.

Source: own calculations.

3.3.3. Bank lending channel – analysis on individual data

In accordance with the traditional approach to the bank lending channel (Bernanke and Blinder, 1988), the main constraints on lending are constituted by reserves and loanable funds, and a monetary policy tightening relaxes these constraints. The empirical strategy in studies based on this approach (for example, Ehrmann *et al.*, 2001) consists in checking the non-linearity in loan responses to interest rate changes due to the characteristics providing “resistance” to monetary policy impact (size, liquidity position, capital position).

However, recent studies by Disyatat (2010) and Jakab and Kumhof (2015) show that lending is mostly influenced by capital requirements and the expected profitability and solvency. Moreover, central banks provide reserves as demanded (irrespective of the interest rate level) while commercial banks are not intermediaries of loanable funds. Therefore, the first of the above authors suggests other mechanism of the bank credit channel – monetary policy transmission may be strengthened if the interest rate influences the strength of banks’ balance sheets (measured by the share of non-performing loans, profitability and the capital buffer). The operation of this mechanism in Poland has been studied by investigating the impact of banks’ balance sheet strength on lending⁵² (loans denominated in zloty and foreign currency), subsequently analysing the monetary policy impact on balance sheets (Kapuściński, 2016).

In our study we have used quarterly panel data comprising the period between the first quarter of 2001 and the first quarter of 2015. We have removed cooperative banks and branches of credit institutions from the sample. After mergers or acquisitions we created separate banks in the data. Additionally, in the sample we have only included banks with more than half of the observations in terms of time and we performed *winsorizing* (replacement of observations with extreme values for specific periods by the relevant percentile)

⁵² Information on the adverse impact of capital buffer and profitability reduction on loan supply can be found in own reports of banks (PKO BP, 2015).

in order to suppress the outliers. After all the adjustments the sample covers 2/3 of the credit market, on average.

The first stage of the study consisted in the estimation of panel models in the reduced form for lending growth. Data comprised 42 banks and 56 periods. Due to the fact that the number of banks was relatively small and we additionally used a lagged explained variable as a regressor, none of the estimators was defect free. Eventually, in base regressions we used the *fixed effects* estimator, which is biased in dynamic panel models, however, this bias expires as the number of periods increases (the number being “reasonably” large in our case). In order to check the robustness we used the instrumental variables method estimator. In this latter case, individual effects were removed by forward orthogonal deviations, see: Arellano and Bover, 1995), instead of a simple within group transformation; the non-transformed variables were used as instruments for transformed variables. In each equation, two macroeconomic variables were included – the ESI (economic sentiment indicator) and the domestic interest rate (WIBOR 3M). Variables measuring the strength of banks’ balance sheets – the capital buffer (the difference between the solvency ratio and its level at which the Polish Financial Supervision Authority allows payment of the dividend), return on assets (ROA), return on equity (ROE) and share of non-performing loans (NPL) – were added separately and jointly. In order to avoid endogeneity, only lagged variables were used as regressors. The number of lags, four for each variable, was selected with the use of the Schwarz information criterion. Results are shown in Table 22.

Table 22. Estimation results – *fixed effects* models for lending

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Loans (change %)	0.70*** (0.04)	0.68*** (0.04)	0.69*** (0.04)	0.70*** (0.04)	0.68*** (0.04)	0.66*** (0.04)	0.66*** (0.04)
ESI	0.39*** (0.04)	0.36*** (0.04)	0.37*** (0.04)	0.38*** (0.04)	0.36*** (0.04)	0.32*** (0.04)	0.31*** (0.05)
Domestic interest rate (change)	-3.65*** (1.09)	-2.59** (1.14)	-3.59*** (1.11)	-3.61*** (1.10)	-4.24*** (1.09)	-2.95** (1.18)	-2.93** (1.17)
Capital buffer		0.42*** (0.11)				0.37*** (0.12)	0.38*** (0.12)
ROA			0.72 (0.54)			0.73* (0.40)	
ROE				0.06 (0.07)			0.09* (0.05)
NPL (change)					-1.27*** (0.35)	-0.85** (0.34)	-0.85** (0.34)
R² (general)	0.54	0.52	0.54	0.54	0.55	0.53	0.53

Note: In the parenthesis - resistant standard errors. *, ** and *** means statistical significance, at 10-, 5- and 1-per cent significance level, respectively.

Source: own calculations

In accordance with the estimates, the improvement in business conditions supports lending whereas a rise in the interest rate reduces it. Higher capital buffers and lower shares of non-performing loans translate into a higher growth of loans. This result is robust, irrespective of whether those variables are taken into account in the model separately or jointly. The long-run multiplier for the buffer seems low; however, additional analysis shows that it varies depending on initial conditions. The lower the buffer, the higher the multiplier (for banks with a low buffer – 2.18, for banks with a high buffer – 0.29). This leads to the conclusion that the application of the anti-cyclical capital buffer, representing a macroprudential policy instrument, could turn out effective. Profitability measured by ROA and ROE is statistically significant only in models controlling for other characteristics and only at a 10-per cent significance level.

The application of the instrumental variables method estimator generated similar results in qualitative terms. The estimated impact of the capital buffer and profitability is higher; the latter variable is significant in each

specification. The estimate of the impact of non-performing loans is slightly lower, or even statistically insignificant in models with all characteristics. Inclusion of additional control variables – house prices, foreign interest rate and index VIX – also did not change the results. We also checked the GDP deflator and the exchange rate, yet they were found statistically insignificant.

The second stage of the study was based on estimation of panel vector autoregressive models (PVAR) using almost the same set of variables as before. We focused on identifying monetary policy shocks, using the high frequency identification method⁵³ for that purpose. It is based on the use of an unexpected component of current interest rate change, calculated outside the model using high frequency data, as an additional variable (Bagliano and Favero, 1998), instead of the interest rate (Barakchian and Crowe, 2010), or as an instrument for the interest rate (Gertler and Karadi, 2014). In base specifications we used the first approach, adding the Z_1 variable described in section 3.1.4. to models. We adopted the assumption that it has a simultaneous impact on other variables.⁵⁴ Once again, we added balance sheet variables separately and jointly, and we removed individual effects by deducting mean values from future observations. Due to the fact that this time the total number of parameters to be estimated is much higher, we set the number of lags at two. However, results did not change considerably when four lags had been used. Responses to the monetary policy impulse are shown in Figure 56.⁵⁵ A rise in interest rate has a slightly delayed adverse impact on economic conditions and lending. Banks' balance sheets also deteriorate – the capital buffer and profitability declines; share of non-performing loans starts increasing with a slightly longer lag. Responses of balance sheet variables are linked with each other – a higher share of non-performing loans reduces banks' profits and the capital buffer. Profits and the buffer also limit the adverse impact of interest rate on prices of financial assets.

Models with all balance sheet variables indicate a slower deterioration of the loan portfolio quality, and the cumulative response is not statistically significant after 10 quarters. For other variables the results are similar for different specifications. The results do not change after introducing new control variables as exogenous variables.

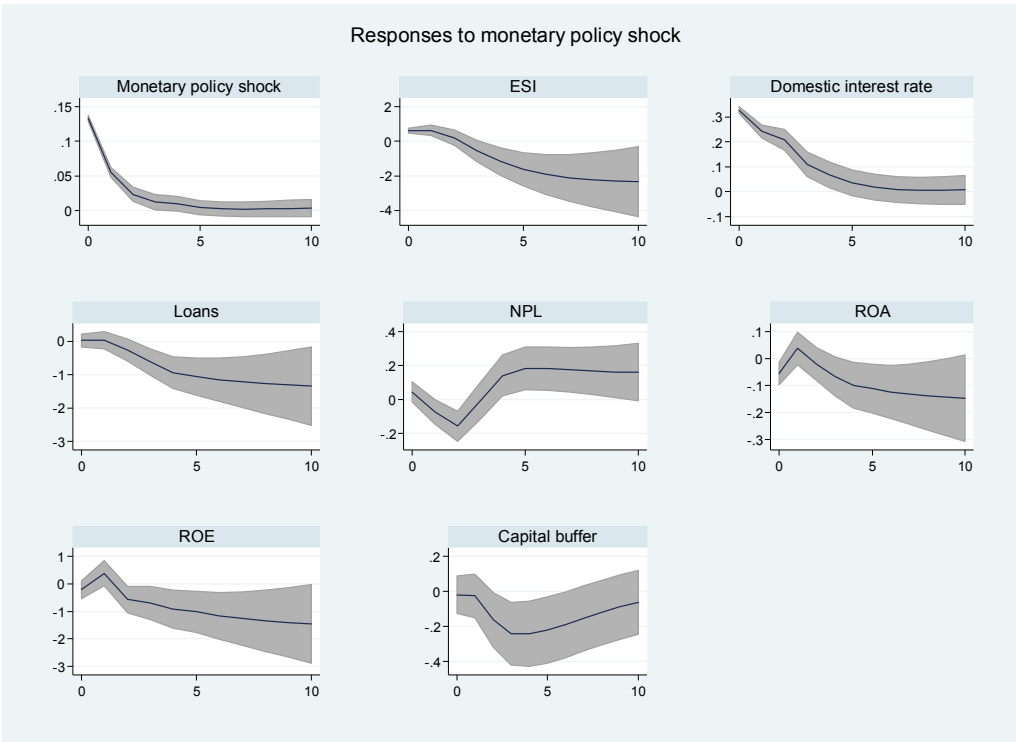
In order to evaluate the role of interaction: strength of banks' balance sheets-lending, in strengthening of monetary policy shock effects, we compared the original response functions with the response functions after this interaction had been excluded. It was done by replacing the estimates of parameters at NPL, ROA/ROE and the capital buffer by zero in the equation for lending. The results for the base specification (2 lags, balance sheet variables jointly) are shown in Figure 59. Without interaction, the response of loans to a monetary policy shock for the individual horizons would be smaller by 0.01-0.13 p.p. The cumulative response after 20 quarters would be smaller by approximately 15 per cent. Consequently, the bank loan channel strengthens the effects of the monetary policy in Poland.

⁵³ The use of this method enabled us to leave out less interesting variables in terms of the considered problem in base specifications, such as inflation or exchange rate. For identification of monetary policy shocks by short-term restrictions they would be necessary.

⁵⁴ Within the framework of resistance testing, the specification which did not additionally include the interest rate was also checked (only a variable illustrating the unexpected component of change in the current interest rate). It does not bring a qualitative change of the results presented below.

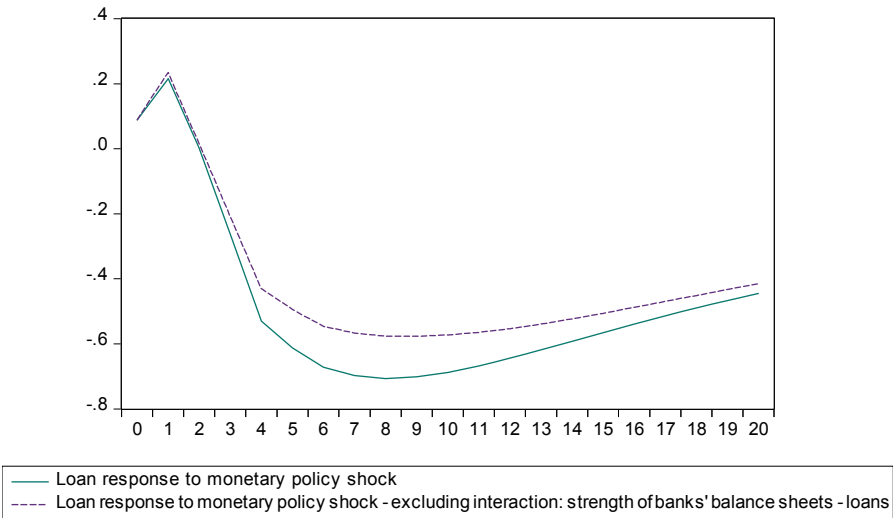
⁵⁵ Responses of balance sheet variables to the interest rate impulse presented below were generated from models in which NPL, ROA, ROE and the capital buffer had been included separately.

Figure 56. Responses to monetary policy impulse – PVAR models



Source: own calculations

Figure 57. Loan response to the monetary policy shock



Source: own calculations.

3.4. The role of inflation expectations

Inflation expectations of the private sector make an important point of reference for the monetary policy. Their level may have a significant impact on the path of inflation processes in the economy. The process of expectation formation is important for the transmission mechanism of monetary policy impulses. For this reason central banks try to affect the expectations, striving to anchor them at a level corresponding to the inflation target.

For the purpose of empirical verification of the features of inflation expectations which are important for the monetary policy transmission mechanism in Poland, we refer to direct measures of short-term inflation expectations of consumers, enterprises and financial sector analysts. Moreover, for the purpose of analysis of anchoring of inflation expectations we analyse probabilistic forecasts of experts of the NBP Survey of Professional Forecasters going beyond one-year-ahead horizon. The sample contains observations from the beginning of 2001 to mid-2015.

In the following parts of this chapter we try to answer to the following questions: Are survey measures of inflation expectations useful in macroeconomic analyses, in particular, in inflation modelling and forecasting? What are the features of inflation expectations of various groups of agents and what are the factors affecting them? Has the process of forming inflation expectations in the period of financial crisis and low inflation changed as compared to the pre-crisis period? Do inflation expectations remain anchored? Before attempting to answer the above questions, we will offer a few remarks on the measurement of inflation expectations.

3.4.1. Remarks on the measurement of inflation expectations

Inflation forecasts of the financial sector analysts are based on Reuters surveys. In our analyses we also use inflation forecasts of a broader group of professional forecasters provided by the NBP Survey of Professional Forecasters – in this case, however, the sample of available observations is significantly shorter, since it covers a period from late 2011.

Inflation expectations of consumers and enterprises are quantified on the basis of qualitative survey data. Taking into account the survey methodology (number of respondents, phrasing of survey questions), we treat the survey conducted by the Central Statistical Office (GUS) on a monthly basis from 2004 as our preferred source of consumer survey data (see Łyziak, 2012). For the earlier period we extrapolate the balance statistics needed to quantify inflation expectations.⁵⁶ In the probabilistic method of quantification of inflation expected by consumers, it is required to adopt the assumption concerning consumer perceptions of current price changes. As a proxy of inflation perception, we use the so-called Consumer Perceived Price Index (CPPI), proposed in the study by Halka and Łyziak (2013). In accordance with the results of this study, opinions of Polish consumers concerning price changes depend, to a greater extent, on a relatively broad basket of frequently purchased goods and services, rather than on the CPI inflation. Moreover, consumers tend to ignore price reductions. As a result of the aforementioned mechanism of formulating the opinion on the current growth of prices, the perceived inflation significantly exceeds the current inflation – the average values of both variables for 2001-2015 amount to 4.3 per cent and 2.3 per cent, respectively. It results in a relatively high level of price changes predicted by consumers.

⁵⁶ We perform this on the basis of Ipsos questionnaire surveys, available for a period from 1992 to 2014.

Inflation expectations of enterprises are measured on the basis of survey data from the so-called Quick Monitoring conducted by Narodowy Bank Polski. Since the 3rd quarter of 2008, the survey question concerning changes in prices has been qualitative, whereas earlier a quantitative question was asked. In order to obtain a consistent series for the whole analysed period, individual responses to the quantitative question asked until 2008 Q2 have been translated into the qualitative terms consistent with the currently qualitative question of the Quick Monitoring survey, to subsequently be aggregated and quantified with the use of the probability quantification method (see Łyziak, 2013).

Our source of information about inflation expectations of financial sector analysts is the survey conducted by Reuters as well as the NBP Survey of Professional Forecasters (NBP SPF), in which analysts constitute the biggest group of respondents. Reuters' questions refer to point forecasts and the median of those forecasts is the measure of the expectations. NBP SPF questions refer to subjective probability distributions. Participants of NBP SPF present three percentiles of their distributions, i.e. the 5th and 95th percentile, which determine an interval with the probability of 0.9 and the 50th percentile, referred to as the central forecast. For the needs of this report, expectations of NBP SPF participants are represented in two ways. The main measure of inflation expectations is the median of distribution resulting from aggregation of individual probability distributions. An additional measure, useful in terms of comparability with Reuters data, is the median of the set of individual central forecasts.

Time series of forecasts derived from NBP SPF are too short to be analysed with econometric models and statistical tests, as we do in two following sections of the report. While analysing inflation forecasts derived from the NBP SPF we will concentrate on the problem related to measurement of anchoring of expectations and monitoring changes which may be significant for the transmission mechanism in the future.

Measures of short-term inflation expectations used in this report are presented in Table 23 and Figure 58.⁵⁷

Table 23. Short-term inflation expectations in Poland, 2001-2015

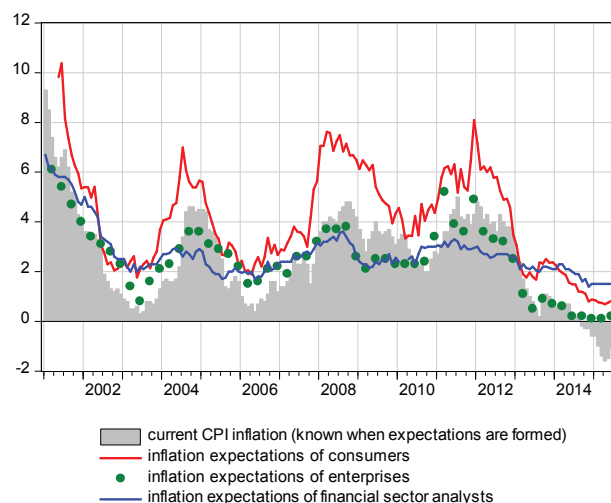
Category	Data source	Mean (%)	Standard deviation	Variability coefficient
Consumers' inflation expectations⁽¹⁾	GUS	4.1	2.0	49.0
Enterprises' inflation expectations⁽²⁾	NBP	2.5	1.4	56.0
Inflation expectations of financial sector analysts⁽¹⁾	Reuters	2.7	0.9	32.3
Current inflation (known while declaring expectations)	GUS	2.4	1.7	70.5

Notes: ⁽¹⁾ – monthly data, 2001:01-2015:08; ⁽²⁾ – quarterly data, 2001Q1-2015Q2.

Source: Own calculations based on GUS, NBP data and Reuters.

⁵⁷ In order to check the robustness of conclusions to the applied quantification method of inflation expectations of consumers and enterprises, other measures were also used. The alternative measure of consumers' inflation expectations was quantified with the use of an alternative measure of perceived inflation, quantified directly on the basis of survey data, in accordance with the method by Łyziak and Mackiewicz-Łyziak (2014). The alternative method of enterprises' inflation expectations was developed through direct connection of series of the mean expectations declared quantitatively (until the 2nd quarter of 2008) and the probabilistic measure of expectations quantified on the basis of qualitative data (from the 3rd quarter of 2008).

Figure 58. Short-term inflation expectations in Poland, 2001-2015



Notes: ⁽¹⁾ – monthly data, 2001:01 – 2015:08; ⁽²⁾ – quarterly data, 2001 Q1 – 2015 Q2.

Source: Own calculations based on GUS, NBP data and Reuters.

3.4.2. Usefulness of survey-based measures of inflation expectations in macroeconomic analyses⁵⁸

Before describing how various groups of agents form inflation expectations, we analyse the usefulness of inflation expectations measures derived from surveys in economic analyses. We do it with the use of estimated versions of the New-Keynesian Small Model of Monetary Policy (MMPP),⁵⁹ in which various measures of expectations are taken into account: rational expectations, i.e. expectations consistent with the model (MMPP-RE model), consumers' inflation expectations (MMPP-C model), enterprises' inflation expectations (MMPP-E model) and inflation expectations of financial sector analysts (MMPP-F).

In order to evaluate the forecasting properties of various MMPP model versions, simulations in the sample are performed, within which counterfactual paths of macroeconomic variables are forecasted.⁶⁰ On the basis of the derived counterfactual values, standard measures of inflation forecast errors are calculated, inter alia, mean absolute error (MAE), mean absolute percentage error (MAPE) and the root mean square error (RMSE) for various forecasting horizons. Additionally, forecasting properties of the models are compared in formalised way with the use of Diebold-Mariano (1995) test.

The results of this analysis indicate that the survey measures of inflation expectations of consumers, financial sector analysts and, in particular, enterprises, clearly improve the forecasting properties of the MMPP model in relation to its version assuming rational expectations (Figure 59). Enterprises' inflation expectations seem the most significant from macroeconomic point of view. The mean absolute error (MAE) of the model using

⁵⁸ This chapter was prepared on the basis of the study by Lyziak (2016a).

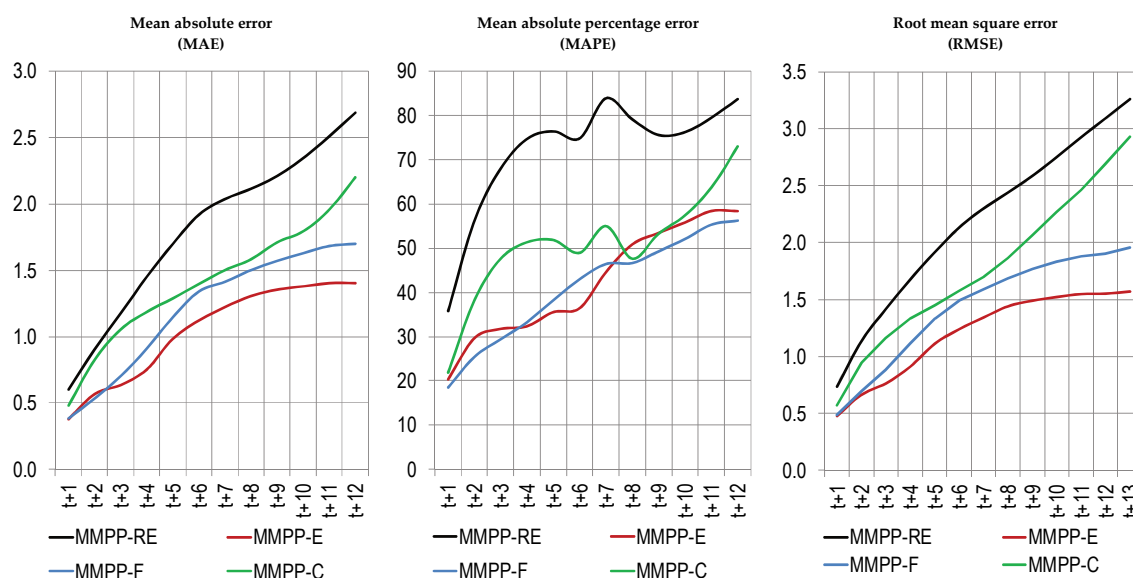
⁵⁹ The MMPP is a standard New Keynesian model of the monetary policy transmission mechanism. In comparison with the version presented in Demchuk *et al.* (2012) the current version is estimated. The model is constructed around four main relations consisting of: IS curve, exchange rate equation (a modified version of UIP, in which a hybrid model of exchange rate expectations), hybrid New Keynesian Phillips curve (HNKPC) and the monetary policy rule (Taylor rule with interest rate smoothing). Versions of the model using various measures of inflation expectations were (jointly) estimated with the use of the GMM method on a sample: 2001 Q1 - 2014 Q2.

⁶⁰ The first counterfactual simulation starts in the first quarter of 2005, whereas the last one - in the fourth quarter of 2011.

this measure of expectations is smaller than errors of the remaining models (an exception is the model with inflation expectations of financial sector analysts, which demonstrates comparable forecasting properties within a short-term horizon, i.e. one and two quarters in advance). On the other hand, in the case of the mean absolute percentage error (MAPE) the MMPP model with enterprises' inflation expectations fits the data within the horizon of the transmission mechanism (4-6 quarters) relatively best.

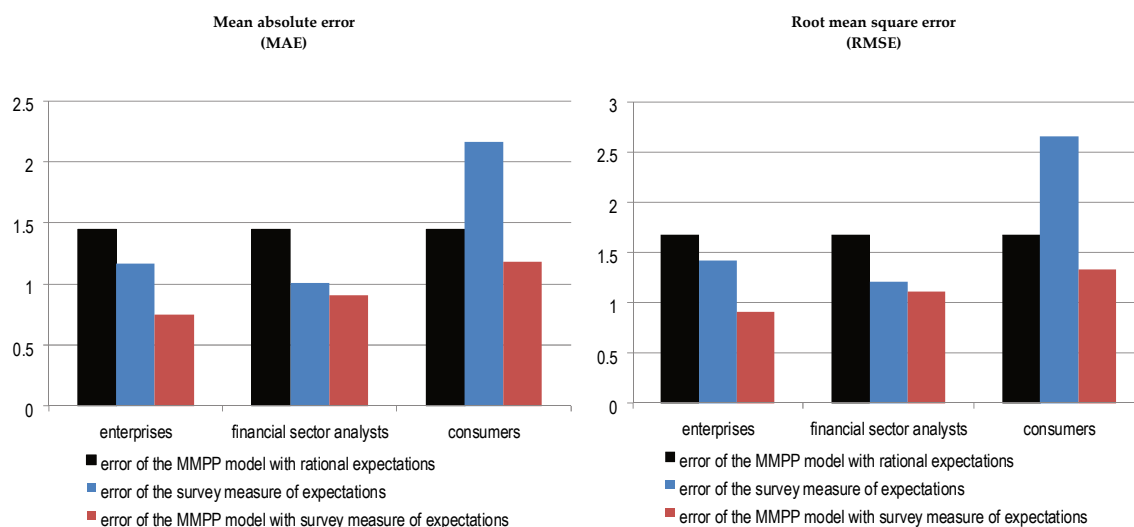
In order to extend the above analysis, errors of the MMPP model with rational expectations were compared with errors of raw measures of inflation expectations and with errors of the MMPP model using the measures of inflation expectations derived from the surveys. This comparison refers to the 4-quarterly forecasting horizon and it was conducted on the comparable observation sample (2005Q1-2015Q2). Results of the comparison (Figure 60) indicate that, in contrast to consumers' inflation expectations, the survey measures of inflation expectations of financial sector analysts and enterprises demonstrate smaller errors (MAE and RMSE) than forecasts of the MMPP-RE model. However, in the case of all types of agents, it turns out that forecasting properties of MMPP models with survey measures of expectations are better than predictive properties of those measures as such and the model assuming rational expectations. Forecasts from the model using the measure of enterprises' inflation expectations derived from the surveys are most accurate.

Figure 59. Errors of counterfactual forecasts obtained from various versions of the MMPP model in various forecasting horizons



Source: Own calculations based on GUS, NBP data and Reuters.

Figure 60. Errors of counterfactual forecasts obtained from various versions of the MMPP model in the 4-quarter horizon vs. errors of survey-based measures of inflation expectations



Source: Own calculations based on GUS, NBP data and Reuters.

Thus, it can be concluded that survey measures for each of the analysed groups of agents, in particular, enterprises, should be treated as an important element of the set of information used for analysing the monetary policy and its transmission mechanism.⁶¹

Box 4. Do low inflation expectations discourage consumers from making major purchases?⁶²

Consumers' inflation expectations have been decreasing since the beginning of 2012: the percentage of respondents expecting growth of prices within the next 12 months was decreasing and the percentage of consumers expecting stabilisation of prices was increasing. In June 2015 approximately 40% of consumers expected stabilisation of prices, as compared to only 5% anticipating acceleration of the perceived inflation. The percentage of consumers expecting a decline of prices increased, however, it remained minor (below 2%). Due to this tendency and to continuing deflation, concerns have arisen that consumers may postpone purchases anticipating declines in prices. In order to answer the question whether such a risk exists, we analysed the link between consumers' inflation expectations and their readiness to make major purchases.

The relation between inflation expectations and household expenditure arises from two economic relationships: consumption equation which is a function of, inter alia, the interest rate, and the Fisher equation which determines a real interest rate as a nominal rate minus the expected inflation. It is usually believed that a rise (decline) of inflation expectations is accompanied by a rise (decline) of consumption in the current period, with stronger effect expected in the case of durable goods rather than non-durable goods (e.g. Bachmann *et al.*, 2015). However, theory does not provide a clear answer concerning the direction of the impact of change of real interest rate (and, consequently, also inflation expectations) on consumption: the ultimate result depends, inter alia, on whether the substitution and

⁶¹ It is worth adding that simulations using the MMPP model, in which survey measures of enterprises' inflation expectations are used, show that the impact of changes in the interest rate and exchange rate on inflation in Poland is stronger than it would arise from the model in which no survey data are used. The coefficient of sacrifice estimated in the MMPP model containing survey measures of enterprises' inflation expectations is slightly lower than in the MMPP model with inflation expectations consistent with the model (more on this issue in: Łyziak, 2016a).

⁶² The Box was prepared on the basis of the study conducted by F. Premik and E. Stanisławska (description of the results under preparation).

wealth effect of the rise in interest rate would exceed the income effect and whether the impact of uncertainty on consumption is taken into account (Fernandez-Corugedo, 2004). However, the impact of inflation expectations on consumption may be studied empirically.

Below we present conclusions following from the study into the relation between inflation expectations and consumers' readiness to make major purchases in Poland. We have used data from GUS Consumer Opinion Survey, in which respondents declare the expected direction and strength of changes in prices during the nearest year and evaluate the current period as favourable or unfavourable for making major purchases (e.g. furniture, electrical and electronic equipment). To describe the relation between those variables we employed a ordered choice model (with a heteroscedastic error term), in which the readiness to spend (i.e. the assessment of the current period as favourable, neutral or unfavourable to make major purchases) was explained by respondent's inflation expectations and a set of control variables.⁶³ The use of individual data in the analysis reduces the potential risk of endogenous relations between inflation expectations and the readiness to spend.

Our findings confirm that inflation expectations have a statistically significant impact on consumers' readiness to spend. However, the relation between those variables is neither linear nor significant in quantitative terms (Table R 4.1).⁶⁴ The probability of assessing the current period as favourable for making major purchases is very close for consumers expecting a stabilisation of prices or their rise, and it is higher (by approximately 4.5 p.p.) for consumers expecting a decline in prices. The lowest probability of assessing that the current period is not favourable for making major purchases is observed in the case of consumers expecting no price changes or their rise at a rate similar to that recorded currently.⁶⁵ It grows in the case of expectations of decline in prices (by approximately 4.8 p.p.), expectations of faster growth in prices (by approximately 3.2 p.p.) and slower growth in prices (by approximately 1 p.p.). In other words, consumers expecting a rise in prices are more inclined to declare that the current period is unfavourable to make major purchases than those expecting no changes in prices, whereas opinions of consumers expecting the decline in prices are divided: in this group, a probability of assessing the current period both as favourable and as unfavourable to make major purchases is higher as compared to respondents expecting that no change in prices will occur.⁶⁶

Taking into account that the share of consumers expecting a decline in prices is insignificant in the whole sample,⁶⁷ and in the recent period, i.e. in the years 2013-2015, the biggest flows have been recorded between groups of respondents expecting a faster growth in prices and no change in prices, it can be concluded that the decline of inflation expectations was associated with a minor growth of the readiness to spend.⁶⁸ This result is not consistent with the intuition presented at the beginning of the Box, yet, similar result was obtained for the US consumers

⁶³ Social and demographic variables (gender, age, marital status, education, occupation, income, number of persons in a household), assessment of the situation of respondent's household (current and expected), assessment of the economic situation of the country (current and expected, expectations related to unemployment), macroeconomic indicators (inflation, unemployment rate, leading consumer sentiment index).

⁶⁴ A higher impact of inflation expectations on the readiness to spend was obtained in the model with a lower number of control variables, in particular, ignoring respondents' expectations related to the future economic situation of the country (more on this issue: in the work by Premik and Stanisławska, under preparation).

⁶⁵ Currently perceived by consumer.

⁶⁶ This group of respondents less frequently selects a neutral response ("neither favourable nor unfavourable period"). It is worth highlighting that the number of consumers belonging to this group is very limited, which results, inter alia, in greater standard errors of coefficients.

⁶⁷ On average, it amounts to approximately 0.5% in the whole sample and the maximum value in a monthly survey reaches 1.6%.

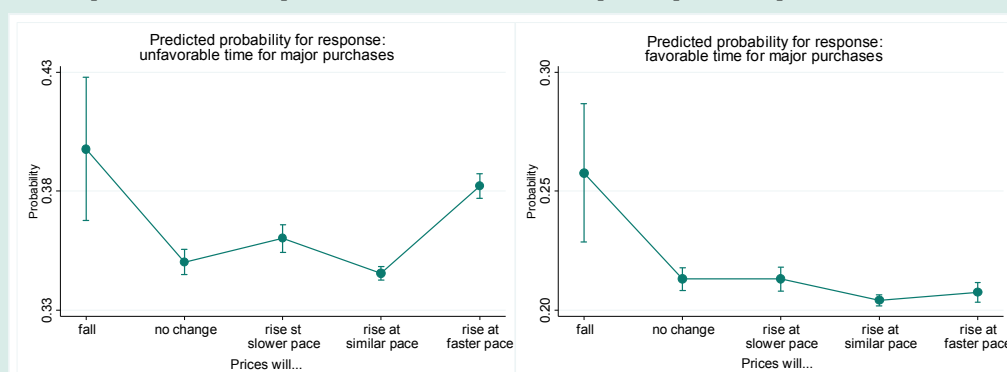
⁶⁸ The conclusion about negative relation between inflation expectations and the readiness to spend is robust to choice of measure of consumers' inflation expectations: the results are similar if we use a quantitative measure of inflation expectations (derived from the additional question in the questionnaire where consumers are asked to provide the value of expected changes in prices) instead of qualitative one. The model with a quantitative measure of inflation expectations is easier for interpretation, however, it is doubtful whether consumers are able to assess expected inflation in quantitative terms (see: Łyziak and Stanisławska, 2006).

(Bachmann *et al.*, 2015 and Burke and Ozdagli, 2013).⁶⁹ In literature, three groups of explanations for the weak and negative relation between consumers' inflation expectations and their readiness to spend can be found:

- The first group of arguments refers to the real interest rate. Consumers may fail to distinguish the nominal and the real interest rate (the real interest rate illusion; Bachmann *et al.* 2015) or do not use information on the real interest rate due to a bounded rationality (Maćkowiak and Wiederholt, 2012).
- The second group of arguments refers to the relation between inflation expectations and the expected real income. Burke and Ozdagli (2013) point out that the growth of inflation expectations may result in a decline of consumption (current and future) due to their adverse impact on the expected real income. This effect will not occur only if consumers' nominal income (at an individual level) rises at least at a rate of inflation. Similarly, Bachmann *et al.* (2015) observe that under the conditions of nominal wage rigidity, higher inflation expectations decrease the expected future income of households.
- Third, higher inflation expectations may be associated with a higher uncertainty concerning monetary policy and signal bad times ahead (Bachmann *et al.*, 2015). Inter alia, the buffer savings model focuses on the adverse impact of growing uncertainty on consumption (Carroll, 1992, 1997).

It is worth noting that other factors have a greater impact on the readiness to spend, such as household's financial situation, assessment of the current economic situation in the country, or expectations concerning unemployment.

Figure R4.1. Impact of inflation expectations on the readiness to spend – predicted probabilities



Notes: The figure shows predicted probabilities (with the 95% confidence intervals) of declaring that the current period is favourable or unfavourable for making major purchases, depending on respondents' inflation expectations. Results based on the heteroscedastic ordered probit estimated on a sample 2004:01 – 2015:08.

Source: own calculations based on GUS data.

The impact of the real interest rate (and, at the same time, inflation expectations) on consumption may vary depending on consumers' financial situation (Bachmann *et al.*, 2015; Fernandez-Corugedo, 2004). In the case of debtors, the substitution effect is strengthened by an income effect operating in the same direction. On that basis it may be suspected that the impact of inflation expectations on expenditure will be stronger in the case of indebted consumers. However, they may not be able to increase their expenditure (to the desirable level) due to the lack of access to further loans (Ichiue and Nishiguchi, 2013).

⁶⁹ A positive relation between inflation expectations and current expenditure was found for Japan by Ichiue and Nishiguchi (2013) and for Germany (D'Acunto *et al.*, 2015).

Table R4.1. Impact of inflation expectations on the readiness to spend – marginal effects

Inflation expectations	Δ Probabilities of response selection		
	<i>Favourable time for major purchases</i>	<i>Neither favourable nor unfavourable time for major purchases</i>	<i>Unfavourable time for major purchases</i>
prices will decline	4.5***	-9.2***	4.8***
prices will grow at a slower pace	0.0	-1.0**	1.0**
prices will grow at a similar pace	-0.9***	1.4***	-0.5
prices will grow at a faster pace	-0.6*	-2.6***	3.2***

Note: The values in the table indicate the change in probability (in percentage points) of given response to the question on readiness to spend, if respondent's inflation expectations change (the benchmark response is expecting no change in prices). The results based on the heteroscedastic ordered probit, estimated on a sample 2004:01 – 2015:08. */**/** means the statistical significance of the marginal effect at a level of 10%, 5% and 1%.

Source: own calculations based on GUS data.

In order to find out whether the impact of inflation expectations on the readiness to spend is different among consumers with diverse financial situation, we used an additional survey question in which consumers declared whether they currently (a) are able to increase their savings, (b) make both ends meet, (c) are drawing on their savings, (d) are running into debt. We have evaluated a model, analogous to that presented above, in which the response of the readiness to spend to inflation expectations depends on consumers' financial situation: whether they are currently able to save, or are they forced to spend savings or increase their debt.⁷⁰ It turns out that inflation expectations have a greater impact on readiness to spend in the group of consumers in a good financial situation, as compared to consumers in a poor financial situation (Table R 4.2), which is consistent with the argument presented by Ichiue and Nishiguchi (2013). It is interesting to note that in the sub-group of consumers able to save, holding deflationary expectations is related to higher probability of indication that the current period as unfavourable to make major purchases (by approximately 8.2 p.p.) as compared to consumers expecting stable prices. Similarly, consumers expecting a faster growth in prices more frequently assess the current period as unfavourable to make major purchases (growth of probability by 2.9 p.p. as compared to consumers expecting no change in prices). It is worth noting that in the case of consumers able to save, a non-intuitive growth of probability to assess the current period as favourable to make major purchases for consumers expecting a decline in prices, does not occur (as it is the case for the whole sample).⁷¹

Summing up, consumers expecting a rise in prices have tendency to declare lower readiness to spend than consumers expecting stable prices. The impact of deflationary expectations is unclear: expectations related to the decline in prices are associated with a higher probability of assessing the current period both as favourable and as unfavourable to make major purchases (as compared to consumers expecting stable prices). The impact of inflation expectations on the readiness to spend is slightly stronger in the group of consumers with good financial situation as compared to those with poor financial situation.

⁷⁰ The current financial situation of a household is the closest, although imperfect, available proxy of whether a household is a net debtor or a net creditor. In addition, due to a limited number of households with the worst financial situation, we have merged two response categories: "we are drawing on savings" and "we running into debt".

⁷¹ The marginal effect is positive, however, statistically insignificant.

Table R4.2. Impact of inflation expectations on the readiness to spend among consumers with various financial situation - marginal effects

Inflation expectations	Δ Probabilities of response selection		
	<i>Favourable time for major purchases</i>	<i>Neither favourable nor unfavourable time for major purchases</i>	<i>Unfavourable time for major purchases</i>
good financial situation: increasing savings			
prices will decline	1.2	-9.4***	8.2***
prices will grow at a slower pace	-1.0*	-0.6	1.7***
prices will grow at a similar pace	-3.0***	2.2***	0.8*
prices will grow at a faster pace	-0.8	-2.1***	2.9***
average financial situation: covering expenditure with current income			
prices will decline	6.2***	-8.8***	2.6
prices will grow at a slower pace	0.3	-0.9**	0.6
prices will grow at a similar pace	-0.2	2.1***	-1.8***
prices will grow at a faster pace	-0.2	-2.9***	3.1***
poor financial situation: using savings or incurring loans			
prices will decline	4.0	-8.2***	4.1
prices will grow at a slower pace	0.6	-0.6	0.0
prices will grow at a similar pace	-0.7	1.5***	-0.8
prices will grow at a faster pace	-0.1	-2.8***	2.9***

Note: The values in the table indicate the change in probability (in percentage points) of given response to the question on readiness to spend, if respondent's inflation expectations change (the benchmark response is expecting stable prices). The results based on the heteroscedastic ordered probits, estimated on a sample 2004:01 – 2015:08. */**/** means the statistical significance of the marginal effect at a level of 10%, 5% and 1%. Source: own calculations based on GUS data.

3.4.3. Basic features of the model of inflation expectations formation⁷²

Results of the studies on the process of forming inflation expectations in Poland generally confirm the conclusions of earlier studies indicating diverse models of expectation forming by consumers, enterprises and financial sector analysts (Łyziak, 2014). Consumers' inflation expectations develop under the predominant impact of perceived inflation, whereas expectations of the remaining groups are, to a certain extent, forward-looking and affected by the NBP inflation target. In this chapter we will present new empirical results related to formulating inflation expectations in Poland, stressing, in particular, changes of expectations formation models the during the period of financial crisis and low inflation.

Table 24 presents errors related to survey-based measures of inflation expectations of analysed groups of agents. Taking into account a full sample, it is found that the accuracy of inflation expectations of enterprises and financial sector analysts is clearly greater than of naive forecasts, whereas consumers' inflation expectations demonstrate the biggest errors. In the case of inflation expectations of enterprises and, to a lesser extent, financial sector analysts, a decline of errors can be observed in the period following the collapse of the Lehman Brothers. In this period, the errors of enterprises' inflation expectations are comparable with errors in expectations of financial sector analysts (or even slightly lower).

⁷² Results presented in this section are discussed in more detailed way in the following material: Łyziak (2016b).

Table 24. Errors of inflation expectations in Poland

Category	Period	Mean absolute error (MAE)	Root mean square error (RMSE)
Consumers' inflation expectations	2001:01-2015:08	2.51	3.06
	2001:01-2008:08	2.45	3.13
	2008:09-2015:08	2.58	2.97
Enterprises' inflation expectations	2001:01-2015:08	1.53	1.84
	2001:01-2008:08	1.74	2.06
	2008:09-2015:08	1.27	1.52
Inflation expectations of financial sector analysts	2001:01-2015:08	1.57	1.96
	2001:01-2008:08	1.58	2.03
	2008:09-2015:08	1.55	1.87
Naive forecast	2001:01-2015:08	1.85	2.21
	2001:01-2008:08	2.11	2.49
	2008:09-2015:08	1.53	1.80

Note: In the case of the above analysis, as well as analyses presented hereunder in this section, a number of inflation expectations of enterprises, with a quarterly frequency, is interpolated to a series with a monthly frequency.

Source: Own calculations based on GUS, NBP data and Reuters.

In order to analyse changes in the mechanism of inflation expectation formation we mainly use the hybrid model of expectations. In comparison with the typically used versions of this model, containing a single proxy of extrapolative component (static or adaptive expectations) and forward-looking component (future inflation or central bank inflation target), in the estimated models we take into account one extrapolative variable, i.e. past inflation and two forward-looking variables, i.e. future inflation and the NBP inflation target.

Results of the estimation (Table 25) for the full analysed period, i.e. for the years 2001-2015, indicate that the method of formulating inflation expectations is diversified among groups of entities under consideration. Consumers develop their expectations under the predominant impact of current inflation perception, with a negligible role of the NBP inflation target. In the case of inflation expectations of enterprises, groups of backward- and forward-looking agents are relatively similar to each other, whereas among forward-looking entities the share of enterprises whose expectations correspond to the condition of unbiasedness of the rational expectations hypothesis is more or less equal to the share of enterprises adopting the central bank inflationary target as a point of reference. Financial sector analysts' expectations depend to a definitely lesser extent on current inflation, on the other hand, the weight of the inflation target in this case is over three-fold higher than the weight of the future inflation. It indicates strong anchoring of inflation expectations of this group of agents.

Whereas the way in which consumers' inflation expectations were formed before and after the crisis remained relatively stable, in the case of enterprises and financial sector analysts interesting changes can be observed. With reference to financial sector analysts, the weight of the inflation target remained mostly unchanged; the weight of current inflation weight decreased to the statistically insignificant level, whereas the group of analysts forming expectations in accordance with the unbiasedness property of the hypothesis of rational expectations increased. In the case of enterprises, the role of inflation target in the formation of those expectations decreased, whereas the percentage of enterprises forming expectations in a rational and static way increased. In conjunction with the earlier conclusion concerning the significant role of enterprises' inflation expectations for inflation modelling, it may mean a higher importance of inflation expectations –

better adjusting to information affecting future inflation – in the Polish monetary policy transmission mechanism.⁷³

Table 25. Factors affecting inflation expectations in Poland, a simple hybrid model

Category	Period	Current inflation weight	Future inflation weight	NBP inflation target weight
Consumers' inflation expectations	2001:01-2015:08	0.87	0.13	-
	2001:01-2008:08	0.91	0.09	-
	2008:09-2015:08	0.94	-	0.06
Enterprises' inflation expectations	2001:01-2015:08	0.48	0.35	0.17
	2001:01-2008:08	0.31	-	0.64
	2008:09-2015:08	0.59	0.31	0.10
Inflation expectations of financial sector analysts	2001:01-2015:08	0.15	0.19	0.66
	2001:01-2008:08	0.13	-	0.87
	2008:09-2015:08	-	0.15	0.85

Note: In the case of consumers, we consider inflation perceived by consumers instead of current inflation.

Source: Own calculations based on GUS, NBP data and Reuters.

In order to deepen the analysis of the macroeconomic information affecting inflation expectations of individual groups of agents, hybrid models of inflation expectations have been additionally estimated in the version proposed in the study of Cerisola and Gelos (2009). Explanatory variables in this model include: current inflation, central bank inflation target and various variables which may potentially affect future inflation.⁷⁴ The decomposition of inflation expectations on the basis of estimated models of this type shows that consumers, enterprises and financial sector analysts formulate their expectations using various information sets (Figure 61, Figure 62, Figure 63). The perception of current inflation has a dominating impact on consumers' inflation expectations.⁷⁵ Using a full sample of observations, it is also possible to demonstrate a minor impact of developments in the exchange rate, industrial output and wages on the level of consumers' inflation expectations, whereas the role of the NBP inflation target turns out statistically insignificant. In the case of inflation expectations of financial sector analysts and enterprises, the inflation target plays a much more important role than current inflation. Both groups of agents take into account the short-term interest rate while formulating the expectations. Moreover, enterprises take into account information concerning industrial output into consideration.

While comparing the results of estimates of the above equations in the pre- and post-crisis period, it can be seen that in the years 2008-2015 the role of real variables (industrial output, unemployment rate and wages) for formulating inflation expectations by enterprises and financial sector analysts increased. Although in the case of enterprises it was accompanied by the decline of the role of the NBP inflation target, simultaneously, those expectations started to respond strongly to changes in the short-term interest rate. In the case of financial sector analysts, the role of the inflation target was even strengthened (which was not shown by

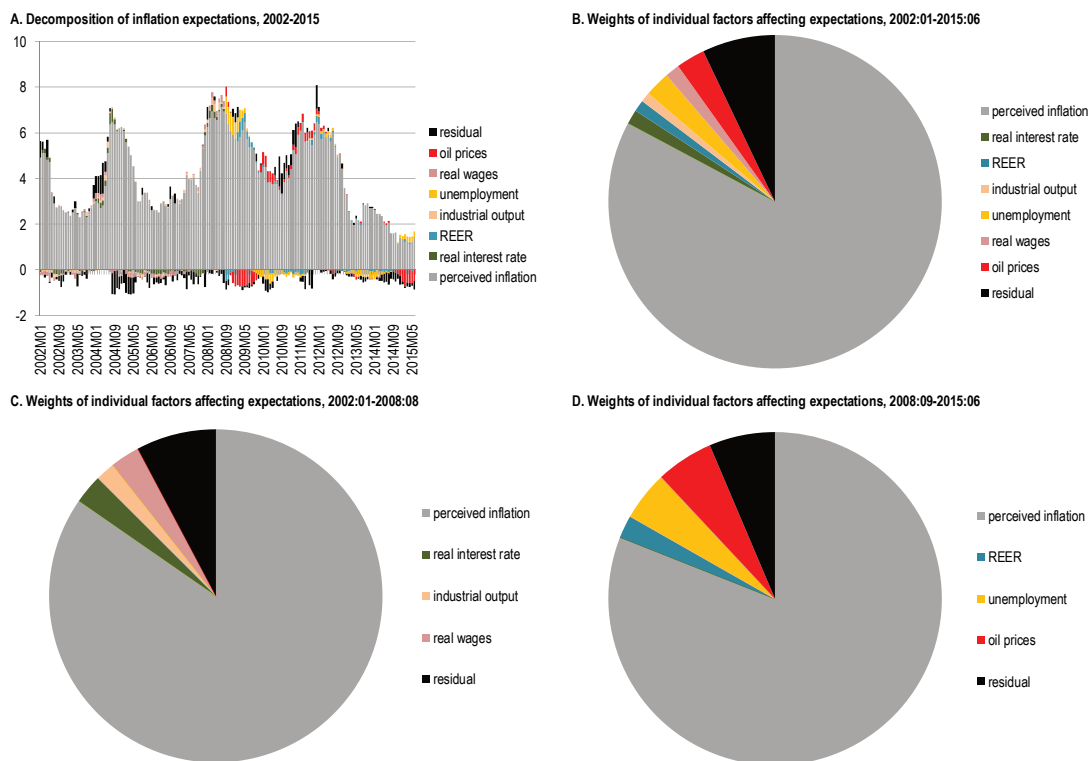
⁷³ It is worth emphasising that a similar conclusion may be drawn on the basis of estimates of the QMOTR 2 structural model. Results of Phillips curve estimates show that in the recent period the anticipatory level of inflation has significantly increased.

⁷⁴ Among the latter, we have taken the following variables into consideration, in accordance with the study of Cerisola and Gesol (2009): real interest rate gap, real exchange rate gap, real wage gap, unemployment gap, industrial output gap, primary balance of government deficit as well as the growth rate of oil prices in the global markets. The level of correlation of those variables is not high enough to generate risk of co-linearity of explanatory variables.

⁷⁵ Opinions of consumers concerning changes in prices are formed based on the sub-basket of often purchased goods and services, whereas negative changes in prices of elements of this sub-basket are ignored (Hałka and Łyziak, 2015).

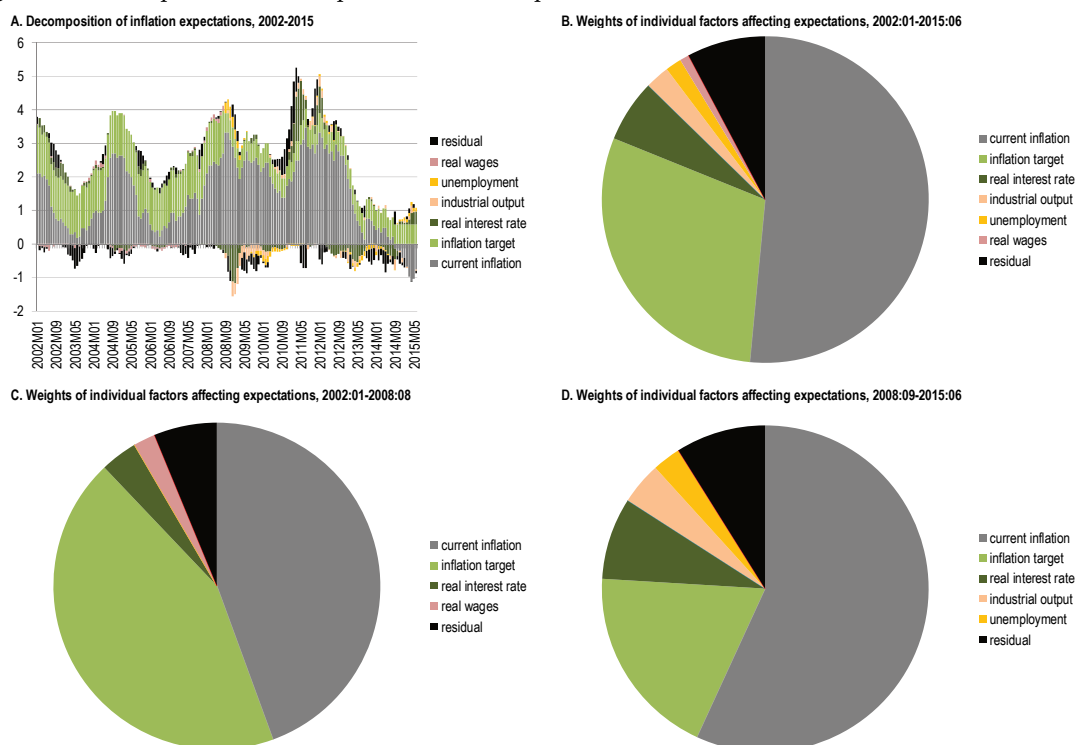
simple hybrid models of expectations). Certain changes were also observed in the case of consumers' inflation expectations, inter alia, they started to react to changes in oil prices, similar to inflation expectations of financial sector analysts. At the same time, the impact of the interest rate on those expectations declined, whereas the impact of the exchange rate increased (more on this issue, see: Łyziak 2016b).

Figure 61. Decomposition of consumers' inflation expectations



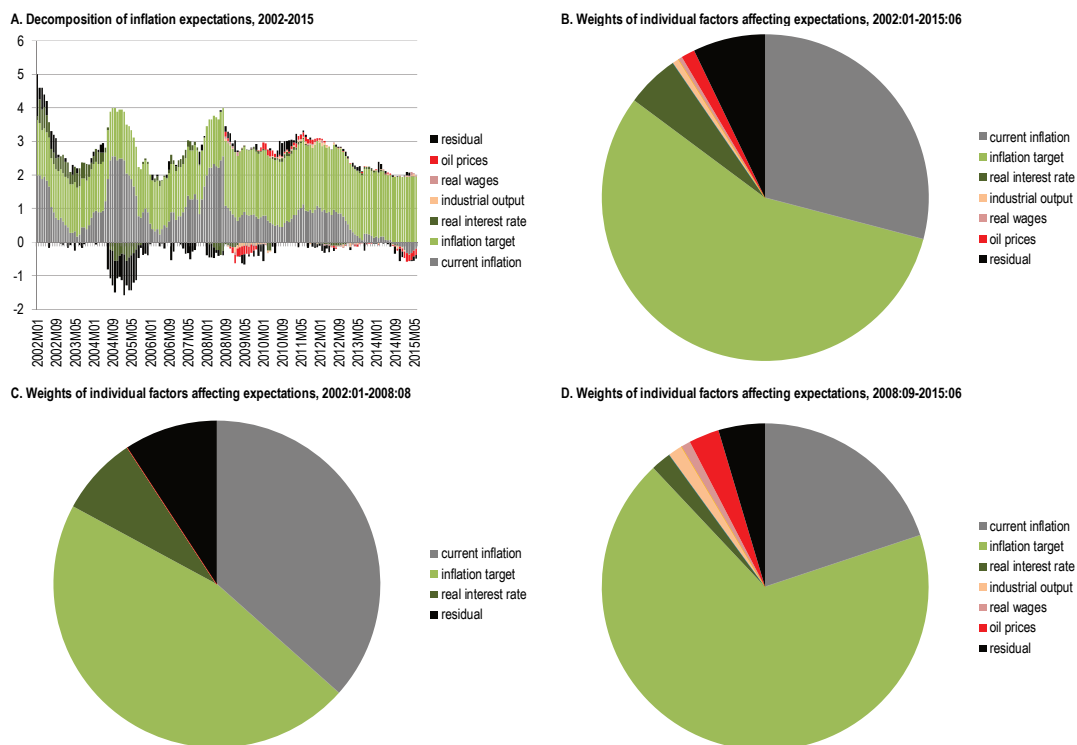
Source: Own calculations based on NBP data.

Figure 62. Decomposition of enterprises' inflation expectations



Source: Own calculations based on NBP data.

Figure 63. Decomposition of inflation expectations of financial sector analysts



Source: Own calculations based on GUS, NBP data and Reuters.

Thus, results derived from both types of hybrid models consistently indicate that the model of formation of inflation expectations of enterprises and financial sector analysts has been subject to significant changes in the recent years. The level of forward-lookingness of those expectations grows, in particular, through the increased impact of real variables and – in the case of enterprises – the short-term interest rate, on their formulation.⁷⁶

The above observations are confirmed by current results of estimates related to the weight of anticipatory behaviours in one of the transmission mechanism structural models used by us, i.e. QMOTR 2 (see also, section 2.2, Appendix 1). Comparing to corresponding estimates of the previous versions of the model (Kapuściński *et al.*, 2014), we see an increase of the weight of forward-lookingness of inflation: the weight of future inflation in the Phillips curve increased from 22% to 45% (Table 26).⁷⁷

Table 26. Coefficients of forward-looking terms in major relationships of the QMOTR model

	Model estimated on the sample: 2000 Q1 - 2013 Q2	Model estimated on the sample: 2000 Q1 - 2015 Q2
Output gap	0.28	0.23
Phillips curve	0.22	0.45
Real effective zloty exchange rate deflated by HICP	0.96	0.88

Source: own calculations.

The above results suggest that the channel of expectations may play a growing role in the monetary policy transmission mechanism in Poland. However, it should be noted that the effect of increasingly anticipatory character of inflation expectations may partly arise from the specific nature of the period of recent years, dominated by the monotonous decline of inflation from the level significantly exceeding the inflation target to negative values.

3.4.4. Assessment of the degree anchoring of inflation expectations based on the NBP Survey of Professional Forecasters

Questions addressed to participants of the NBP Survey of Professional Forecasters are of probabilistic nature. This creates a possibility of drawing conclusions on the degree of anchoring of the expectations, not only based on the analysis of point central forecasts but also based on information contained in probability distributions, reflecting opinions of surveys' participants. In particular, it allows taking into account the uncertainty accompanying the forecasts.

The NBP Survey of Professional Forecasters was conducted for the first time in the 3rd quarter of 2011. In the initial period of its functioning, i.e. until the 2012 Q3, experts' forecasts were formulated in the environment of inflation exceeding the upper limit of target band and since 2013 – below the lower limit of inflation band, whereas since 2014 Q3 there is a deflation. The analysed period is too short to formulate conclusions based on statistical tests. However, it seems that some hypotheses about the degree of anchoring of the expectations

⁷⁶ It should be mentioned that results of testing of the macroeconomic effectiveness requirement related to the hypothesis of rational expectations also indicate that the way of processing available information has clearly improved in the period after the collapse of Lehman Brothers. Details in: Łyziak (2016b).

⁷⁷ The weight of forward-looking term in the Phillips curve, estimated for the period from the 1st quarter of 1998 to the 3rd quarter of 2008 amounted to 0.53.

may be formulated, and methods for monitoring its developments, important for the transmission mechanism in the future, can be proposed.

Despite the dynamic changes in the CPI inflation, the medium-term expectations (8-quarters-ahead) remained well-anchored, which is indicated by the analysis of point and probabilistic forecasts, both at individual and at the aggregate level. Symptoms of de-anchoring of short-term expectations have been observed since the 2014 Q2. From the point of view of future changes in the transmission mechanism, it is essential whether the effect will be short-lived or may it become permanent. It seems that in this situation analysing the expectations on the background of NBP projections will become particularly important.

Symptoms of anchoring based on point forecasts

Anchoring of individual point forecasts is suggested, inter alia, by the fact that although the current level of inflation plays significant role in shaping current year inflation forecasts, it loses on importance when longer forecasts horizons are considered. 4- and 8-quarter-ahead forecasts are much closer to the inflation target. They are also more stable, which is indicated by a lower standard deviation and lower differences between extreme values (Table 27).

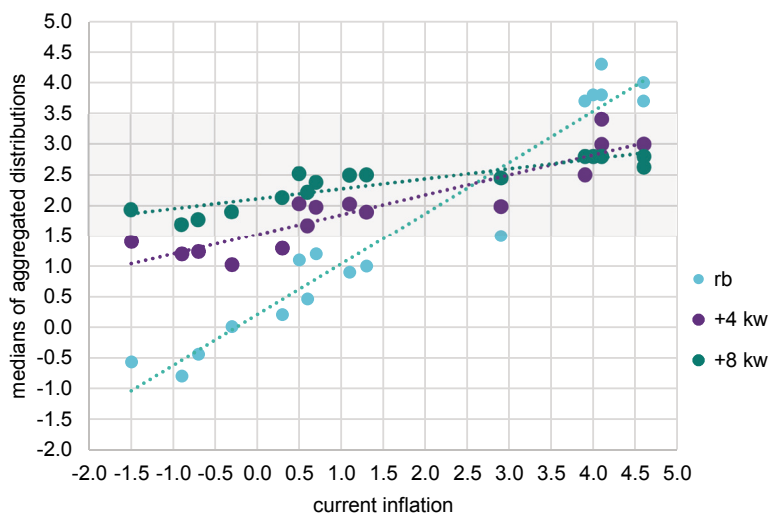
Analogical tendencies are observed while analysing forecasts obtained as a result of aggregation of individual probabilistic forecasts. Figure 64 presents relations between inflation forecasts, represented by medians of aggregated distributions, and the current inflation. The slope of regression line informs of the strength of current inflation impact. For a current year horizon it is much bigger than for longer horizons. It is worth noting that in the case of the 8-quarter horizon, medians of aggregated distributions remain within a tolerance band of deviations against the NBP inflation target, irrespective of the level of the current inflation.

Table 27. Current inflation and individual central forecasts – statistical comparison

	Current inflation	Forecasts, current year	Forecasts, +4 quarters	Forecasts, +8 quarters
mean	1.71	1.74	2.06	2.43
median	1.10	1.10	2.00	2.50
maximum	4.60	4.40	4.50	3.70
minimum	-1.50	-0.80	-0.72	0.80
standard deviation	2.03	1.66	0.78	0.46
number of observations	16	326	323	320

Note: Current inflation corresponds to the quarterly CPI indicator (quarter to the analogical quarter of the previous year), published before the survey date. Individual central forecast means 50 percentiles of the individual distribution.

Source: Own calculations based on GUS and NBP data.

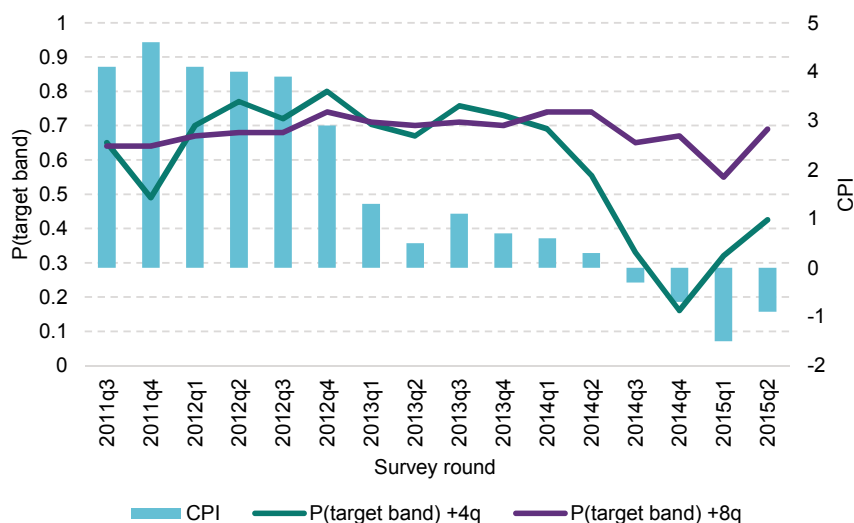
Figure 64. Dependence of inflation forecasts in various horizons on the current inflation

Note: Current inflation corresponds to the quarterly CPI indicator (quarter to the analogous quarter of the previous year), published before the survey date.

Source: Own calculations based on GUS and NBP data.

Symptoms of anchoring based on probabilistic forecasts

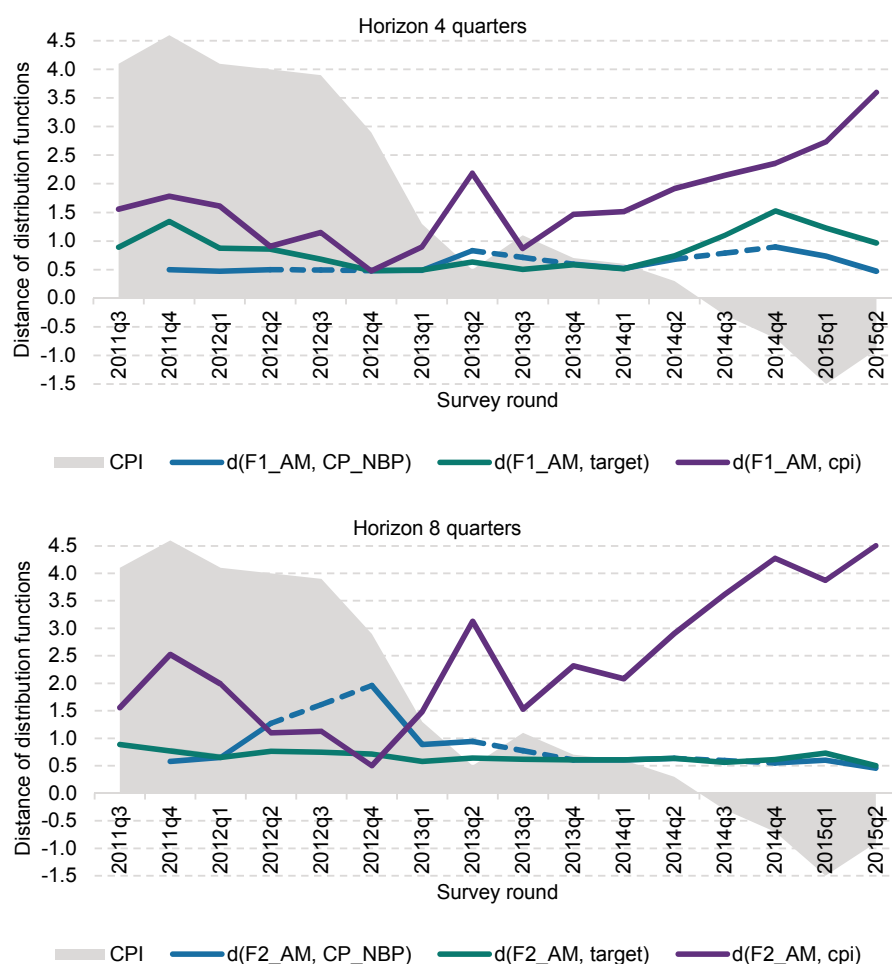
In reports presenting the results of the NBP SPF, the degree of anchoring of inflation expectations is monitored with use of the probability of the tolerance band of deviations from the inflation target (1.5%-3.5%). Based on the experience gathered so far, it can be assumed that a probability over 0.6 corresponds to well-anchored expectations (see also: Figure 65).

Figure 65. Probability of the tolerance band of deviations from the inflation target as information concerning the degree of anchoring

Source: Own calculations based on NBP and GUS data.

For the needs of more detailed analyses we propose a second indicator, measuring the distance between forecasts in the form of distribution of probabilities and a point inflation target. By analogy to the methods used for the assessment of accuracy of probabilistic forecasts (*Ranked Probability Score*), the inflation target is represented by the distribution with the probability concentrated in point 2.5, i.e. by the cumulative distribution in the form of Heaviside function with a step at 2.5. The distance of the probabilistic forecast from the inflation target may be thus defined as a distance between the respective distribution functions. In the same way, distances from other point values taken into account in our analysis were also calculated, i.e. from the current inflation and the central projection from the main NBP forecasting model. Figure 66 shows development of distances of probabilistic forecasts, obtained as a result of aggregation of individual distributions, for the horizons of 4 and 8 quarters. Similar tendencies are observed if we analyse distances of individual distributions.

Figure 66. Distances (in terms of distribution functions) of aggregated probabilistic forecasts from the inflation target, current inflation and NBP central projection in the consecutive rounds of NBP SPF as compared to CPI



Note: $d(x,y)$ means the distance between distribution functions x and y . F1_AM refers to NBP SPF forecasts in the horizon of 4 quarters, F2_AM – to NBP SPF forecasts in the horizon of 8 quarters, CP_NBP – to the central path of NBP inflation projection.

Source: Own calculations based on NBP and GUS data.

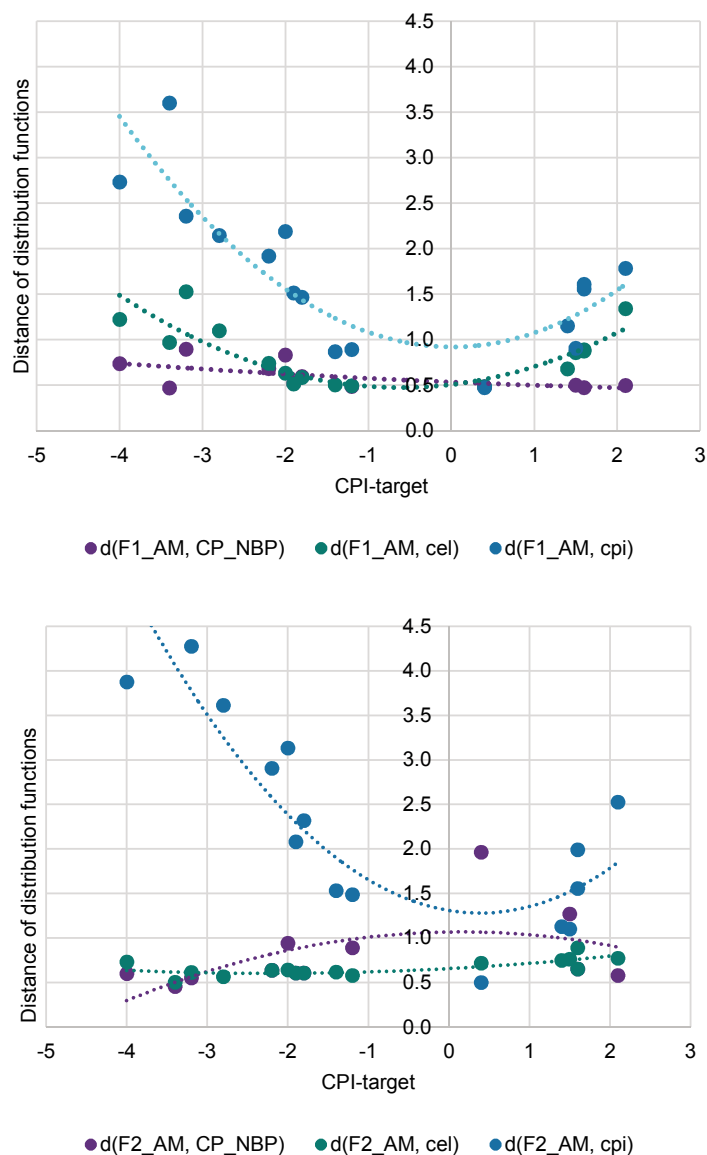
In the case of 4-quarter-ahead expectations, several episodes can be observed, involving both a significant decline of the target band probability and the growth of distance from the target. Those indicators reached extreme levels in the 2011 Q4 and 2014 Q4. In order to assess whether those episodes pose risks for future inflation, their macroeconomic context is important. Risk is much lower in situations when changes of expectations are driven by the same shocks as changes in the NBP projection. Therefore, a distance of the distribution representing expectations from the NBP central projection may be a risk indicator. Although in the aforementioned quarters (2011Q4 and 2014 Q4), a significant departure from the inflation target occurred, it was not accompanied by a significant growth of distance from the NBP projection (the projection deviated from the inflation target even more strongly).

Sensitivity to the deviation of current inflation from the target – conclusions for communication

Despite the optimistic conclusions concerning threats to inflation arising from the expectations, it should be taken into consideration that the degree of anchoring may start falling rapidly after exceeding a certain threshold of sensitivity to current inflation deviation from the target, which is shown in Figure 67, presenting distances of probabilistic forecasts from NBP SPF for the horizon of 4 quarters.

The analysis of distances of NBP SPF probabilistic forecasts from the NBP inflation target, NBP projection and current inflation (Figure 67) enables us to formulate certain hypotheses concerning the importance of publication of projection. It seems that it is an essential factor stabilising both, short-term and medium-term, expectations. It is noticeable that under significant deviations of current inflation against the target, the distance of the distribution representing expectations of NBP SPF participants from the projection is much lower than average, which may suggest greater attention paid to NBP forecasts in more difficult periods.

Figure 67. Distances of probabilistic forecasts from NBP SPF from the NBP inflation target, NBP projection and inflation in a given quarter



Note: $d(x,y)$ means the distance between distribution functions x and y . F1_AM refers to NBP SPF forecasts in the horizon of 4 quarters, F2_AM – to NBP SPF forecasts in the horizon of 8 quarters, CP_NBP – to the central path of NBP inflation projection.

Source: Own calculations based on NBP and GUS data.

3.5. Assessment of effectiveness of selected channels

The effectiveness of the main relations of the transmission mechanism is calculated based on vector autoregressive models. It depends on both the parameter estimates at the variables creating the individual sequences of relations in the model and on their statistical significance. Those sequences are defined by the relevant settings of variables in the VAR model. We define three sequences of relations describing the exchange rate channel, interest rate channel and credit channel:

- Exchange rate channel: WIBOR 1M → nominal effective exchange rate → industrial production → credits and loans denominated in PLN granted to enterprises and households → CPI;
- Interest rate channel: WIBOR 1M → industrial production → credits and loans denominated in PLN granted to enterprises and households → CPI;
- Credit channel: WIBOR 1M → credits and loans denominated in PLN granted to enterprises and households → industrial production → CPI.

In this method, precise separation of effects of interest rate impact from credit effects is not possible. The dependence of loan demand on changes in the real sector is incorporated into the effectiveness of interest rate channel. On the other hand, in the sequence of relations describing the effects of the credit channel, loans granted (a resultant of supply and demand) have a direct impact on the real sector, i.e. also on the loan demand. Therefore, effects of the credit channel may contain a significant part of effects attributed to the interest rate channel. Effectiveness of the credit channel was adjusted (decreased) by the value of demand effects attributed to the interest rate channel. The method for assessing the effectiveness of the transmission mechanism is presented in Appendix 2.

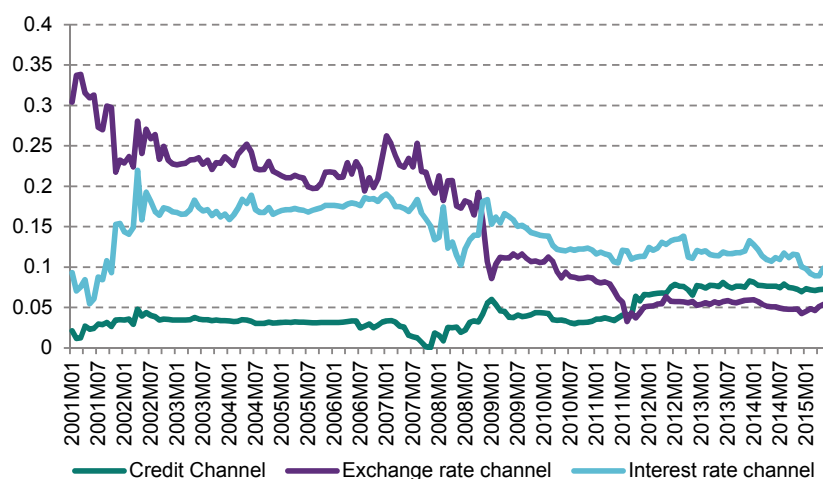
The analysis of the effectiveness of selected monetary transmission mechanism channels in Poland (Figure 68), shows that up to November 2008 the exchange rate was the most efficient channel. The effectiveness of the impact exerted by the sequence of relations associated with the exchange rate decreases steadily under the influence of structural changes, moreover, it varies across the business cycle. The change of the exchange rate regime (adoption of the floating exchange rate in 2000) was a structural shock. Over the next two years following adoption of the floating exchange rate the effectiveness of the exchange rate channel decreased by half. On the other hand, Poland's accession to the EU (with unchanged exchange rate regime) was a shock disrupting the business cycle, which led to only transitory disturbances in the effectiveness of the exchange rate channel. In turn, the financial crisis reduced the effectiveness of this channel rapidly, by 55% within three months from its outbreak (October 2008-January 2009). Secondary effects of the crisis were observable until the end of 2011. In total, with the exactness to the changes due to cyclical component, the financial crisis resulted in an over 70% reduction in the effectiveness of the exchange rate channel. This reduced level of efficiency was sustained until September 2015 (end of the sample), with no signs of its future recovery. This suggests the structural nature of changes in effectiveness and is associated both with the fall in the P-T effect and with a slight impact of the exchange rate on the real economy which, in turn, is connected with the dominating role of external demand and domestic demand in explaining the growth of the volumes of exports and imports.

The effectiveness of the interest rate channel increased significantly after the implementation of the direct inflation targeting strategy in Poland and may be interpreted as reflecting the development of financial intermediation sector as well as growth of central bank credibility. From 2002 until the collapse of the Lehman Brothers the effectiveness of this channel practically did not change and its slight fluctuations were caused by changes in the business cycle. The financial crisis, as in the case of the exchange rate channel, decreased the effectiveness of the interest rate channel by 44%. From the end of 2011 until September 2015, with some adjustments related to the business cycle, this effectiveness remain unchanged.

Until the outbreak of the financial crisis, the effectiveness of the credit channel was insignificant. The effectiveness of this channel was 5-6 times smaller than the effectiveness of the interest rate channel. One reason behind it was the surplus liquidity in the banking sector, limiting the effectiveness of the NBP impact on the value of granted loans. The 16-17% share of loans denominated in foreign currency in the total value of

lending had a similar impact. During the crisis, the effectiveness of the credit channel increased relatively (however, it was still smaller than the effectiveness of the interest rate), and in the first period of economy's adjustment to new conditions (until the end of 2010) it remained at almost unchanged level, with the simultaneous decline in the effectiveness of the interest rate and exchange rate. With the adoption of prudential regulations (including those limiting the availability of foreign currency loans), credits started to play an increasing role in the monetary transmission mechanism, in particular, since mid-2011.

Figure 68. Effectiveness of the monetary transmission channels in Poland



Source: own calculations.

Conclusions

The picture of the monetary policy transmission mechanism in Poland, based on the findings of the most recent studies, is consistent with that presented in the previous report (Kapuściński *et al.*, 2014). The strength of the response of economic activity and inflation to changes in short-term interest rates remains fairly stable, although the relative strength of the individual transmission channels is changing. We reaffirm that the pass-through of the exchange rate movements to consumer prices has been on a steady decrease. We also provide new evidence to support the conclusion on a growing part of forward-lookingness in the economy. The enhanced forward-lookingness, together with a rising role of credit in the transmission mechanism, as highlighted in this report, compensate for the weakening of other transmission mechanisms, in particular, the exchange rate channel.

The present analysis adds to the knowledge on the monetary policy transmission mechanism in Poland in several detailed areas.

- First of all, we point to the essential role of credit in the monetary policy transmission mechanism and test a new concept of the operation of the bank credit channel, according to which monetary policy affects the strength of commercial banks' balance sheets and, further – loan supply. We prove the existence of the bank loan channel in the monetary policy transmission mechanism in Poland.
- Secondly, when analysing developments in interest rates on loans, we do it both in terms of decomposition of risk components contained in the interest rates and in terms of banks' financing costs. We propose an indicator of banks' financing cost which seems to reflect changes in commercial banks' marginal cost better than the WIBOR 3M interbank market rate.
- Thirdly, we highlight the significant role of enterprises' inflation expectations – both as a factor determining actual inflation and as an element of the monetary policy transmission mechanism in Poland. We show that changes in the formation of enterprises' inflation expectations, which became more forward-looking and reacting to changes in interest rates, potentially restore an important transmission mechanism channel, associated with management of expectations.
- Fourthly, we analyse the cyclical features of the monetary policy mechanism within the structural model. In particular, we show that both the monetary policy rule and the mechanism of its impulse transmission vary across the phases of the business cycle. In the recovery inflation response to monetary policy decisions is stronger and faster than in the recession phase. This may be partly associated with cyclical differences in the central bank response function, since in recession periods interest rate changes are more persistent (a higher interest rate smoothing) than in recovery periods.
- Fifthly, we show that monetary policy effects should not be considered only in terms of changes in short-term interest rates. While analysing spreads in the money market we show the importance of liquidity management policy pursued by the central bank, approximated by the proposed liquidity management index. On the other hand, for the developments related to bond yields, share prices, exchange rate and expectations (concerning interest rates and inflation) the communication policy of the central bank is significant. Within this policy, publishing of inflation projections by the central bank plays a special role, which – especially in periods of high uncertainty – act as an important benchmark for professional forecasters in formulating their short- and medium-term inflation expectations.

We believe that the aforementioned conclusions shall contribute to better understanding of the monetary policy transmission mechanism in Poland, simultaneously opening perspectives for further studies and providing a platform for scientific discussions, to which readers of this report are invited.

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Appendix 1

Description of structural models of the monetary policy transmission mechanism and the basic response functions

Quarterly Model of (Monetary) Transmission, QMOTR 2

Description of the model

1. Objective: To create a relatively simple model, useful in analysing the monetary transmission mechanism, with a structure more flexible than DSGE models and more resistant to the Lucas critique than classical macroeconometric models. Such an intermediate type of model, dubbed by the authors as 'semi-structural', was developed by an International Monetary Fund team led by D. Laxton and operates under the name GPM (Global Projection Models; see: Carabenciov *et al.*, 2008).
2. Models of the GPM series, similarly as the DSGE models, view economic processes through shocks: shocks cause a deviation of the economy from its steady state; entities (domestic and foreign producers, domestic and foreign consumers and the central bank) react in an optimal way, then the effects of shocks are removed and the economy returns to equilibrium. However, in contrast to a strict theoretical structure of the DSGE models, a less rigorous one is admissible in the semi-structural models, e.g. instead of production function, built-in trends reflect the supply side of the economy. The built-in trends make it possible to obtain equilibria inside the model and enable identification of non-observable variables. Or, in the exchange rate equation, a disparity of the interest rates can be complemented by the variables which reflect the real side of the economy.
3. QMOTR 2 enlarges the set of economic agents represented in the standard model with the foreign trade sector (block of exports and imports) and for the government sector (block of government spending). QMOTR belongs to the class of the New Keynesian models and is built around four fundamental relationships: the IS curve, the Phillips curve, the exchange rate equation inspired by the concept of the uncovered interest rate parity and the interest rate rule.
4. The model is estimated using Bayesian techniques. Classical methods of estimation in the case of the relatively short time series may be uncertain in some circumstances. The way to solve the problem is to either parameter calibration (a subjective judgment of experts) or Bayesian estimation, allowing a combination of expert knowledge with the information contained in the data. Moreover, Bayesian estimation allows for the specification of more shocks than the number of observable variables, which affords the possibility of introducing a set of variables describing potential (equilibrium) which are consistent with the model.
5. The introduction of expert knowledge to the model is carried out by an appropriate choice of parameters of distributions of explanatory variables.

Assumptions

1. The model assumes that there is price and wage rigidity in the economy; therefore, the increase of the nominal interest rate causes an adequate increase in the real interest rate. The real interest rate affects the real exchange rate, real sector activity, and finally – inflation. The effect of nominal interest on real

variables is only temporary; in the long-term real variables return to their equilibrium levels (potential levels).

- In the QMOTR model all real variables are expressed by the difference between the current and potential state (gaps). Gaps are stationary, which ensures the return to equilibrium after a shock.
 - Potential levels of real variables are described by the state space models. Separation of shocks in the observation equation and in the state equation can distinguish between long-term changes, e.g. influenced by a change of technology, and disturbances caused by short-term cyclical factors. An exception is the model of the equilibrium exchange rate: its equilibrium rate is affected by the domestic and foreign output gap and by random disturbances (e.g. shock in the forex market). All potential (equilibrium) levels of real variables are model-consistent, which refers to: GDP and government spending potential, the natural interest rate, the natural rate of unemployment, the equilibrium exchange rate and the corresponding potentials of external variables (foreign output gap, EURIBOR).
2. The main players participating in the model include: domestic and foreign producers, domestic and foreign consumers, the central bank, the banking sector and the government sector.
- Domestic producers operate under monopolistic competition. This means that there exists a number of companies producing goods having enough specific characteristics to allow companies to determine the price of the products sold. For production, companies use goods from the domestic and foreign market. Manufactured goods are sold on the domestic market and partly exported. Exports depend on foreign demand and on the real exchange rate of the zloty against the euro and the U.S. dollar.
 - Consumers (households) derive utility from domestic and foreign products. Consumers save by buying domestic or foreign assets. The allocation of savings between domestic and foreign assets depends on the disparity of interest rates, the expected exchange rate of the zloty against the euro and the U.S. dollar and on the risk premium reflecting the macroeconomic risk, both domestic and foreign.
 - The central bank conducts a monetary policy under which economic agents (banks, enterprises) make conclusions concerning the persistence of the interest rate and its sensitivity to deviations against the inflation target. On that basis, banks determine interest rates on loans and enterprises take decisions on developments in prices and wages.
 - The government sector performs fiscal policy with the revenues from treasury bonds and taxes. From its revenues, the government finances the public sector, expenditures for social policies and co-finances EU projects. A fixed part of expenditure has a constant share in the gross domestic product, enlarging or reducing it in line with the changes of government revenue, depending on the business cycle, deviating against the equilibrium path.

Basic equations of the model

1. **IS curve.** The QMOTR model uses a hybrid concept of the aggregate demand equation. The output gap (the difference between the current GDP and its potential level) is explained by its expected future value and the value delayed, the difference between the expected real interest rate (nominal interest rate deflated with the expected change in prices) and the natural interest rate, the deviation of current

government spending from potential spending, the difference between the real effective exchange rate (80% EUR and 20% USD) and the equilibrium exchange rate and by the current net exports gap.

Entities participating in the model operate in a constantly changing environment. In each quarter shocks occur which cause the deviation of the output gap from its equilibrium. These shocks are of a demand nature (e.g. change in consumption preferences, change in external demand) and of a supply nature. The supply disturbances consist of shocks to potential GDP and to the natural interest rate, i.e. disturbances of the total factor productivity and the marginal productivity of capital. In this configuration, the shock to potential GDP may relate primarily to disturbances in labour productivity (assuming that the potential GDP state space model is an analogue of the production function).

Money market interest rate is described by the standard Taylor rule, taking into account changes in the real rate. It deviates from the equilibrium level due to shocks on the financial market. The equilibrium is determined by the natural interest rate. In turn, the natural interest rate is linked to potential GDP and to the deviations of the current inflation against the inflation target.

Net exports gap is a function of volumes of exports and imports which depend on the foreign and domestic demand and on the real exchange rate as well as of the equilibrium net exports. The equilibrium net exports changes under the influence of the equilibrium exchange rate and the change in net exports share in GDP.

2. **Phillips curve.** Inflation (HICP q/q excluding unprocessed food and energy) depends on its delayed and expected value, the output gap and the real exchange rate (pass-through effect). Alternatively to the output gap, the unemployment gap is used in the Phillips curve. The unemployment gap is linked with the output gap via Okun's law, and the natural rate of unemployment is described by the state space model.
3. **The real effective exchange rate** is, by definition, a combination of two concepts of the exchange rate: uncovered interest rate parity and purchasing power parity. The expected change in the real exchange rate depends on the real interest rate disparity and the difference between the natural rates at home and abroad (i.e. from the "equilibrium" risk premium). This means that an increase in the domestic interest rate should result in an immediate appreciation of the domestic currency, provided that the relationship between the equilibrium interest rate in the home country and abroad does not change. In such a situation, the exchange rate risk premium and the exchange rate of the domestic currency will change in an expected way. On the other hand the shock on the exchange rate risk premium (e.g. change in the degree of uncertainty in the financial market, change in the fundamentals of the economy) will cause the deviation of the expected exchange rate from its equilibrium, triggering the process of return to the equilibrium.
4. **The interest rate rule.** The central bank aims to achieve a nominal equilibrium interest rate (the natural rate plus the inflation target) by adjusting its current rate, depending on the deviation of current inflation from the inflation target and on the current output gap. The introduction of the shock allows the central bank for reactions that do not arise directly from the interest rate equation. Tying the current level of interest rates to its past values (smoothing) prevents excessive fluctuations of interest rates.

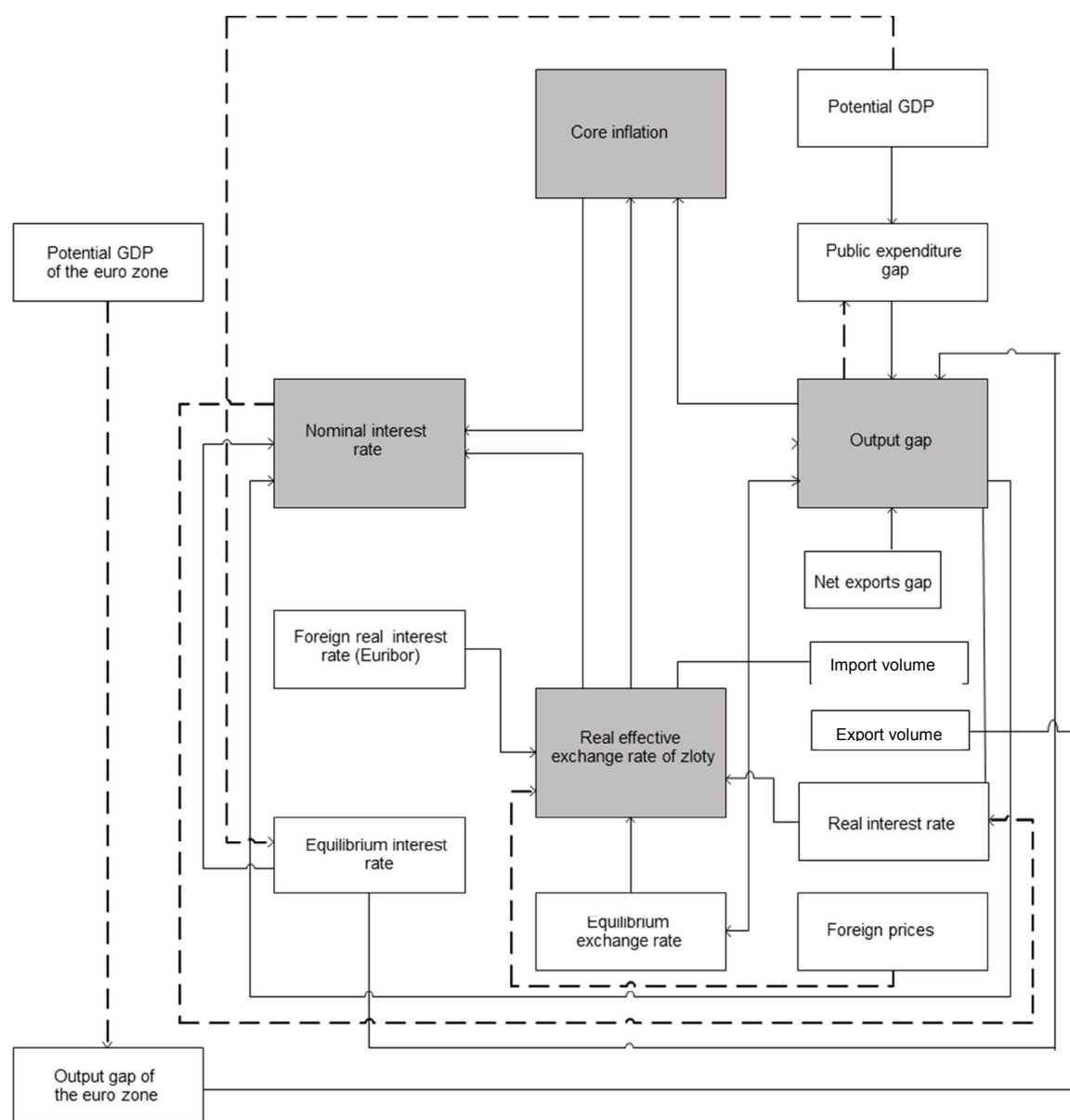
The model was estimated for a period from 2000 Q1-2015 Q2 and for the subperiods associated with the business cycle (recession and recovery, and slump and prosperity periods) proxied by the output gap. The

dynamic properties of the model are presented in section 2.2 (for the whole period) and in section 2.3 (for subperiods linked with the business cycle).

The decomposition of the variance of selected economic categories is shown in Table A1. In QMOTR 2 model economic processes are perceived through 18 shocks which have been aggregated in 5 groups, i.e.:

- Supply shocks (comprising shocks of potential GDP (2), potential government spending, prices, natural interest rate)
- Demand shocks (output gap, government spending, nominal interest rate)
- External shocks (comprising shocks in the euro area: potential GDP (2), output gap, prices, real interest rate)
- Zloty exchange rate (real exchange rate and equilibrium exchange rate shock)
- Foreign trade (shock of volume of exports, imports, potential net exports).

Scheme of the QMOTR 2 model



Source: own elaboration.

Table A1. Decomposition of variance of output gap, government spending, volume of exports, volume of imports, HICP excluding foodstuffs and fuels as well as nominal effective zloty exchange rate for the full estimation period and subperiods linked with the business cycle (in %; $\tau=0.2$)

Variance	Supply	Domestic demand	Net exports	External factors	Exchange rate
Output gap (y)					
2000 Q1 - 2015 Q2	31.54	20.5	7.9	39.3	0.76
Recession ($y_{t+1} < y_t$)	31.06	16.37	6.91	45.04	0.62
Recovery ($y_{t+1} > y_t$)	32.02	26.6	8.89	30.97	1.52
Slump ($y_t < \tau$)	29.33	15.47	7.11	47.22	0.87
Prosperity ($y_t > \tau$)	33.15	28.63	9.6	27.42	1.2
Government spending					
2000 Q1 - 2015 Q2	14.46	81.76	0.96	2.71	0.11
Recession ($y_{t+1} < y_t$)	13.8	83.86	0.97	1.3	0.07
Recovery ($y_{t+1} > y_t$)	6.23	85.44	0.48	7.76	0.09
Slump ($y_t < \tau$)	14.09	79.87	0.96	5.06	0.02
Prosperity ($y_t > \tau$)	4.16	87.44	0.97	7.31	0.12
Exports, volume					
2000 Q1 - 2015 Q2	5.54	4.95	13.6	68.11	7.8
Recession ($y_{t+1} < y_t$)	4.23	3.31	7.16	75.72	9.58
Recovery ($y_{t+1} > y_t$)	7.32	6.43	14.61	64.74	6.9
Slump ($y_t < \tau$)	4.52	3.4	3.9	80.08	8.1
Prosperity ($y_t > \tau$)	7.91	8.33	15.71	62.17	5.88
Imports, volume					
2000 Q1 - 2015 Q2	20.99	26.1	18.67	28.24	6.0
Recession ($y_{t+1} < y_t$)	15.12	21.04	16.36	39.18	8.3
Recovery ($y_{t+1} > y_t$)	24.3	28.44	19.46	22.5	5.3
Slump ($y_t < \tau$)	15.13	23.45	14.17	38.42	8.83
Prosperity ($y_t > \tau$)	25.4	29.22	20.42	20.15	4.81
HICP					
2000 Q1 - 2015 Q2	6.48	17.72	9.43	60.53	5.84
Recession ($y_{t+1} < y_t$)	4.72	7.67	11.03	71.17	5.41
Recovery ($y_{t+1} > y_t$)	7.82	24.82	5.72	56.53	5.11
Slump ($y_t < \tau$)	2.93	8.8	1.45	84.7	2.12
Prosperity ($y_t > \tau$)	9.17	27.5	2.02	53.21	8.1
NER					
2000 Q1 - 2015 Q2	9.5	27.72	18.8	39.98	4
Recession ($y_{t+1} < y_t$)	9.56	23.68	20.37	44.28	2.11
Recovery ($y_{t+1} > y_t$)	9.34	37.12	19	28.48	6.06
Slump ($y_t < \tau$)	9.4	30.4	18.19	40.11	1.9
Prosperity ($y_t > \tau$)	9.17	33.0	18.5	31.62	7.71

Source: own calculations.

The decomposition of the variance of basic economic categories show how much the Polish economy depends on the external environment. The volume of exports, which is the main transmitter of external stimuli to the economy, depends on external factors in almost 70%, and changes from slightly over 60% in the growth phases of the business cycle to almost 80% in downturn phases. The PLN exchange rate has a minor impact (7.8%) on the volume of exports. It changes from approximately 6% during prosperity to over 9% during recession. On the other hand, 40% of changes in PLN exchange rate is explained by external factors. Changes in the volume of exports directly affect the output gap – consequently, the 40% weight of external factors in explaining of the output gap (approximately 30% in the prosperity to over 45% during downturn phases of the cycle).

While assessing the HICP inflation from the perspective of the economy as described by QMOTR, the argument is confirmed on the minor impact of changes in PLN exchange rate on changes in prices. The exchange rate explains less than 6% of inflation throughout the entire period of analysis; from 2% in the slump and 8% in the recovery. On the other hand, external factors dominated in inflation decomposition (explain 60% of changes). Domestic demand factors, directly affected by the monetary policy, determine less than 20% of changes in prices. Their role definitely increases in the period of prosperity (over 1/4) and clearly falls in the downturn phases of the cycle (approx. 8%).

Small Model of (Monetary) Transmission, version 2.1 (MMT 2.1)

Specification of the model

- Small Model of Monetary Transmission (MMT 2.1) is a follower of the MMT and MMT 2.0 model used in the previous Monetary Transmission Reports. It serves to analyse the monetary policy transmission mechanism, including transmission in the banking sector (interest rate pass-through and attempt to include the credit channel). It allows for simulations of the impact of domestic and foreign interest rates, foreign demand, foreign inflation and global oil prices on the main macroeconomic variables, such as output gap, inflation or loans in PLN.
- MMT 2.1. belongs to the class of the New Keynesian models and is built around four core relationships: the IS curve, the Phillips curve, the exchange rate equation inspired by the concept of the uncovered interest rate parity and purchasing power parity, and the interest rate rule. It also contains the financial sector block comprising: (i) interest rate pass-through from the money market rate to interest rate on bank credit and yield of Treasury bonds, (ii) bank credit equation.
- Estimates of parameters of the model have been obtained with the OLS and GMM. Individual equations were estimated independently, and subsequently we performed simulations of the whole system.

Assumptions

1. In the model it is assumed that prices and wages are rigid, thus an increase in the nominal interest rate leads to an increase in the real rate of interest. The real rate of interest has an impact on the real effective exchange rate, the real sector and, finally, on inflation. The effect of nominal interest rate on real variables is only temporary; in the long-term real variables return to their equilibrium levels (potential levels).

All real variables in the model are expressed as a difference between current and potential levels (gaps). Gaps are stationary, which ensures the return to equilibrium after a shock. Gaps were obtained using filtering (the Hodrick-Prescott filter), which ensures their stationary nature. Thus, they are of purely statistical nature; the HP filter may generate incorrect estimates of gaps at the end of a sample. This problem was resolved by filtering series extended by 8 quarters (forecast). Potential levels of real variables derived from the HP filter are subsequently proxied using autoregressive models.

2. In the model there are domestic and foreign producers, domestic and foreign consumers, the central bank, the banking sector and the government sector.
 - Domestic producers operate under monopolistic competition. This means that there exists a number of firms producing goods which have to some extent unique features allowing firms to determine the price of their products. For production, companies use goods from the domestic and foreign market. Manufactured goods are sold on the domestic market and partly exported. Exports depend on foreign demand and on the real exchange rate of the zloty against the euro and the U.S. dollar.
 - Consumers (households) derive utility from domestic and foreign products. Consumers save by buying domestic or foreign assets. The allocation of savings between domestic and foreign assets depends on the differential between domestic and foreign interest rates, the expected exchange

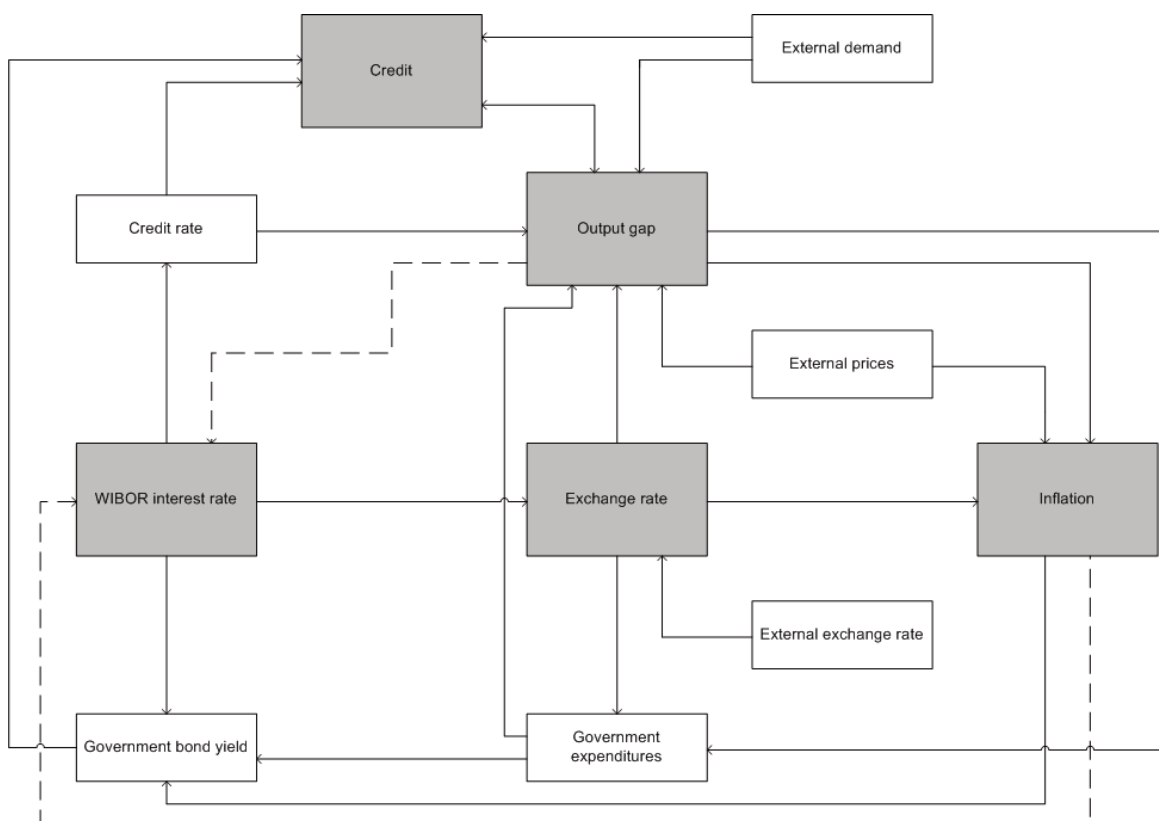
rate of the zloty against the euro and the U.S. dollar and on the risk premium reflecting the macroeconomic risk, both domestic and foreign.

- Like enterprises, banks act under monopolistic competition. They set interest rates on loans, taking into account the money market rate (refinancing cost) and demand for loans. In the long-run, the money market rate and loan rate stay in equilibrium. Banks can allocate consumers' savings into loans or treasury bonds. They extend loans for consumption and production.
- The government sector performs fiscal policy with the revenues from Treasury bonds and taxes. From its revenues, the government finances the public sector, social expenditures and co-finances EU projects. "Rigid expenditure" (*involving mostly the debt service cost and subsidies to the social insurance and national health funds – translator's note*) holds a constant share in the gross domestic product, rising or falling it in line with the changes of government revenue, depending on the business cycle, deviations from the equilibrium path. Variable expenditure is counter-cyclical (due to the effect of automatic stabilisers).

Basic equations of the model

1. **IS curve.** The output gap (i.e. the difference between real and potential GDP) depends on: (i) its lagged value, (ii) the real (ex ante) interest rate gap on loans, (iii) the real effective exchange rate gap (we use a proxy – average weighted by 80% for euro and 20% for USD), (iv) foreign demand gap, (v) government expenditure gap and (vi) the gap of real household and corporate loans in PLN (credit gap is supposed to capture the effect of credit channel). GDP deviations from the potential are mainly driven by demand factors.
2. **The real effective exchange rate** is a behavioural relation with elements of two concepts of the exchange rate: uncovered interest rate parity and purchasing power parity. The expected change in the real exchange rate depends on the real interest rate differential and the difference between the natural rate in the home country and abroad. In addition, the macroeconomic risk premium is proxied by the domestic output gap. An increase in the domestic interest rate should result in the appreciation of the domestic currency, provided that the relation between the equilibrium rate in the country and abroad and the domestic output gap does not change.
3. **The Phillips curve.** Inflation (HICP q/q without unprocessed food and energy) depends on its delayed and expected value, the output gap and the real exchange rate (pass-through effect).
4. **The interest rate rule.** The interest rate depends on its past value (smoothing), current inflation and the current output gap.
5. The model also contains equations for the lending interest rate, yields on Treasury bonds of maturity of one year, loan demand equation, the public expenditure gap and the capital adequacy ratio (since 2014 – required total capital ratio).

Scheme of the MMT 2.1 model



Source: own elaboration.

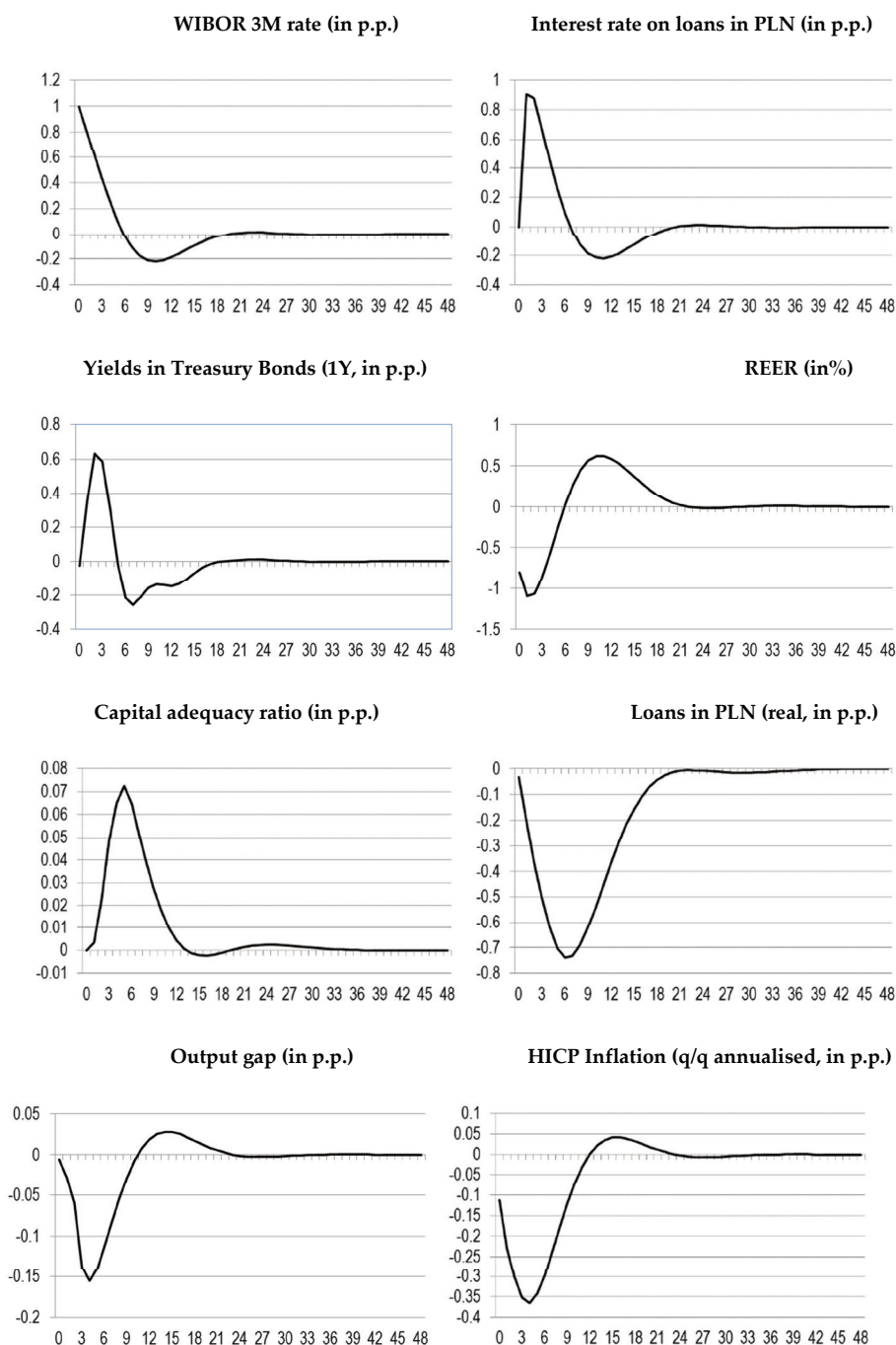
The model's dynamics

To demonstrate the dynamic properties of the model we show responses of its basic variables to the following impulses:

- the impulse of the domestic interest rate – increase by 1 p.p. for 1 quarter (Figure A1); the description is included in the main body of the report.
- the impulse of the foreign demand – an increase in the euro area output gap by 1 p.p. for 1 quarter, (Figure A2). The impulse of the foreign demand translates into the growth of the domestic output gap, credit and inflation. Accordingly, the domestic interest rate increases, followed by the loan rate and bond yields. Increasing interest rate and growing output gap lead to zloty appreciation (good fundamentals), followed by a reduction of the output gap and inflation returning to the baseline.
- an increase in the foreign interest rate – by 1 p.p. for one quarter (Figure A3). The impulse of the foreign interest rate translates into a minor rise in domestic interest rates (lending rate, bond yields), which do not have impact of loan demand. Nonetheless, interest rate differential increases, resulting in capital outflows and zloty depreciation. The depreciation triggers growing demand for Polish exports; loans, output gap and inflation slightly increase. However, it should be stressed that all those effects are minor. It is a slightly different result than that obtained from the (S)VAR model with sign restrictions (see section 2.1); in that case the only effect of a rise in the foreign interest rate was GDP decline, instead of its growth (in the structural model we have the output gap). However,

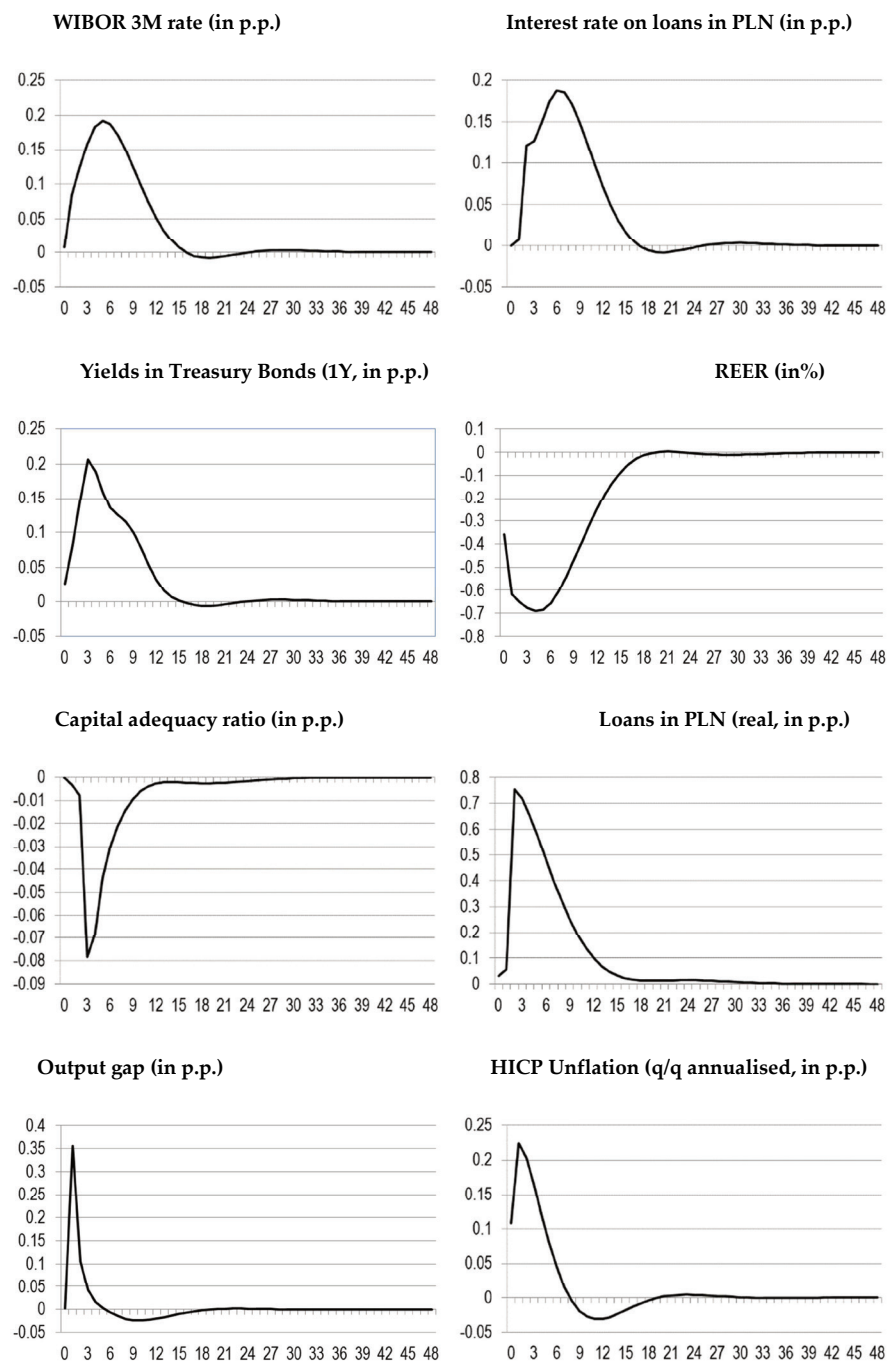
at that time we were facing a situation in which the growth in foreign interest rate triggered the decline in production and prices in the euro area. In the MMT 2.1 model, the foreign interest rate, foreign demand and inflation are treated as exogenous variables which are not interrelated.

Figure A1. Interest rate (WIBOR 3M) impulse, horizontal axis: quarter after the impulse



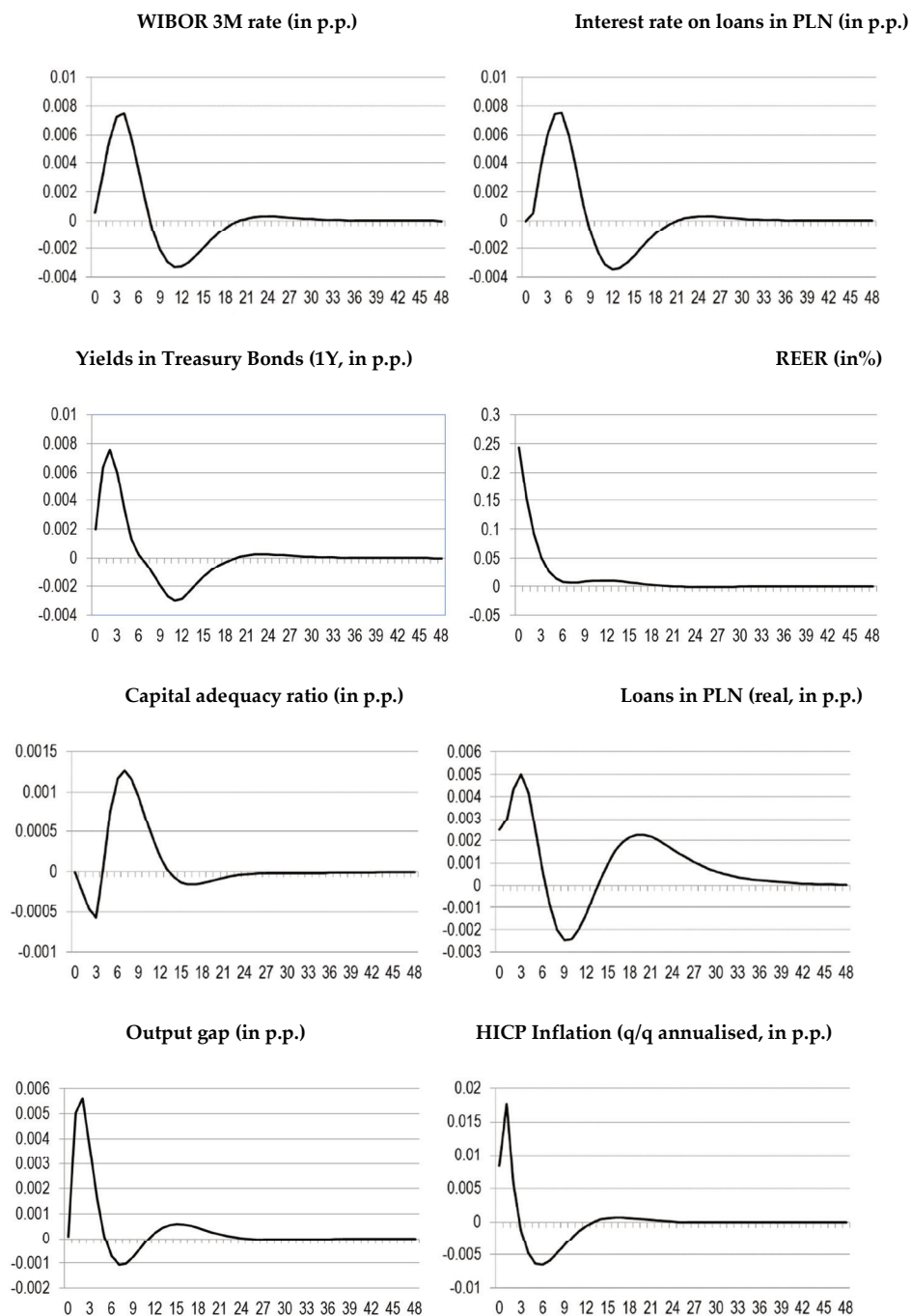
Source: own calculations.

Figure A2. Foreign demand impulse, horizontal axis: quarter after the impulse



Source: own calculations.

Figure A3. Foreign interest rate impulse, horizontal axis: quarter after the impulse



Source: own calculations.

Appendix 2

Method of estimating the effectiveness of channels of the monetary policy transmission mechanism

The method of estimating the effectiveness of channels of the monetary policy transmission mechanism in Poland is consistent with the approach proposed by Bates and Vaugirard (2009). The vector autoregressive model (VAR), serving as a basis for effectiveness analysis, uses data on monthly frequency and is presented in section 3.5 of the report. The number of lags, determined on the basis of the Schwartz information criterion and analysis of distribution and autocorrelation of residuals, amounts to 3. The model is estimated on levels to capture the long-term relationships between variables.

The sequences of relations of the monetary policy transmission mechanism, describing the exchange rate, interest rate and credit channels are defined by the adequate ordering of variables, namely:

- Exchange rate channel: WIBOR 1M → nominal effective exchange rate → industrial production → credits and loans denominated in PLN granted to enterprises and households → CPI;
- Interest rate: WIBOR 1M → industrial production → credits and loans denominated in PLN granted to enterprises and households → CPI;
- Credits: WIBOR 1M → credits and loans denominated in PLN granted to enterprises and households → industrial production → CPI.

The effectiveness of monetary policy transmission (MTE) in a given sequence of transmission relations is defined as standardized elasticity ($e_{y2/y1, yA}$) between instrumental (y_1) and target (y_2) variables, elasticity that is conditional on variables participating in the transmission process (y_A), if the parameters at respective variables are statistically different than zero (at the significance level pv):

$$MTE_{y_1 \rightarrow y_2, y_A} = (1 - pv_{y_A, y_1})(1 - pv_{y_2, y_A}) \frac{|e_{y_2 / y_1, y_A}|}{(1 + |e_{y_2 / y_1, y_A}|)}$$

where:

$$e_{y_2 / y_1, y_A} = e_{y_2 / y_A} \cdot e_{y_A / y_1}$$

To calculate the dynamic MTE, the basic VAR model is re-estimated with the number of lags larger by one with respect to their optimal number, i.e. with 4 lags in our case. The over parametrization allows for using the MNK estimator and conduct a rolling estimation (see: Harvey, 1991).

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