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Monetary policy transmission mechanism in Poland What do we know in 2013?

Mariusz Kapuściński, Tomasz Łyziak, Jan Przystupa, Ewa Stanisławska, Anna Sznajderska, Ewa Wróbel

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Economic Institute
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Summary

For a central bank knowledge of the monetary policy transmission mechanism is a prerequisite for achieving its final goal, i.e. price stability. Therefore, this area of analyses and research is of key importance for central banks, including Narodowy Bank Polski (NBP).

Every two years since 2011, the Research Bureau of the Economic Institute at NBP, prepares a report on the functioning of the transmission mechanism in Poland. Our aim is to gather the results of the most recent studies and to present them in a non-technical manner. Though we remain within the New-Keynesian school, we treat the theoretical achievements – according to Mayer's (1996) terminology – rather in terms of *empirical-science theory* than *formalistic theory*. Therefore, the studies presented in this report share a common empirical character and aim at finding the most complete answer to the question on the role of monetary policy for the main economic variables in Poland.

In our analyses we employ a broad set of various modelling tools. Thus, following monetary transmission literature, we use structural vector autoregression models (SVAR) as they are an important tool of inference on stylized facts, main transmission channels and their effectiveness. To examine the strength and delays in the transmission mechanism and ways in which the central bank affects the economy, we use classic structural models, i.e. the new version of the structural monetary transmission model (MMT 2.0) and the model based on the *Global Projection Models*, adjusted for specific features of the Polish economy, called QMOTR. In contrast to the previously used models, the new ones explicitly treat equilibria of the main macroeconomic categories and allow for a higher degree of forward-lookingness[1]. To assess the impact of the exchange rate on the real sector, we use another structural model, i.e. the natural exchange rate model, NATREX. Finally, to analyse interest rate pass-through we apply error correction models (ECM).

As in the previous report (Demchuk *et al.*, 2012), presentation of model results is preceded by an assessment of the structural features of the Polish economy, which are potentially important for the functioning of the monetary policy transmission.

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In the first part of the report, we review briefly theories of transmission channels and analyse the structural features of the Polish economy. They include characteristics of the real sector of the economy, the degree of its openness, as well as the structure of the financial system. Conclusions from this part of the study suggest that development of the financial intermediation rather tends to strengthen monetary transmission. Growing economic stability and increasing monetary policy credibility might constrain the impact of the exchange rate on consumer prices and shorten lags in the monetary policy transmission.

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The second part of the study brings the empirical results on the most important features of the monetary transmission.

[1] It should be stressed that versions of the models employed in the report have a very preliminary character.

On the basis of structural vector autoregression models, we show stylized facts of the monetary policy transmission. They indicate that interest rate shocks influence economic activity (GDP and industrial production) in a statistically significant way. The impact of the exchange rate shocks on price dynamics is well documented, while the impact of interest rate impulse on price dynamics is less conclusive[2]. It is worth noting that the impact of the exchange rate shocks on prices is much smaller than that estimated in our previous report (Demchuk *et al.*, 2012).

The structural models serve us to identify the strength and delays of the monetary policy transmission. We assess them from a perspective of the maximum reaction of economic activity and inflation (year-on-year rate) to a change in the central bank interest rate. It should be underlined that these reactions are conditional not only on the models applied, but also on the character of the monetary impulse (i.e. on the length of period for which the interest rate is changed), as well as on the type of the economic activity and inflation measure analysed (levels, quarterly dynamics, annual dynamics).

- Looking through the lenses of the models a 1 p.p. increase in the money market interest rate (for 1 quarter) is followed by a 0.1-0.2 p.p. decrease of GDP dynamics (y-o-y). In the QMOTR model the reaction of economic activity to the monetary policy impulse is slightly weaker than in the MMT 2.0 and appears with a shorter lag. Monetary policy tightening results also in a fall of inflation (y-o-y). The peak response of the core inflation (i.e. HICP inflation excluding foodstuffs and energy) is 0.3-0.4 p.p. This decline is slightly stronger and faster in the QMOTR than in the MMT 2.0.

- Additional simulations conducted on the MMT 2.0 indicate that the maximum reaction of year-on-year inflation to a 1 p.p. interest rate increase lasting 4 quarters amounts to about -0.7 p.p. and takes place in the 6th quarter after this impulse. In a tentative decomposition of this reaction to effects of transmission channels which are represented in the model, we evaluate that more than half of the maximum decline of inflation might be attributed to the interest rate channel, while the remaining part – to the effects (of a similar size) of the exchange rate and credit channels.

- The reaction of inflation to the monetary policy impulse based on the MMT 2.0 model is stronger than the one presented in our previous report. It results, on the one hand, from the fact that the currently applied model entails more features of the transmission mechanism – especially credit and expectations, which leads to a more comprehensive assessment of the monetary transmission. On the other hand, the stronger reaction of inflation to the monetary policy impulse might be related to a faster and slightly stronger transmission of demand pressure to inflation. To some extent, it may also result from an increase in the degree of forward-lookingness of the economy. Both effects might, however, be temporary, and reflect asymmetric behaviour of agents unveiled after the outburst of the financial crisis.

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[2] There is a price puzzle after the interest rate shock, therefore in the optics of VAR models inflation falls with a lag. There are some proofs, however, that adding to the model fiscal variables or some variables describing the real sector makes it easier to obtain the response without a puzzle.

The third part presents selected results showing the effects of supposedly the most powerful monetary policy channels. The main conclusions on the pass-through from the NBP reference rate to money market rates and retail rates in the banking system are the following:

- Despite the fact that since the Lehman Brothers collapse transactions in the money market remain subdued, the impact of disturbances in the interest rates behaviour fades away. Money market rates adjust reasonably well to the NBP reference rate, and spreads have narrowed significantly.

- Deposit and lending interest rates (retail sector averages) adjust completely to changes in the money market rates. In the case of deposit rates it is due to instruments with a very short maturity, i.e. from 1 to 3 months. Interest rates on some loans, e.g. for housing purposes, that is for products where a significant parallel market in foreign currencies exists, are affected not only by domestic money market rates, but also by the foreign interest rate, EURIBOR.

- In a majority of cases, spreads between deposit and lending rates in banks and money market rates remain higher than in the pre-crisis period. Comparing changes in the strength of adjustment of retail rates in both sub-periods, we conclude that rates on deposits with maturity from 1 to 3 months, for which banks have competed most strongly during the sharp phase of the crisis, react to market rates more than previously, while lending rates – less. Weaker transmission to lending rates might be related to asymmetries in the adjustment process in periods of interest rate increases and decreases.

- Individual features of banks, reflected in their balance sheets, seem to have a minor impact for the interest rate pass-through. They alter rather the speed of adjustment than its scale in the long-run. We find that for the interest rate transmission the most important individual characteristics of banks are: the size of assets, liquidity and strength of deposit base. They differentiate mostly the speed of transmission between market rates and rates on banks' products, and to a lesser degree, its strength. Reactions of deposit rates are more diversified than those of lending rates.

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Analyses of loans behaviour, including operation of the credit channel, show that:

- An interest rate increase leads to a reduction in credit volumes. Loans in Polish zloty to households decrease faster and stronger than loans to the enterprise sector, while the strongest reaction is typical for loans to sole entrepreneurs. It might suggest that this kind of borrower is considered by banks as the most risky, and the observed reactions reflect not only a fall in demand (interest rate channel), but also in the supply (credit channel).

- Credit channel operation is confirmed by the results of estimates of the long run credit supply and credit demand functions. They indicate that credit demand reacts strongly to changes in economic activity, while credit supply to changes in the spread between the lending rate and the money market rate. Credit supply elasticities seem to be higher for households than firms. The functioning of the credit channel is, however, distorted by exogenous credit supply shocks occurring in the economy – *in-*

ter alia in the period following the outbreak of the financial crisis, when increased risk perception induced banks to lower the credit supply despite monetary policy easing[3].

- The possibility of borrowing in foreign currency reduces the effectiveness of monetary policy transmission. Loans in foreign currencies grow after an increase in the domestic interest rate. On the other hand, loans in foreign currencies to households do not react to the NBP monetary policy shock in a statistically significant way.

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Over the last years we have observed a substantial change in the operation of the exchange rate channel:

- The impact of the exchange rate on the volume of Polish exports has been decreasing over time – in 2013 the exchange rate explained about 23% of exports growth, comparing to almost 40% in 1998. We interpret this as a result of the increasing role of international companies, which settle their accounts within a capital group. In turn, among the determinants of imports volume we observe that the significance of the exchange rate remains on a relatively stable level (about 20%), while the importance of exports increased substantially. This reflects a growth of import intensity of exports, which contributes to impairment of the exchange rate impact on the real sector. According to our estimates, a 10% depreciation of the real effective exchange rate results, with one quarter lag, in about a 0.3 p.p. increase in the GDP y-o-y growth rate.

- The assessment of the transmission of the exchange rate changes to consumer prices (exchange rate pass-through) shows that it has substantially weakened over recent years. The exchange rate pass-through to consumer prices (CPI) estimated on a sample covering the period from 1998 to 2010 amounted to about 0.20, while the most recent evaluation for the years 2000-2013 suggests that it dropped to 0.07.

- The decreasing impact of the exchange rate on consumer prices is a typical sign of growing economic stability and monetary policy credibility, a similar phenomenon was also observed in the industrialized countries in the late 80's and early 90's. The fall of the exchange rate pass-through to producer prices (PPI) and acceleration of reaction of these prices reflect significant changes in the production process and might suggest a permanent drop in the pass-through to consumer prices. At the same time, taking into account that exchange rate pass-through to transaction prices of consumption goods remains still relatively high, it seems that the fall of sensitivity of consumer prices to the exchange rate is cyclical to some extent. Therefore, we expect the exchange rate pass-through to increase slightly, but to the level only narrowly exceeding 0.1.

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[3] See data from NBP surveys conducted among chairmen of credit committees in tens of largest banks operating on the Polish market: http://www.nbp.pl/homen.aspx?c=/ascx/subgen.ascx&navid=5060.

In the report we also discuss inflation expectations as an important determinant of the monetary policy transmission. The main conclusions are as follows:

- The processes of setting inflation expectations by consumers, enterprises and financial sector analysts are diversified, they all seem, however, to be more sophisticated than typical for static expectations, depending only on the current inflation.

- Inflation expectations of enterprises and analysts of the financial sector are characterized by a relatively high degree of forward-lookingness and anchoring in the NBP inflation target, as well as of effective use of macroeconomic information. However, none of the analysed groups uses effectively information on the influence of interest rate on future inflation, although the scale of inflation expectations errors related to the incorrect perception of the monetary policy transmission seems to be limited.

- From the point of view of adaptive learning approach, we find that in the process of inflation expectations formulation consumers use a very simple forecasting rule, based only on past inflation. Moreover, consumers put more weight on inflation outcomes from the near past than on older observations. It seems that events from the last five years have the greatest impact on their beliefs about inflation.

■

Estimates of transmission channels effectiveness which depends on both the identified elasticities among variables essential to these channels, as well as their statistical significance, lead to the following conclusions:

- In the first few years after inflation targeting adoption the effectiveness of the monetary transmission underwent substantial changes. Together with the development of the financial system and growing credibility of monetary policy, the effectiveness of the interest rate channel tended to increase. The growing importance of bank credit strengthened the effectiveness of the credit channel. At the same time, a change in the exchange rate policy, i.e. the adoption of a floating regime, together with lower and less variable inflation, contributed to a gradual decrease in effectiveness of the exchange rate channel. Since the Polish accession to the European Union in 2004, until 2008, we have observed a stabilization of the effectiveness of transmission channels. Then, disturbances due to the financial crisis have significantly lowered the effectiveness.

- Currently, the interest rate channel of the monetary policy transmission mechanism is considered as the most efficient one, the exchange rate channel – as a slightly less efficient, and the credit channel – as the least efficient (however, more efficient than in our previous estimates). In general, this gradation corresponds to the assessment of the relative strength of channels based on the structural model MMT 2.0.

- After the outbreak of the global financial crisis, the effectiveness of the exchange rate channel has declined the most. This is a structural phenomenon, related to a lower effect of exchange rate pass-through to consumer prices and a small impact of exchange rate on the real sector. On the other hand, we attribute the decrease in effectiveness of the interest rate channel mostly to cyclical factors. A long period of subdued growth in developed economies and macroeconomic uncertainty impairs investment in spite of the accommodative monetary policy of NBP. Financial crisis has also strongly, but ra-

ther temporarily, disturbed the effectiveness of the credit channel. Banks significantly reduced credit supply, especially in the first phase of the crisis.

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Finally we summarize the results on asymmetries in the monetary policy transmission:

- There is a stronger and faster impact of money market rates on deposit and lending rates in the periods of relatively lower liquidity of the banking sector. Moreover, deposit and lending rates (except for rates on loans to sole entrepreneurs), for which asymmetry has been found, react stronger to interest rate increases than decreases.
- Estimations of the hybrid new Keynesian Phillips curve show that in periods of prosperity the role of inflation expectations in price setting increases.
- The exchange rate pass-through effect depends on the phase of the business cycle – it decreases in periods of economic slump and increases during a recovery. The influence of exchange rate on consumer prices depends also on the direction of exchange rate changes (stronger for depreciation than appreciation) and exchange rate volatility (stronger for low volatility, weaker for high volatility).

1. Theoretical considerations and structural features of the economy important for the monetary policy transmission mechanism

1.1. Theory on channels of the monetary policy transmission mechanism

The monetary policy transmission mechanism describes the influence of the monetary policy on the behaviour of economic agents and, hence, on output and the price level. Monetary policy signals are transmitted through channels, which in this paper are divided into the *interest rate channel* (and within it: the *asset price channel*), the *exchange rate channel* and *credit channels*. In the previous report (Demchuk *et al.*, 2012) we described relations and stages of the transmission mechanism in detail. In this paper we shall present transmission channels very briefly, with reference to the scheme depicted in Figure 1.

1.1.1. Interest rate channel

A change in central bank interest rates influences short-term interbank rates, which affect deposit and loan rates in commercial banks, as well as government and corporate bond yields. Owing to rigidities in the economy, the central bank influences not only nominal, but also real interest rates. Furthermore, expectations of economic agents on the future path of short-term interest rates, based on inflation expectations and perceived reaction function of the central bank, affect long-term interest rates. Real interest rates (current and expected) influence decisions on investment and consumption or saving.

An increase in interest rates translates *ceteris paribus* into an increase in the cost of capital – financing investment through debt becomes more expensive. It discourages corporations and households from investment, reducing output and inflation (*direct interest rate channel*).

An interest rate increase alters the slope of consumption profile (current saving for consumption in the future becomes more profitable than current consumption). It reduces current consumption, additionally decreasing output and inflation (*intertemporal substitution effect*).

Within the interest rate channel (or next to it) one can distinguish the asset price channel. It is related to the impact of changes in central bank interest rates on stock market and real estate prices.

Monetary policy tightening (an interest rate increase) contributes to a decline in the demand for shares and real estate, reducing their prices. It has two important consequences. Firstly, a decrease in share prices lowers the relation between the market value of corporations and the replacement cost of capital (*Tobin's q*). If the relation is low, corporations can issue shares only at a price that is low in comparison with the cost of buying fixed assets, which should reduce new emissions and investment. Secondly, a decrease in share and real estate (or other assets) prices reduces household wealth. According to the life-cycle theory (Modigliani theory) it should decrease consumption (*wealth effect*).

1.1.2. Exchange rate channel

A change in central bank interest rates affects the relation between return on domestic and foreign securities. An interest rate increase, according to the theory of uncovered interest rate parity, should translate into the appreciation of the exchange rate (it restores equality between expected returns). As a result, the prices of imported goods in domestic currency decrease (directly reducing inflation) and prices of exported goods in foreign currency increase. This boosts imports and reduces exports, decreasing net exports.

This impact might be partially offset by balance sheet effects, i.e. a decrease in liabilities of economic agents denominated in foreign currency, if they do not have a similar amount of assets in foreign currencies. If a country is a net borrower, the exchange rate appreciation strengthens balance sheets, which should boost domestic demand.

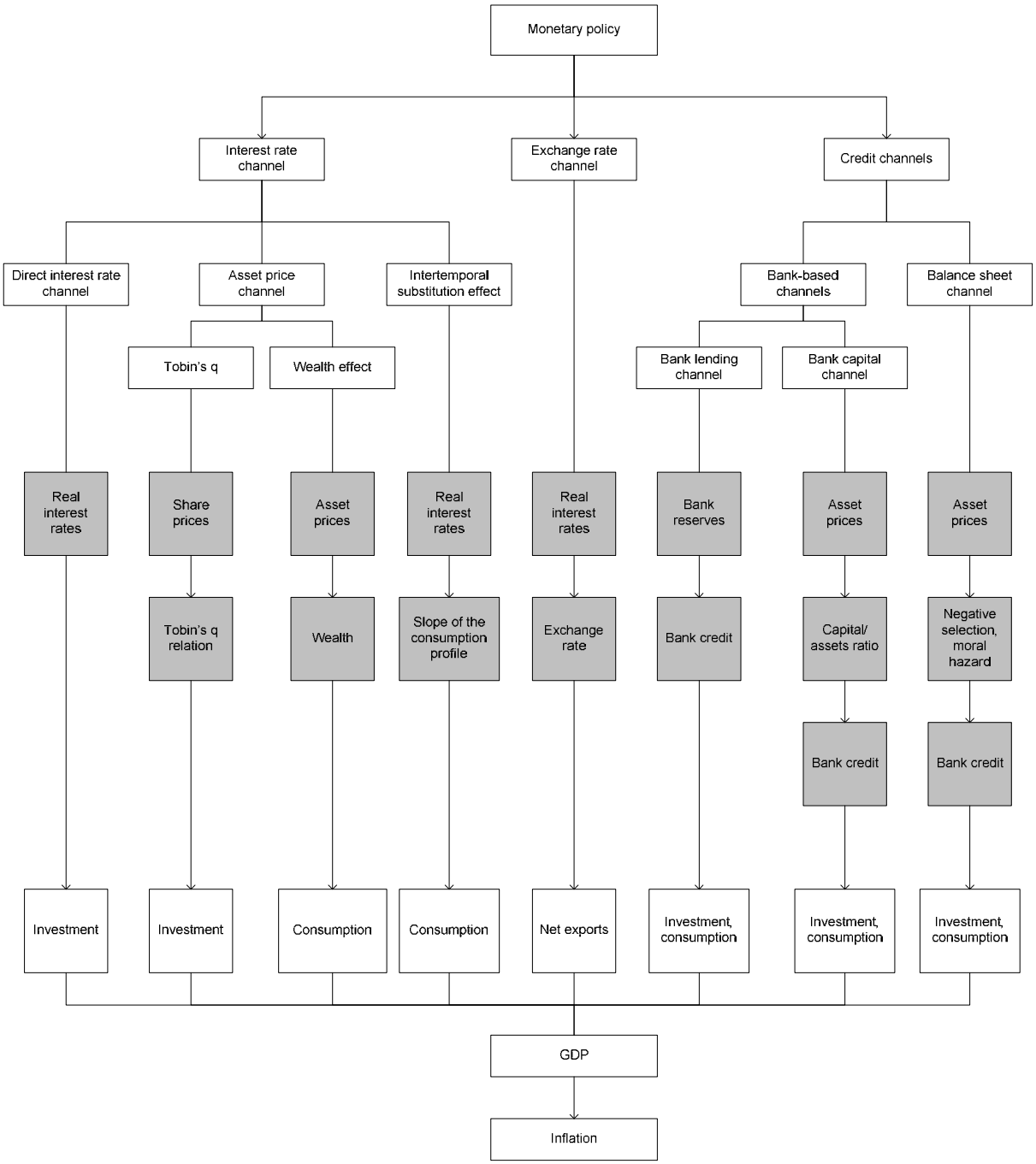
1.1.3. Credit channels

Due to market imperfections (such as information asymmetry and segmentation) monetary policy can also influence output and inflation through credit channels. These are related to the impact of interest rate changes on credit supply. The channels can be divided into channels based on bank's balance sheets and on balance sheets of other agents.

Within the first group it is indicated that banks play a special role in the financial system (and the transmission mechanism), because they cope well with the problem of information asymmetry on credit markers. It causes imperfect substitution between bank credit and other sources of financing – certain borrowers would not have access to external sources of financing if they did not borrow funds from banks. Tight monetary policy reduces bank reserves, decreasing credit supply (*bank lending channel*). Furthermore, a decrease in asset prices (caused by the interest rate hike) can lead to losses in bank's portfolios, and diminution of their capital. To improve their capital-asset ratio banks can additionally reduce access to credit (*bank capital channel*). Because many borrowers are dependent on bank credit in financing their activity, lower credit supply should reduce investment and consumption.

A decline in asset prices, besides worsening bank's balance sheets, causes a reduction in net worth of economic agents. It lowers collateral, contributing to increased problems of adverse selection and moral hazard on credit markets. In such an environment, lenders can be less prone to grant loans (*balance sheet channel*).

Figure 1. Relationships within the monetary policy transmission mechanism



Note: The scheme does not reflect the direct effects of the exchange rate channel, i.e. the influence of exchange rate changes on prices of imported goods, as well as balance sheet effects of exchange rate fluctuations.

Source: own elaboration based on Boivin *et al.* (2010).

1.2. Structural features of the Polish economy and their impact on the transmission channels

The relative effectiveness of particular transmission channels is affected by structural characteristics of the economy under consideration. They also determine the general effectiveness of monetary policy and the distribution of effects of monetary policy on output and inflation. Before describing the results based on various models of the monetary policy transmission in Poland, we shall present the characteristics of the Polish economy that are the most important for the transmission mechanism. We concentrate on the period between 2004 and 2012, however in some cases we also refer to the tendencies observed in the longer term, covering the years since the adoption of the inflation targeting strategy by NBP.

1.2.1. Development and structure of the financial system

The role of the financial system in Poland (measured by the relation between the financial system assets or the money supply and GDP) is similar to the CEE countries, but significantly lower than in the euro area. Nevertheless the system has been expanding – between 2004 and 2012 the financial system assets to GDP ratio increased by a half. Thereby, the scope of monetary policy influence is widening, which should enhance its general effectiveness.

The structure of the Polish financial system is dominated by the banking sector (however its share has been decreasing in comparison with other financial institutions), which is a typical feature in continental Europe. Between 2004 and 2012 the bank credit-to-GDP ratio has doubled, however it remains significantly lower than in the euro area. The relatively low non-financial sector debt in banks reduces the influence of the monetary policy.

The corporate bond market in Poland is less developed than in other CEE countries and in the euro area. It can be expected that the pass-through from NBP interest rates to yields on corporate bonds is therefore relatively weak (however there is not much research in that field for Poland yet).

The Warsaw Stock Exchange has the biggest market capitalisation in relation to GDP in the CEE countries, but slightly lower than stock markets in the euro area. The capitalisation remains lower than in 2007, i.e. before the beginning of the global financial crisis (since then there have been new issuances, but it did not compensate for the share price decrease). The increase in the role of the stock market should strengthen the asset price channel (Table 1, Table 2).

1.2.2. Banking sector and other credit institutions

The functioning of the interest rate channel is enhanced by relatively low (lower than in the other CEE countries and in the euro area) concentration of the banking sector. It reflects high competition in the sector, which should translate into fast pass-through between interbank rates and retail rates. Between 2008 and 2012 the concentration has slightly increased, following a decline between 2004 and 2008 (mergers and a significant increase in activity of some of the largest banks contributed to the latest increase) (Table 1, Table 2, Table 3).

Interest rate pass-through is also strengthened by high and increasing mismatch in the term structure of loans and deposits. Low coverage of long-term loans by long-term deposits should induce banks to adjust retail rates to interbank rates quickly (Table 4).

The effectiveness of the monetary policy of NBP might be reduced by a dominant position of foreign investors in the ownership structure of the banking sector, because foreign parent-companies can provide banks with financing independent from domestic monetary conditions. Since 2009 the share of foreign investors (mostly from Italy, Germany and Holland) has been decreasing and in 2012 it reached the lowest level since 1999 (Table 5).

The interest rate channel and credit channels are weakened by a high level of liquidity in the banking sector. Firstly, surplus liquidity of banks, reflected in the large scale of open market operations absorbing liquidity conducted by NBP, can weaken the transmission of interest rates. Secondly, a high share of highly liquid assets reduces the adjustment of credit supply after changes in interest rates. On the other hand, high liquidity makes up a buffer when the interbank market dries-up, as after the collapse of the Lehman Brothers in 2008 (Table 6).

The strength of the interest rate and exchange rate channels is reduced by a high share of foreign currency loans in the total value of loans. Due to access to foreign currency lending, after an interest rate increase (decrease) a decrease (increase) in demand for PLN loans is partially compensated by an increase (decrease) in demand for loans in foreign currency (Brzoza-Brzezina *et al.,* 2010). Moreover, after the exchange rate appreciation (depreciation), besides a negative (positive) impact on net exports, there is also a positive (negative) impact on balance sheets (Poland is a net borrower), supporting domestic demand. The role of foreign currency lending was reduced by recommendation S implemented in 2006 (and changed in 2008, 2011 and 2013) by the Polish Financial Supervision Authority (KNF). In June 2013 foreign currency loans constituted 3% of new housing loans, compared with 70% in June 2008 (Table 7).

The effectiveness of the monetary policy is reduced by the important role of trade credit. At the end of 2012 it amounted to 16.6% of GDP, which is more than bank loans for corporations (15.3% of GDP). Marzec and Pawłowska (2011) indicate that in periods of tight monetary policy there occurs substitution between trade credit and bank loans in corporations (this also took place during global financial crisis).

The monetary policy transmission mechanism in Poland might be weakened by the activity of credit unions (SKOK) and loan corporations. However, the scale of their activity is very low, hence the importance of this factor for the effectiveness of monetary policy can be neglected (Table 2)[4].

[4] At the end of 2012 loans granted by credit unions constituted less than 1% of GDP (in spite of having more than 2.5 million members). The scale of activity of loan corporations is even smaller – less than 0.15% of GDP. Credit unions do not participate in the interbank market, thus the impact of monetary policy on rates on deposits and loans granted by these institutions is probably low and takes place mainly by competition with banks. From 2014 credit unions will be obliged to participate in the reserve requirements system, which will enable some influence of monetary policy of NBP.

1.2.3. Non-financial sector

Non-financial corporations are dominated by small entities, especially micro-companies (employing up to 9 persons). The main external source of financing of investment for small companies is a bank credit, so their high share should enhance credit channels. However, large companies have the highest share in revenues. These might substitute bank credit with bond or share issuance, which weakens the strength of credit channels (Table 8).

Corporations finance 75% of their investment through internal sources. Among external sources of financing bank credit dominates, however its share has been gradually decreasing. The high share of internal sources of financing reduces the general effectiveness of the monetary policy; however a dominant role of bank credit among external sources strengthens the relative influence of the credit channels (Table 9).

As far as the households and non-commercial institutions sector is concerned, from the point of view of the transmission mechanism its financial and housing wealth is important. Currently, the financial wealth (measured by financial assets in percentage of GDP) is lower than in the other CEE countries and in the euro area. Despite an increase of 13 p.p. in 2008-2012, it remains 1.5 p.p. of GDP lower than before the global financial crisis (stock wealth is lower by 15.4 percentage points of GDP). Housing wealth decreased between 2008 and 2011 by 24.3 p.p. of GDP, mainly due to the decline in house prices (Table 1, Table 2).

1.2.4. Openness of the economy

The Polish economy is less financially open than the other CEE countries and the euro area, and is characterised by lower trade openness relative to other CEE countries. Between 2004 and 2012 there was a gradual increase in openness, which should strengthen the influence of the exchange rate channel. The increase in trade openness can also reduce lags in the transmission mechanism of monetary policy (Havránek, Rusnák 2012).

The exchange rate channel can be weakened by a significant (but lower than in the compared CEE countries) foreign value added content of gross exports. Due to this, the exchange rate appreciation (depreciation), besides worsening (improving) the price competitiveness of exports, causes a decrease (increase) in prices of imported intermediate goods (Table 1, Table 2).

1.2.5. Rigidities and other characteristics

The recent research on price rigidities in Poland (Macias, Makarski 2013) indicates that prices are being changed every 10.9 months on average (the frequency of changes amounts to 18.8%). Thereby, prices in Poland are less rigid than in the euro area (frequency – 15.3%), but more rigid than in the US (26.1%). The less rigid the prices, the less monetary policy shocks should influence output and the more they should affect inflation.

Labour market rigidities are influenced by employment protection legislation and union density. In Poland employment protection is similar to the compared CEE countries but much lower than in the euro area (in recent years it was broadly unchanged). Union density is relatively low and decreasing. Comparatively low employment protection should reduce lags in the transmission of shocks (including monetary policy

shocks). Furthermore, decreasing union density reduces the bargaining power of employees and the probability of second-round effect after negative supply shocks (a temporary increase in inflation to a lower extent fuels wage claims). In effect, there is less need for an interest rate increase when such shocks occur. The Polish labour market is distinguished by a high share of flexible forms of employment, which increases flows on the market and the probability of finding and losing a job, as well as supports wage discipline[5]. The percentage of employees with temporary contracts is higher than in the compared CEE countries and in the euro area – in 2008-2012 it stabilised at the level near 27% (there was a significant increase between 1998 and 2004 – from 4.8 to 22.7%)[6].

In the medium term Poland is characterised by an investment-to-GDP-ratio close to the compared CEE countries (with the exception of the Czech Republic, where it is slightly higher) and in the euro area. The share of investment – i.e. the part of GDP with relatively high elasticity with respect to interest rate changes – should not differentiate the transmission mechanism in comparison with these groups of countries.

Since 1998 Narodowy Bank Polski has conducted its monetary policy within the inflation targeting strategy. The strategy appeared to be efficient in fighting inflation, which between 2004 and 2012 was just slightly above the inflation target of NBP (2.5%); however, the deviation from the target did not diminish monotonically in 4-year sub-periods. The increasing creditworthiness of monetary policy is reflected in increasing stability of the economy, measured by variability of inflation and GDP growth[7] . The relatively low level of inflation and credible monetary policy should reduce lags in the transmission mechanism and exchange rate pass-through (Égert, MacDonald 2008) (Table 1, Table 2).

1.2.6. Conclusions

Summing up, Poland is characterised by a systematic development of the financial system, which should be increasing the general effectiveness of monetary policy, widening the scope of influence for monetary authorities' decisions. Within particular transmission channels of monetary policy there can be identified factors enhancing, as well as reducing, the influence on the behaviour of economic agents.

The effectiveness of interest rate and credit channels is enhanced by the dominant position of the banking sector in the financial system, high competition in the banking sector and the structure of the corporate sector. It is reduced by a low credit-to-GDP-ratio, surplus liquidity of the banking sector and a high share of foreign currency loans in total loans. The functioning of the exchange rate channel is improved by increasing financial and trade openness, but worsened by a high foreign value added content of gross exports. The increase in the role of the stock exchange should gradually enhance the influence through Tobin's q and wealth effect. The increasing creditworthiness of monetary policy should reduce lags in the transmission mechanism and relatively low inflation should weaken exchange rate pass-through.

[5] *Badanie Ankietowe Rynku Pracy. Raport 2013*, Economic Institute, NBP, http://www.nbp.pl/publikacje/arp/raport_2013.pdf.

[6] The labour market is also more flexible due to the tendency to employ people on contracts based on civil law. According to the Central Statistical Office of Poland (GUS) data, the number of people employed in 2012 on fee-for-task agreements and specific-task contracts in companies employing more than 9 people stated 11.8 % of the number of employees in this group of entities at the end of 2012.

[7] Between 1997-2004 and 2005-2012 the variation coefficient for inflation decreased from 0.7 to 0.4, for quarterly GDP growth rate from 1.1 to 0.6 and for annual GDP growth rate from 0.6 to 0.5.

Table 1. Key structural features of the Polish economy significant to the transmission mechanism as compared with other countries, 2012

	Poland	Czech Republic	Hungary	Euro area
Financial system assets/GDP [1]	123.0	153.3	136.4	502.2
M2/GDP [2]	56.4	76.7	54.1	95.4
M3/GDP [2]	57.8	77.3	60.0	103.5
Banking system/financial system assets [1]	68.9	78.7	68.2	68.6
Bank loans/GDP [1]	50.7	55.9	43.5	103.2
Bank deposits/GDP [1]	45.4	78.6	35.1	83.1
Stock market capitalisation/GDP [1]	35.3	18.4	16.2	53.2
Corporate debt securities/GDP [3]	8.1	21.3	13.8	101.8
Banking sector concentration (share of assets held by 5 largest banks) [4]	44.4	61.5	54.0	47.0
Financial assets of households and NPISH [5]	86.3	104.3	102.3	196.7
Financial openness [6]	148.9	182.5	276.3	362.9
Trade openness [7]	93.1	150.4	182.0	89.0
OECD employment protection legislation index [8]	2.14	2.17	1.92	2.50
Trade union density [9]	14.6	17.3	16.8	21.6
Percentage of employees with temporary contracts [10]	26.9	8.8	9.4	15.2
Share of investment in the GDP [10]	20.4	23.3	17.5	18.4
Average inflation 2004-2010 [11]	3.0	2.5	5.2	2.1
Foreign value added content of gross exports [12]	27.9*	39.4*	39.9*	Non-available

* 2009

[1] NBP, *Financial System Development in Poland 2012*. (available only in Polish).

[2] Own calculations based on data from central banks and Eurostat.

[3] Sub-category *securities other than shares excluding financial derivatives* within category *debt securities*. Own calculations based on ECB and Eurostat data.

[4] ECB. For the euro area weighted average for 17 countries.

[5] Eurostat. For the euro area data for 2011.

[6] Financial openness is defined as sum of asset and liabilities of international investment position in relation to GDP. Own calculations based on Eurostat data.

[7] Trade openness is defined as sum of exports and imports in relation to GDP. Own calculations based on Eurostat data.

[8] Since 2010 the OECD has not published overall employment protection legislation index, however it has published its components. Own calculations were conducted based on OECD data. For the euro area weighted average for 15 countries (without Cyprus and Malta.

[9] OECD. For the euro area weighted average for 14 countries (without Cyprus, Malta and Luxembourg). 2008 data for Hungary, 2004 data for the Czech Republic, 2010 data for Poland and the euro area.

[10] Eurostat.

[11] Own calculations based on GUS (for Poland – CPI inflation) and Eurostat data (for Czech Republic, Hungary and the euro area – HICP inflation).

[12] Own calculations based on OECD data.

Table 2. Key structural features of the Polish economy significant to the transmission mechanism in years 2004, 2008 and 2012

	2004	2008	2012
Financial system assets/GDP [1]	78.6	110.4	123.0
M2/GDP	39.9	51.8	56.4
M3/GDP	40.8	52.2	57.8
Banking system/financial system assets [1]	74.1	73.8	68.9
Bank loans/GDP [1]	26.0	46.6	50.7
Bank deposits/GDP [1]	34.0	38.8	45.4
Stock market capitalisation/GDP [1]	25.4	18.0	35.3
Corporate debt securities/GDP	Non-available	3.6	8.1
Banking sector concentration (share of assets held by 5 largest banks)	50.0	44.2	44.4
Financial assets of households and NPISH	72.0	73.3	86.3
Financial openness	92.9	117.8	148.9
Trade openness	77.3	83.8	93.1
OECD employment protection legislation index	2.14	2.14	2.14
Trade union density	19.0	15.1	14.6 *
Percentage of employees with temporary contracts (proc.)	22.7	27.0	26.9
Share of investment in the GDP	20.1	23.9	20.4
4-year average deviation of inflation from target (pp) [2]	0.9	1.6	1.5
Foreign value added content of gross exports	30.6***	30.7	27.9****
Trade credit to non-financial corporations/GDP (short-term liabilities on the account of deliveries and services) [3]	15.4	16.9	16.6
Credit union loans/GDP [4]	0.31	0.54	0.64
Loan corporation loans/GDP [4]	Non-available	0.12	0.13**
Housing wealth/GDP [5]	181.7	207.9	183.6**

* 2010 ** 2011 *** 2005 **** 2009

Sources and notes as in table 1. In addition:

[1] Additionally, NBP reports *Financial System Development in Poland* for 2004 and 2008 (for 2008 available only in Polish).

[2] Between 2001-2004, 2005-2008 and 2009-2012. Own calculations based on GUS data.

[3] Own calculations based on GUS and Eurostat data.

[4] Own calculations based on KNF and Eurostat data.

[5] NBP estimates.

Table 3. Concentration in the banking sector, %

	2004	2008	2012
Share of assets held by 5 largest banks	50.2	44.6	44.9
Share of loans extended by 5 largest banks	45.4	43.1	39.1
Share of deposits in 5 largest banks	56.7	55.3	44.2

Source: KNF, *Report on the condition of banks*. Reports for 2004, 2008 and 2012 (for 2004 and 2012 available only in Polish).

Table 4. Term structure of loans and deposits of the non-financial sector, %

	2004	2008	2012
Share of short-term (up to 1 year) loans in total loans	32.7	22.2	16.5
Share of short-term (up to 1 year) loans to corporates in total loans to corporates	38.5	35.2	31.4
Share of short-term (up to 1 year) loans to households and NPISH in total loans to households and NPISH	26.1	13.8	9.2
Share of short-term (up to 1 year) deposits in total deposits	93.7	97.2	96.7
Share of short-term (up to 1 year) corporate deposits in total corporate deposits	99.4	99.5	99.0
Share of short-term (up to 1 year) deposits of households and NPISH in total deposits of households and NPISH	91.8	96.1	95.8

Source: own calculations based on NBP data. Annual averages.

Table 5. Banking sector ownership structure, %

	2004	2008	2012
Share of assets held by domestic investors	32.4	27.7	36.4
Share of assets held by foreign investors	67.6	72.3	63.6

Source: KNF, *Report on the condition of banks*. Reports for 2004, 2008 and 2012 (for 2004 and 2012 available only in Polish).

Table 6. Banking sector liquidity

	2004	2008	2012
Balance of open market operation transactions, PLN bn *	-4.9	-8.3	-96.0
NBP bills to banks' assets, %	1.1	1.2	7.2
Share of highly liquid assets, %	20.6	15.6	17.9

* Observations for 2004 and 2008 are outliers (in 2004 open market operations absorbing liquidity were reduced by a decrease in surplus liquidity, caused by an increase in the reserve requirement rate and autonomic factors; in 2008 it was reduced by the global financial crisis.) Since 2009 autonomic factors have increased surplus liquidity and the scale of open market operations absorbing liquidity.

Source: own calculations based on NBP and KNF data. Annual averages.

Table 7. Currency structure of loans and deposits of the non-financial sector, %

	2004	2008	2012
Share of foreign currency-denominated loans to corporates	29.0	19.4	24.3
Share of foreign currency-denominated loans to households and NPISH	26.3	32.3	37.3
Share of foreign currency-denominated deposits of corporates	19.1	17.6	16.9
Share of foreign currency-denominated deposits of households and NPISH	16.6	9.0	7.3

Source: own calculations based on NBP data. Annual averages.

Table 8. Structure of the enterprise sector, %

	Share in the number of enterprises			Share of the revenues of enterprises		
	2004	2008	2011	2004	2008	2011
Small (up to 49 employees)	99.0	98.9	98.9	39.5	37.7	34.9
including: micro (up to 9 employees)	*96.4*	*96.0*	*95.9*	*24.7*	*23.2*	*20.8*
Medium-sized (from 50 to 249 employees)	0.8	0.9	0.9	22.2	21.8	21.0
Large (above 250 employees)	0.2	0.2	0.2	38.3	40.5	44.1

Source: GUS, *Activity of non-financial enterprises*. Reports for 2004, 2008 and 2011.

Table 9. Structure of sources of investment financing, %

	2004	2008	2011
Own funds	80.7	76.1	75.2
Bank loan from domestic banks	9.7	12.0	9.5
Foreign funds	5.7	6.2	6.3
Other sources	3.9	5.7	9.0

Source: own calculations based on: GUS, *Fixed assets in National Economy*. Reports for 2004, 2008 and 2011.

2. General features of the monetary policy transmission mechanism in Poland

2.1. Analysis based on (S)VAR – type models

This part of the report provides a very broad overview of monetary transmission and so-called stylized facts, which will be elaborated more in the next sections. It brings results which are obtained using a limited number of theoretical assumptions, in other words, here we let the data speak. In the next sections we shall compare these results with those obtained from structural models which are based on a more rigorous theoretical background.

The main assumption on which the results of this section are based concerns the monetary policy rule and lags in the reaction of the main macroeconomic variables to a monetary policy instrument. A monetary policy rule in a VAR framework is a set of variables which tend to be considered by the monetary policy decision-making body when fixing the interest rate. We assume that in Poland, this is inflation and some measure of real sector activity. We assume that when setting the interest rate, the monetary authority knows the current (i.e. of the same quarter or month) state of the economy and price developments. For the lags in the monetary transmission, we assume that owing to rigidities in the economy (e.g. price and wage stickiness, habit formation in consumption, etc.), inflation and the real sector react to the monetary policy with a delay. We extract monetary policy shocks using two methods: a simple semi-structural Cholesky factorization, and a more structural decomposition. The latter is supposed to reflect better the properties of a small open economy: it allows for a simultaneous reaction of the exchange rate and interest rate, while in the Cholesky decomposition, the interest rate simply takes into account past (from period *t-1*) information about the exchange rate behaviour.

As in the previous report (Demchuk *et al.*, 2012), we use two data sets, i.e. quarterly and monthly. The monthly data serve us mostly as a robustness check, but are also used in the next parts of the report for estimations in which we check the impact of the monetary policy on other variables, like bank loans, unemployment rate and retail sales. The sample covers the period beginning in the 1st quarter 1998 and ending in the 1st quarter 2013 for the quarterly data and in May 2013 for the monthly data.

We build a four variable benchmark quarterly VAR model. The endogenous variables are as follows: domestic GDP, consumer price index (CPI), monetary policy rate (proxied by 1-month money market rate, WIBOR1M), and the real effective exchange rate deflated by the CPI. The benchmark model comprises also exogenous foreign variables (oil price (Brent) in USD/barrel, euro area GDP (15 countries) to allow for the impact of foreign demand and commodity prices on the domestic economy and a few dummy variables to obtain normally distributed (or at least unskewed) and serially uncorrelated residuals (for the Y2K, Russian crisis, Poland`s EU entry in May 2004, and centred seasonal dummies). On the other hand, we do not plug

in a deterministic trend as an exogenous variable[8]. After analysing stylized facts using the benchmark model, we add private consumption and investment.

The monthly model is built on the same variables, with industrial output replacing GDP and industrial output of the euro area as the respective exogenous variable.

A general overview of Figure 2 reveals that reactions of the main macroeconomic variables to the monetary policy shock are very similar to those obtained in the previous report. As before, there is a statistically significant reaction of GDP and a price puzzle, i.e. an increase in the price index after monetary tightening[9] in spite of using oil prices to pin down inflation expectations. The price puzzle is visibly more pronounced in the results coming from the Cholesky decomposition. Thus, through the lenses of these VAR models, prices tend to fall with a considerable delay. We suppose this is due to the estimation method and limitations of VAR modelling rather than the genuine phenomenon. Plugging in additional variables describing the real sector is sometimes helpful and eliminates the puzzle (see Figure 25 in the Annex 1), suggesting that the basic economic variables which are usually used in transmission VAR modelling, may not be sufficient in the Polish case[10].

After the monetary policy shock there is virtually no adjustment of the exchange rate[11], though one could expect some transitory appreciation. Contrary to the price puzzle, the lack of exchange rate reaction is plausible and may result from a perception of increased risk in the future and expected worse fundamentals.

The decomposition of GDP into private consumption and investment shows that after monetary tightening they tend to fall, and that the response of investment is more pronounced than that of consumption (Figure 3). The estimate is, however, not fully conclusive, since the response of investment, although the point estimate is relatively high, is only close to statistical significance, while that of consumption is significant. In this case, the use of foreign demand as the exogenous variable makes a difference as compared with a model in which it is omitted. A part of investment activity is seemingly explained by foreign demand (exports, FDIs), and this is why reaction ascribed to the interest rate shock is only close to statistical significance (in the previous report we have shown a statistically significant reaction).

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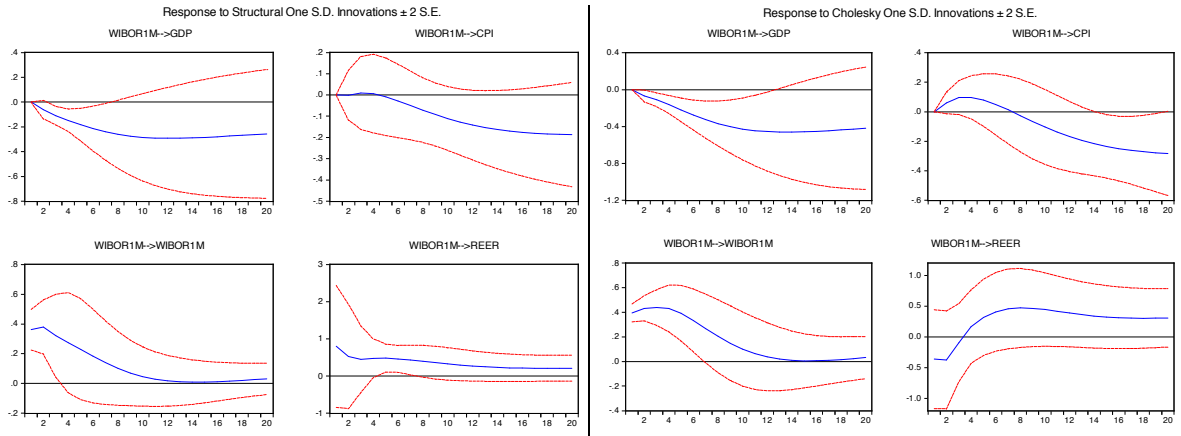
[8] There is a dilemma whether or not to include a deterministic trend in a VAR. For example, it is included for the euro area countries in Mojon, Peersman (2001); it is also used for Poland in Andrle *et al.*, (2013). However, we follow Doan (RATS User`s Guide, 2007, p. 344) who strongly recommends not using a deterministic trend in a VAR, arguing that in most economic series the best representation of a trend is random walk with drift (Nelson and Plosser, 1982). In the regression: $y_t = \propto + \gamma t + \beta_1 y_{t-1} + \cdots + \beta_p y_{p-1} + u_t$, if we expect to see a unit root in the autoregressive part, γ becomes a coefficient on a quadratic trend, while α picks up a linear trend. As one adds variables or lags to the model, there is a tendency of the ordinary least squares estimates of the VAR to "explain" too much of the long-term movement of the data with a combination of the deterministic components and initial conditions (see Sims 2000). While this may "improve" fit in-sample, the resulting model tends to show implausible out-of-sample behaviour. Another dilemma is whether to use differenced data or data in levels. Once again we follow Doan (2007, p. 343) who recommends using levels of the respective variables, arguing that the result in Fuller (1976) shows that differencing produces no gain in asymptotic efficiency in the autoregression, *even if it is appropriate*. Differencing throws information away, for instance, a simple VAR on differences cannot capture a co-integrating relationship, while it produces almost no gain.

[9] Estimates with a deterministic trend plugged in usually show a smaller and shorter-lived price puzzle.

[10] Haug *et al.*, (2013) suggest that it is necessary to employ fiscal variables, which eliminates the price puzzle; the remaining results they obtain are very similar to ours.

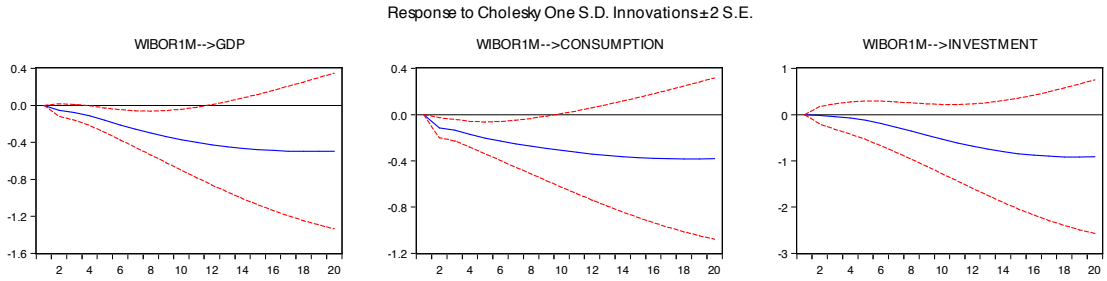
[11] In the previous report (Demchuk *et al.*, 2012) there was an appreciation, but as it appeared with a very long lag we considered it as an artefact.

Figure 2. Response reaction functions to monetary policy shock (interest rate increase) from decomposition allowing for simultaneous reaction of exchange rate and interest rate (left panel) and standard Cholesky decomposition (right panel)



Source: own calculations.

Figure 3. Response reaction functions to monetary policy shock (interest rate increase): reaction of GDP, private consumption and investment, Cholesky decomposition

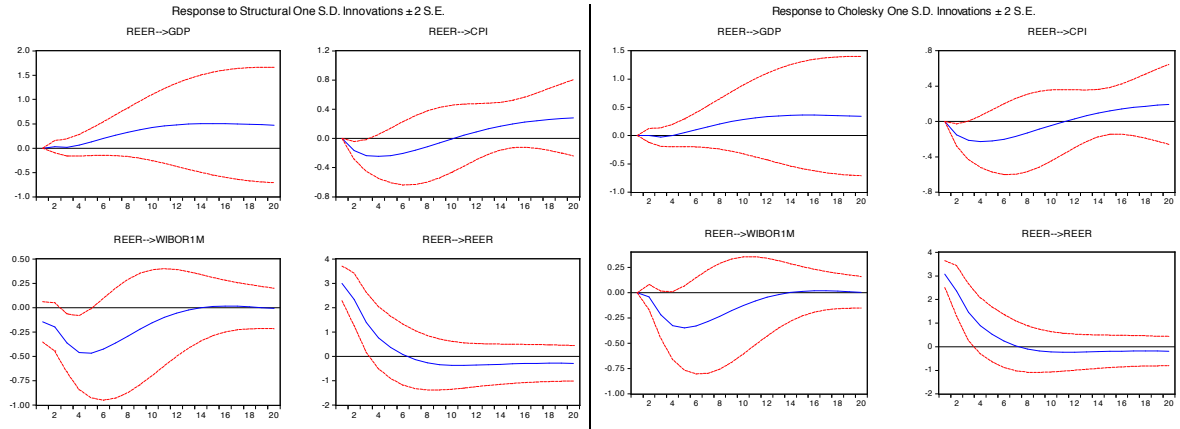


Source: own calculations.

A shock to the exchange rate does not seem to impact GDP (Figure 4). On the other hand, there is a statistically significant albeit relatively low pass-through effect (about 7-8%). Also, there is a statistically significant reaction of the interest rate to the exchange rate.

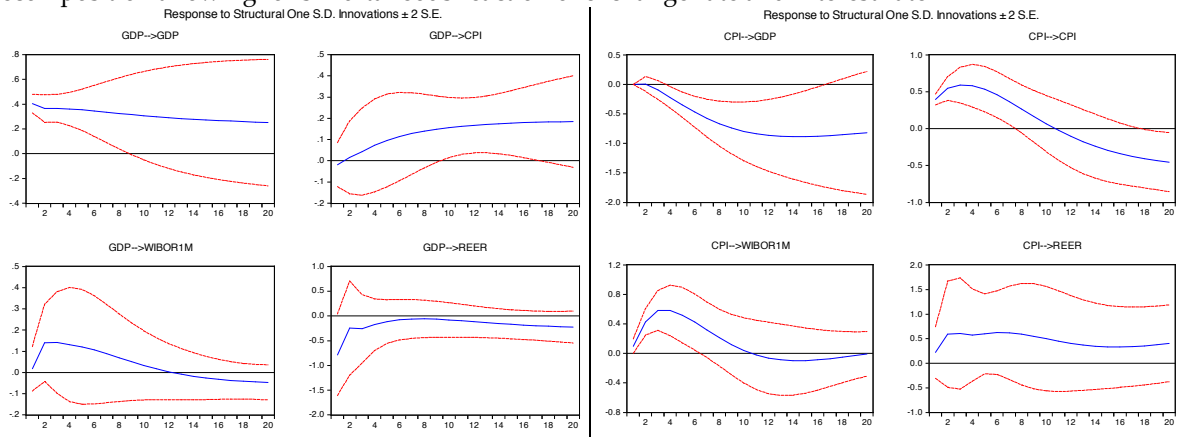
A positive shock to inflation, which can be due to a negative supply-side shock, has a negative impact on output and leads to a statistically significant interest rate increase. A shock to the real sector tends to increase prices, but seemingly does not induce in a statistically significant way interest rate reaction (responses from both decompositions are very similar, thus we show only those obtained from the structural decomposition, see Figure 5).

Figure 4. Response reaction functions to exchange rate shock (appreciation) from decomposition allowing for simultaneous reaction of exchange rate and interest rate (left panel) and standard Cholesky decomposition (right panel)



Source: own calculations.

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



Source: own calculations.

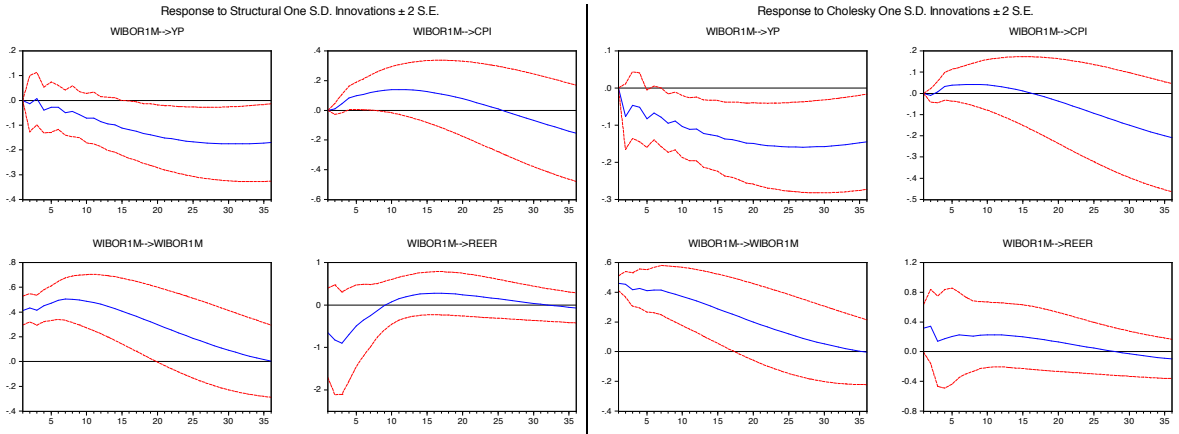
In contrast to results on quarterly data, those of monthly frequency and obtained from a semi-structural (Cholesky) decomposition are more clear and intuitive than those from the structural decomposition[12]. In general though, the picture is similar to the one obtained from our quarterly estimations.

Industrial output falls after monetary policy shock and this effect may be even somewhat stronger than that obtained in the previous report (Demchuk *et al.*, 2012). The reaction of prices is more problematic, since once again we obtain a price puzzle (Figure 6). After the exchange rate innovation (appreciation) there is

[12] In the other part of the report, in which we analyse responses of other variables to the monetary policy shocks, we are referring only to the Cholesky decomposition.

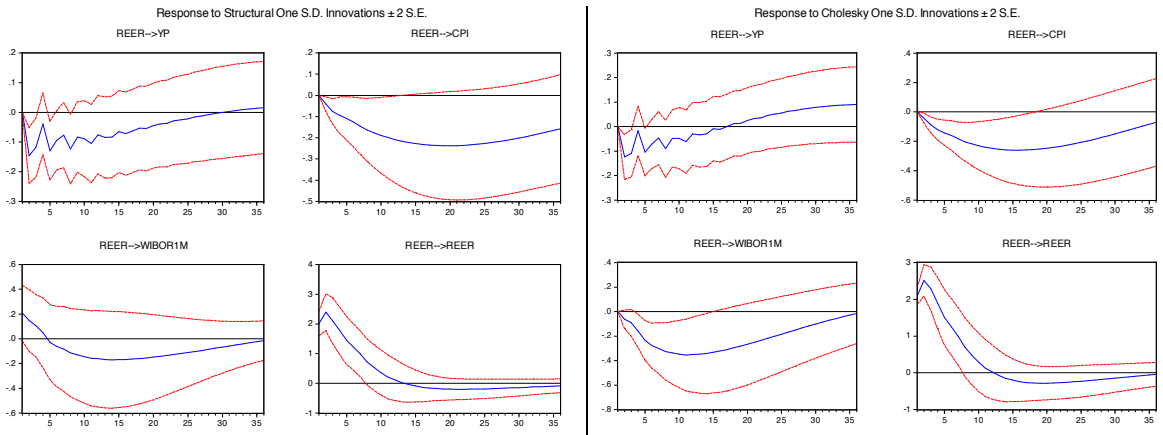
a transitory and small drop in output (Figure 7). Exchange rate pass-through is statistically significant, and here somewhat bigger (it is about 10-15%) than that obtained from the quarterly data. Moreover, as from the quarterly data, monthly estimates (Cholesky decomposition) display a negative response of the interest rate after the exchange rate shock.

Figure 6. Response reaction functions to monetary policy shock (interest rate increase) from decomposition allowing for simultaneous reaction of exchange rate and interest rate (left panel) and standard Cholesky decomposition (right panel)



Source: own calculations.

Figure 7. Response reaction functions to exchange rate shock (appreciation) from decomposition allowing for simultaneous reaction of exchange rate and interest rate (left panel) and standard Cholesky decomposition (right panel)

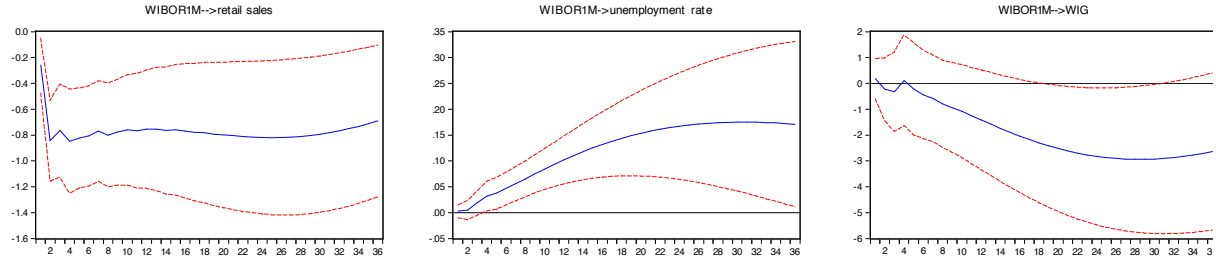


Source: own calculations.

Using VARs we have also checked the impact of monetary policy tightening on other macroeconomic variables (Figure 8). Retail sales drop, the unemployment rate increases as expected. Both results are statistically significant. Monetary policy also affects financial markets: the monetary policy shock lowers the Warsaw

Stock Exchange Index or WIG thereafter (here the result is close to the statistical significance). Figure 26 in Annex 1 also presents the reaction of the main economic variables to a shock to financial assets prices (WIG in real terms). We interpret this as a shock to wealth. There is an increase in output and prices after a positive wealth shock and possibly some appreciation of the exchange rate resulting from capital inflow and a lower perception of risk[13].

Figure 8. Response reaction functions of retail sale of goods and services, unemployment rate and financial assets price (WIG) to monetary policy shock, Cholesky decomposition



Source: own calculations.

All in all, the results obtained from the VAR models show that the real sector reacts to interest rate shocks. GDP, industrial production and retail sales drop after monetary policy tightening. There is an increase in the unemployment rate. On the other hand, the reactions of the real sector to the exchange rate shock are much less visible (there is only a transitory negative effect on industrial output). For prices we conclude that the effect of pass-through is well documented and it seems to be lower than we used to obtain in our previous estimations (Przystupa, Wróbel, 2012). The existence of a price puzzle makes it difficult to draw conclusions about price reactions to the interest rate shock. The interest rate shock has also some impact on the prices of financial assets.

2.2. Simulations of the monetary policy transmission mechanism on small structural models

2.2.1. Structural models MMT 2.0 and QMOTR used for simulations

We analyse the impact of interest rate changes on economic activity and inflation with the use of two recently developed structural models[14].

The first one is the Small Model of Monetary Transmission, MMT 2.0. Its version used in this report is substantially developed with respect to the version used in the previous report (Demchuk *et al.*, 2012). MMT 2.0 is similar to the model used by the Bank of Israel (Argov *et al.*, 2007). It reflects the transmission of monetary policy impulses to financial markets in a more complex way than previously due to the fact that there

[13] Using the WIG 20 index (which is based solely on prices) instead of WIG (which also contains dividends and subscription rights) does not change these results; the reactions of main variables are very similar.
[14] Both models used in this report are still preliminary. A non-technical description of these models is presented in Annex 2.

are three interest rates (i.e. money market rate, loan rate and yields on Treasury bonds) and the volume of loans introduced to its structure. In addition the proxy for fiscal policy is explicitly included in the model as its endogenous variable. Taking into account differences in the estimated degree of forward-lookingness of inflation expectations formed by different groups of economic agents in Poland (see section 3.4 of this report), in the hybrid New Keynesian Phillips Curve of the MMT 2.0 we use model-consistent expectations instead of their survey-based measures.

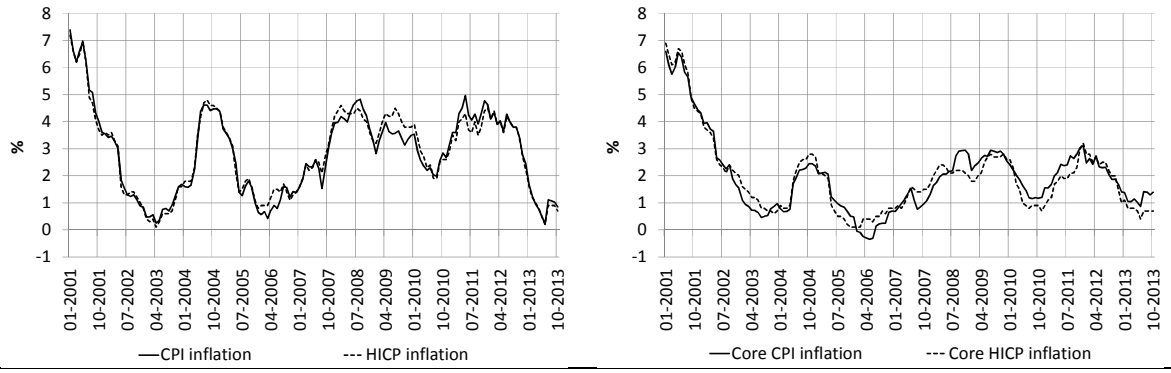
The second tool is the Quarterly Model of Transmission (QMOTR) with stochastic shocks, built on the basis of the concept of Global Projections Models (GPM), developed by the International Monetary Fund (e.g. Carabenciov *et al.*, 2008). QMOTR combines the standard features of GPM models with country-specific solutions. To enrich interpretation possibilities, there are two blocks added, i.e. the block of loan interest rate and the block of government expenditure. In addition, we disaggregated residuals (shocks) in the main equations of the model. The QMOTR model was estimated with the use of Bayesian techniques.

There are two main features linking MMT 2.0 and QMOTR with structural models of the monetary transmission used in our previous analyses. Firstly, they are built in the spirit of new Keynesian macroeconomics. Secondly, the basic variables (interest rate, interest rate on loans, GDP, government spending) are expressed as deviations from their respective long-term equilibria. In turn, endogenisation of macroeconomic equilibria[15] and a greater degree of forward-lookingness are the essential features distinguishing the new models from the previous ones.

It should be mentioned that core HICP inflation excluding foodstuffs and energy is the main measure of inflation used in both these models. The main reason for replacing CPI inflation with HICP inflation was the need to make domestic and foreign variables comparable (in this way the real exchange rate and the real interest rate are deflated with the same type of price index). In 2001-2013 – i.e. the sample period used to estimate both models – the levels of respective types of both indices were similar (Figure 9). The correlation coefficient between CPI and HICP inflation was approx. 0.99, while correlation between core measures of CPI and HICP inflation – approx. 0.97. The correlation coefficient between core HICP inflation and CPI overall inflation was about 0.78.

[15] In MMT equilibria were approximated by constants obtained from individual equations. In MMT 2.0 and QMOTR equilibria are directly built into the model structure. The (rends) are obtained from Hodrick-Prescott filter MMT 2.0 and then incorporated into a model as autoregressive processes. In QMOTR they are embedded in its structure as state space models. Therefore equilibria in MMT 2.0 have a smaller variance (while deviations of each variable from its equilibrium – greater) than in the QMOTR. 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 than in MMT 2.0, whereas the opposite is true for the length of the reaction.

Figure 9. CPI and HICP total inflation (left panel) and CPI and HICP core inflation, without food and energy prices, (right panel)



Source: data from NBP and ECB.

2.2.2. Strength and delays in the monetary transmission mechanism estimated with the use of structural models

To assess the strength and delays of the monetary transmission mechanism in Poland we analyse the results of the simulation, in which the short-term interest rate (WIBOR 3M) is increased by 1 p.p. for a period of one quarter and subsequently is determined on the basis of the monetary policy rule[16].

The results of the simulation obtained from the MMT 2.0 model show that the peak response of GDP growth to interest rate impulse occurs in the 3rd and 4th quarter after the impulse and amounts to approx. -0.2 p.p. The peak response of inflation occurs with a larger, 5-quarter lag and amounts to approx. -0.3 p.p.

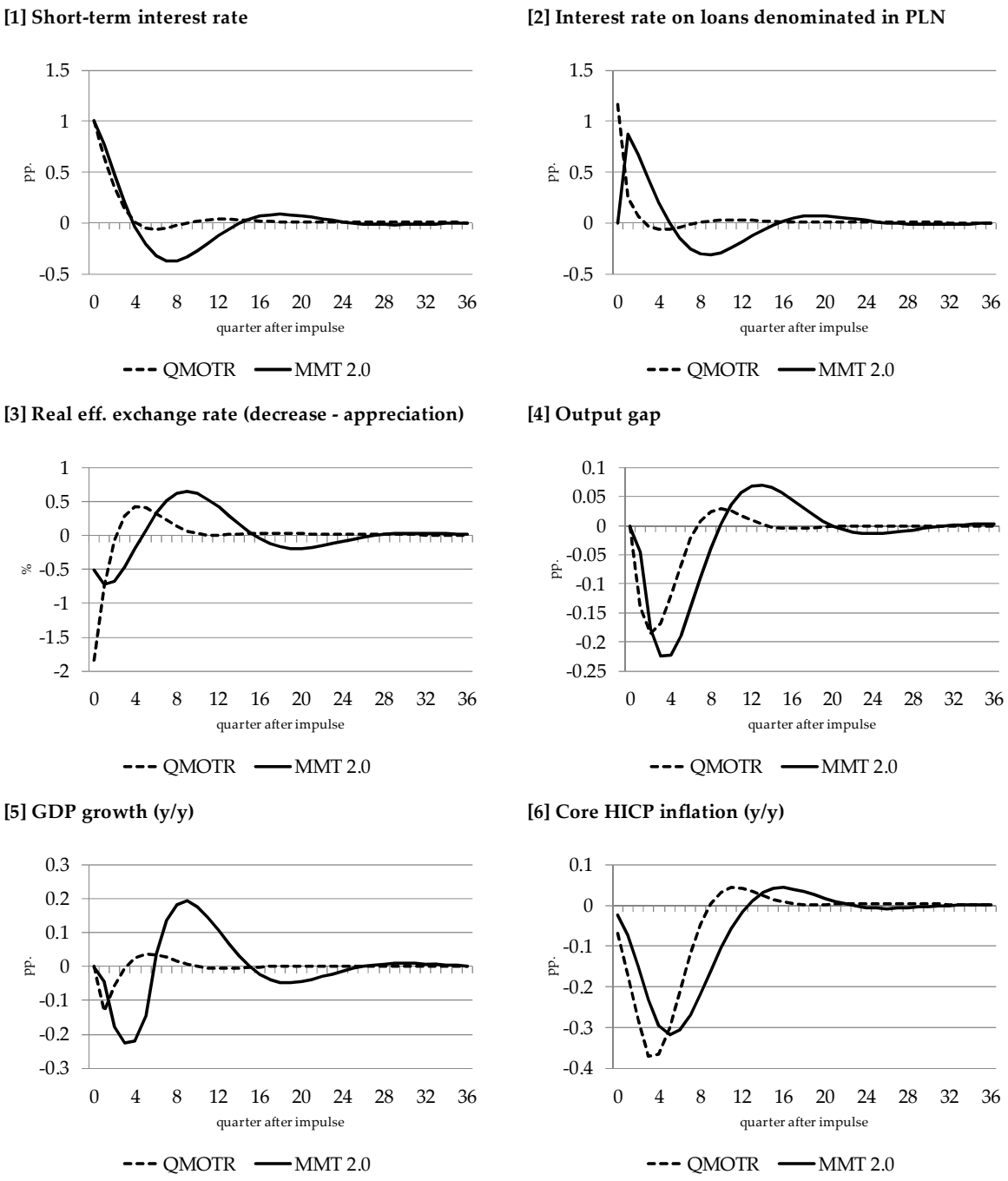
The responses based on the QMOTR model are faster than in the case of the MMT 2.0 model[17]. The peak response of GDP growth to interest rate impulse occurs in the 1st quarter after the impulse and amounts to approx. -0.1 p.p. The peak response of inflation occurs with a 3-quarter lag and amounts to approx. -0.4 p.p.

[16] Let us note that in a similar simulation presented in the previous report (Demchuk *et al.*, 2012), we analysed a change of the interest rate by 1 p.p. for 4 quarters with the subsequent return to its baseline value. The features of the QMOTR model do not allow a repeat of such a simulation. The responses to the interest rate impulse of this kind are presented in the next section (2.2.3).

[17] In QMOTR, dynamics of the economic processes are formed by various shocks, unobserved, identified via data and model. The shocks have an economic interpretation (contrary to residuals in the standard gap models) therefore the reaction functions obtained from this model are similar to the reaction of DSGE models (see Grabek, Kłos and Koloch, 2011; Grabek and Kłos, 2013). Showing differences in reactions between MMT 2.0 and QMOTR we draw attention to a certain duality, uncertainty and immaturity of the economy, which can react to the monetary policy impulse not necessarily always in the same way. For example, if the expected reduction of the NBP reference rate results in the outflow of short-term capital, the depreciation will be immediate and adequately strong, but secondary effects will be relatively small (QMOTR – classic UIP), while in a situation where short-term capital outflow is corrected by an inflow of investment capital, the reaction rate will be weaker, but the period of return to equilibrium – longer (MMT 2.0 – behavioral equation of exchange rate).

The responses of the interest rate on zloty denominated loans (total), real effective exchange rate, output gap and GDP growth, core HICP inflation excluding foodstuffs and energy to the monetary policy impulse is presented below (Figure 10, Table 10).

Figure 10. Monetary transmission mechanism – results from MMT 2.0 and QMOTR models



Source: own calculations.

Table 10. Monetary transmission mechanism – synthesis of results from MMT 2.0 and QMOTR models

	MMT 2.0	QMOTR
Interest rate on credits in PLN		
strength of maximal reaction (in p.p.)	0.88	1.17
lag of maximal reaction (quarter)	1	0
Real effective exchange rate (decrease=appreciation)		
strength of maximal reaction (in p.p.)	-0.72	-1.84
lag of maximal reaction (quarter)	1	0
Output gap		
strength of maximal reaction (in p.p.)	-0.22	-0.18
lag of maximal reaction (quarter)	3-4	2
Dynamics of GDP y/y		
strength of maximal reaction (in p.p.)	-0.22	-0.13
lag of maximal reaction (quarter)	3-4	1
Core inflation HICP y/y		
strength of maximal reaction (in p.p.)	-0.32	-0.37
lag of maximal reaction (quarter)	5	3

Source: own calculations.

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

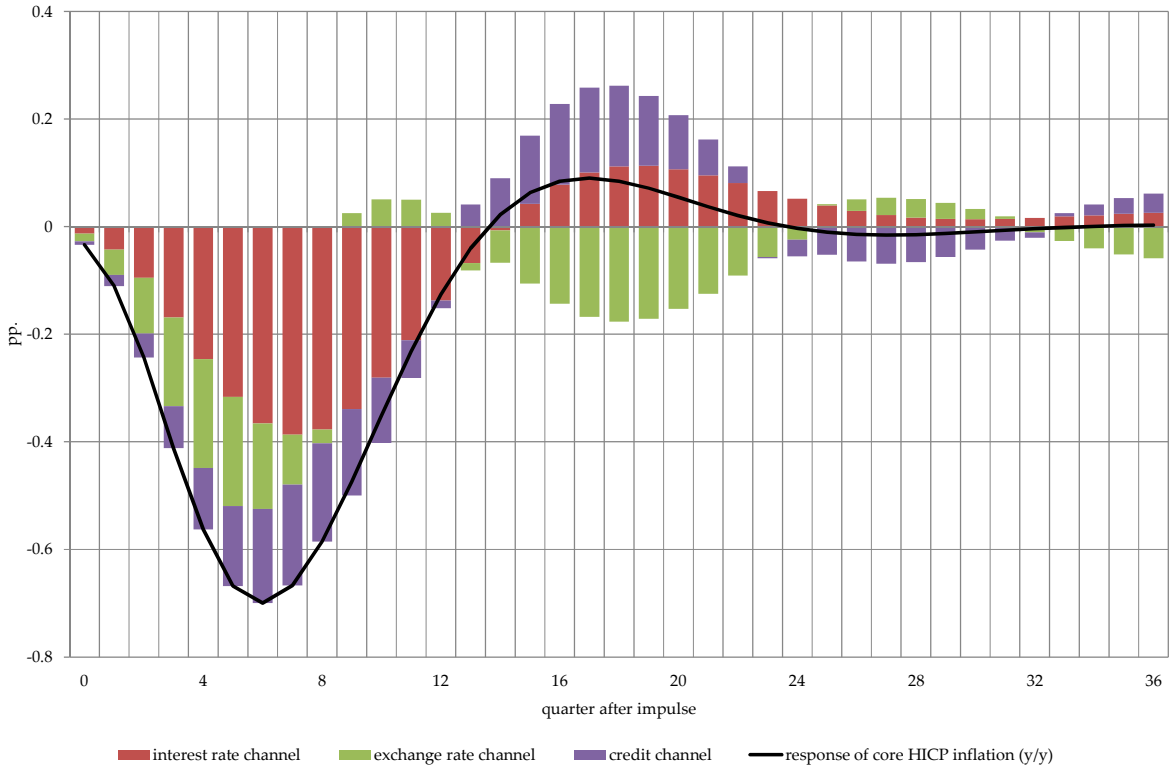
Using the MMT 2.0 model, an additional simulation was run in order to approximately evaluate the relative strength of monetary transmission channels. In the model there are three main monetary transmission channels represented, i.e. the interest rate channel, the exchange rate channel and the credit channel. As far as the credit channel is concerned, we assume that the credit variable in the 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. We are aware that this assumption is simplified and can overestimate the effects of the credit channel.

The exercise was run in three steps. In the first step, the response of inflation to an increase in the short-term interest rate by 1 p.p. for the period of 4 quarters was evaluated. This period is longer than in the simulations of the transmission mechanism described in section 2.2.2, that makes the effects of individual transmission channels more visible and the overall inflation response is comparable with the results described in the previous report (Demchuk *at al.*, 2012). Next, in an analogical simulation, the nominal effective exchange rate was fixed, thus giving an approximation of the effect of interest rates on inflation through the interest rate channel and the credit channel. In the last step, we additionally fixed the proxy for the credit channel operation (i.e. the volume of credit in the IS curve), obtaining the assessment of its relevance.

Taking into account all the channels of the monetary transmission (Figure 11), the peak response of inflation occurs with a 6-quarter lag and amounts approx. to -0.7 p.p. The interest rate is the strongest transmission channel in Poland. The strength of the exchange rate channel and the credit channel are comparable with each other, but the former operates with shorter delays than the latter. The peak response of annual price

dynamics is caused in approx. 52% by the interact rate channel effects, in approx. 23% – by the effects of the exchange rate channel and in approx. 25% – by the effects of the credit channel.

Figure 11. Strength of particular channels of monetary transmission mechanism



Source: own calculations.

Comparing the strength and delays of the monetary transmission mechanism in the MMT 2.0 model with the results of analogous simulation based on the previous version of the model (MMT) and shorter sample of observations (Demchuk *et al.*, 2012) we notice, that according to both models the interest rate channel is the strongest channel of monetary transmission in Poland, while the peak response of inflation to the monetary policy impulse occurs after approx. 6 quarters. Analysing the strength of the monetary transmission mechanism in Poland we observe, however, that the response of inflation presented above is significantly larger than in the MMT model, despite the fact that the output gap and GDP growth in both models respond in a similar way, while appreciation effects in MMT 2.0 are even smaller than in the MMT model (Table 11).

An overview of the structural features of the Polish economy, especially the development of the financial system, explains the results of our subsequent studies[18] suggesting a gradual strengthening of the monetary transmission mechanism in Poland. The relatively strong inflation response presented in this report is, however, somewhat surprising, especially taking into account that we find no substantial changes in the

[18] E.g. Łyziak (2002), Kłos *et al.* (2005), Demchuk *et al.* (2012).

response of economic activity to the interest rate impulse and conclude that the exchange rate channel has become weaker than in the past (both in terms of the scale of exchange rate appreciation after the increase of the domestic interest rate and pass-through effects on consumer prices)[19].

The deepening of the inflation response to monetary policy impulses can be to some extent model-specific, reflecting differences between models used in the current and the previous reports. Including credit volume in the MMT 2.0 and the increased role of expectations makes the model better suited to reflect the functioning of the monetary transmission mechanism in Poland than the MMT model that was likely to underestimate the effects of the credit channel and expectations. Moreover we should point out that the MMT 2.0 model includes time-varying equilibrium values of the main macroeconomic variables and operates with the measures of inflation and inflation expectations (core HICP inflation excluding foodstuffs and energy, model-consistent expectations) different from the MMT model (core CPI inflation excluding foodstuffs and fuels, survey-based measures of inflation expectations). The above reasons suggest that a direct comparison of the simulation results from both models is problematic.

Independently of the model-specific problems indicated above, a deeper analysis of the simulation results suggests some economic factors that can contribute to our findings of a relatively strong impact of the interest rate impulse on price dynamics. Firstly, estimation results of the hybrid New Keynesian Phillips Curve used in the MMT 2.0 model – in line with the evidence on this relationship as estimated with the use of survey-based measures of inflation expectations (Łyziak, 2013a) – show that currently changes in demand pressure influence the price level with smaller delays and their impact is slightly larger than in the past. This observation seems consistent with the results based on the NBP labour market surveys indicating that during the last 3 years the impact of demand variables on wages has become stronger.[20] At the same time, NBP business surveys suggest that the frequency of price adjustments by enterprises has slightly increased recently and the enterprises have used more frequently variable mark-ups than the constant mark-ups.[21]

Secondly, estimation of the MMT 2.0 model equations indicate an increased role of expectations – both in influencing current economic activity and price setting. The estimated degree of forward-lookingness in the MMT 2.0 Phillips curve (approx. 0.44) is similar with forward-lookingness of inflation expectations of Polish enterprises, as estimated on the basis of survey data (see section 3.4.3). It is however higher than in the pre-crisis period (approx. 0.38) and significantly higher than in the previous version of the model that used survey-based measures of consumer inflation expectations while estimating the Phillips curve.

The above factors make the interest rate channel quicker than in the past. Its effects magnify the direct effects of the exchange rate channel exerted on import prices, so the response of inflation becomes stronger than presented in the previous report[22]. It should be highlighted however that this observation is to some extent model-specific, reflecting the higher role of the credit channel and expectations in the MMT 2.0 mod-

[19] The exchange rate pass-through in the MMT 2.0 model (approx. 0.11) is lower than in the previous version of the model.
[20] See: Badanie Ankietowe Rynku Pracy. Raport 2013, Economic Institute, NBP, http://www.nbp.pl/publikacje/arp/raport_2013.pdf.
[21] See: Szybki Monitoring NBP. Informacja o kondycji sektora przedsiębiorstw ze szczególnym uwzględnieniem stanu koniunktury w II kw. 2013 oraz prognoz koniunktury na III kw. 2013 roku, Economic Institute, NBP, http://www.nbp.pl/publikacje/koniunktura/raport_3_kw_2013.pdf.
[22] It should be noted that a significant deepening of the inflation response is caused by the lower delays between changes in the demand pressure and inflation, even with the strength of this relationship unchanged.

el, while economic factors contributing to the presented results can be temporal, connected with the specific features of the recent years added to our analysis (faster adjustment to news of economic agents and the increased role of expectations during the period of financial crisis disturbances).

Table 11. Monetary policy transmission mechanism – synthesis of results from MMT 2.0 and MMT (Demchuk *et al.*, 2012) models

	MMT 2.0	MMT (Demchuk *et al.*, 2012)
Interest rate on credits in PLN		
strength of maximal reaction (in p.p.)	0.90	0.98
lag of maximal reaction (quarter)	4	3
Real effective exchange rate (decrease=appreciation)		
strength of maximal reaction (in p.p.)	-1.24	-1.76
lag of maximal reaction (quarter)	3	2
Demand gap		
strength of maximal reaction (in p.p.)	-0.43	-0.42
lag of maximal reaction (quarter)	5	6
Dynamics of GDP y/y		
strength of maximal reaction (in p.p.)	-0.33	-0.33
lag of maximal reaction (quarter)	5	4
Core HICP inflation y/y		
strength of maximal reaction (in p.p.)	-0.70	-0.34*
lag of maximal reaction (quarter)	6	6

* Core CPI inflation without food and fuels.

Source: own calculations.

3. Operation of respective transmission channels

3.1. Interest rate channel

Analysis of the interest rate channel covers the period from January 2005 to mid-2013 and employs, apart from money market rates, data on interest rates collected by NBP – on both aggregated (i.e. average weighted interest rates for all banks participating in the statistics, section 3.1.2.1) and individual level (i.e. interest rates in individual banks, section 3.1.2.2). It is based on estimates of models assuming the existence of an equilibrium relation between the NBP reference rate and money market rates – in the case of the first transmission step – or between the money market rate and interest on a given bank product – in the further steps of transmission. The advantage of employing individual data is that larger numbers of observations (compared to aggregated data) makes it possible to compare features of interest rate transmission before and after the outburst of the financial crisis.

The results obtained on aggregated and individual data might differ. Firstly, despite the fact that they come from the same source, in the case of individual data, the shortest and/or discontinuous series have been excluded from the sample. Secondly, the aggregated data is influenced mostly by interest rates in banks with a large share in the market (for a given product). Therefore, if the transmission differs across banks (see section 3.1.2.3), it may lead to different results in both approaches.

The analysis is conducted for total deposits and credits to households and firms, as well as for more detailed categories (Table 12, Table 13). Non-financial sector deposits are mostly short-term. In the case of households, the greatest role is played by deposits with maturity up to 1 month and from 1 to 3 months, while in case of firms – those with a maturity up to 1 month. Credits to households make up almost 50% of credits for consumption. The second most important category (in terms of volume) is credit for housing purposes. When it comes to credits to firms, those relatively large (i.e. above 4 million PLN) prevail.

Table 12. Term structure of deposits in PLN from households and firms (new businesses)*

Category	Households' deposits	Firms' deposits
up to 1 month	52%	88%
from 1 to 3 months	24%	10%
from 3 to 6 months	12%	2%
from 6 to 12 months	10%	0%
above 12 months	2%	0%

* Average in 2005-2012, based on interest rate statistics.

Table 13. Structure of credits in PLN granted to households and firms (new businesses)*

Category	Share in total credits in PLN
Credits to households	
consumption credits	45%
credits for housing purposes	31%
credits to sole entrepreneurs	10%
credits for other purposes	14%
Credits to firms	
up to 4 million PLN	32%
above 4 million PLN	68%

* Average in 2005-2012, based on interest rate statistics.

3.1.1. Transmission in the money market

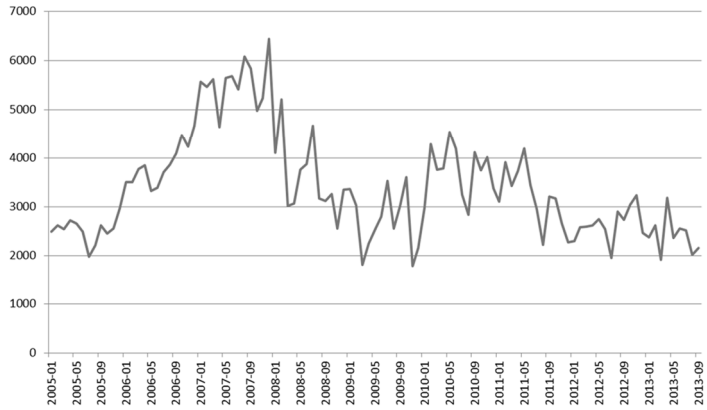
The first stage of the monetary transmission mechanism is the transmission from the central bank interest rate to money market rates. The financial crisis significantly disturbed money market operations: the volume of transactions and their term structure, as well as interest rates.

The volume of transactions in the interbank market is still low (see Figure 12). The market is dominated by short-term transactions, after the financial crisis one-day transactions accounted for about 90% of turnover. The longer term transactions are rare and for low amounts[23]. Nevertheless, the spreads that increased significantly during the crisis, normalized and now are close to zero. POLONIA moves close to the NBP reference rate and changes in the reference rate are well reflected in its changes (Figure 13)[24].

[23] As mentioned in our previous report (Demchuk *et al.*, 2012), during the global crisis the money market rates lost some of their informational value, which led to problems in the subsequent stages of the transmission. But since the end of 2011, NBP and UKNF have introduced several measures that are aimed at improving the quality of WIBOR and WIBID rates. The details are described in the NBP Financial Stability Report 2013.

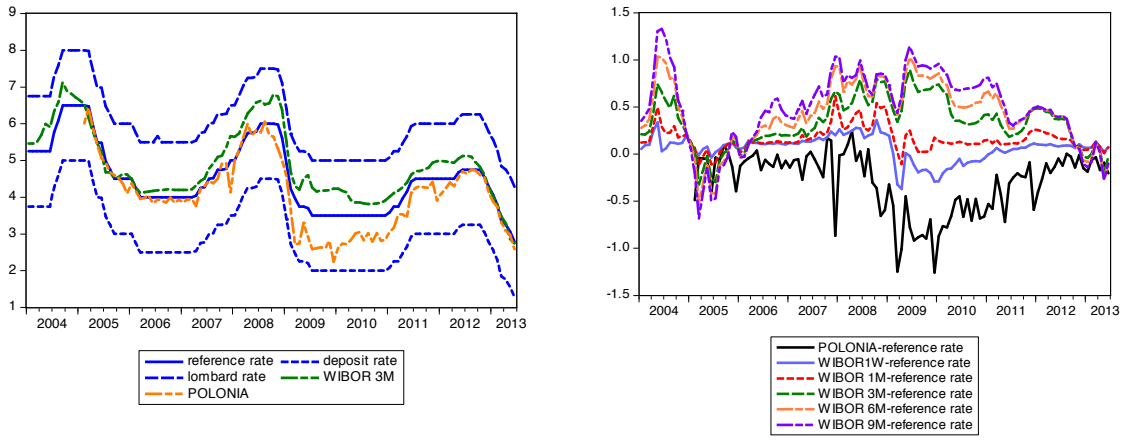
[24] It is worth noting that since June 2012 the POLONIA rate is characterized by a lower variability and its deviation from the reference rate has decreased. This is the result of regular NBP fine-tuning operations.

Figure 12. O/N turnover in the interbank market (in PLN million)



Source: NBP data.

Figure 13. Money market rates (left panel) and spreads between money market rates and the NBP reference rate (right panel)



Source: NBP data.

The assessment of cumulative changes in selected interest rates in periods of monetary policy tightening and easing shows that changes in the NBP reference rate are reasonably well transmitted to the changes in money market rates (Table 14).

Table 14. Cumulated changes of selected interest rates in periods of monetary policy tightening and easing (based on 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	0.78	0.62	0.50
2012:05-2012:06	0.25	0.23	0.20	0.18	0.17	0.17
2012:11-2013:08	-2.25	-1.97	-1.99	-2.08	-2.14	-2.14

* It should be noted that the relatively strong decline in WIBOR rates in this period resulted from their increase at the beginning of the financial crisis with a constant NBP reference rate.

The pass-through from the NBP reference rate to the money market rates is fast and in the case of the rates with maturity below 1 week (POLONIA, WIBOR 1W) it is complete. Both the immediate pass-through and the long-term adjustment are very high. The speed of transmission equals about 0.3 month for WIBOR 1W and WIBOR 1M. The adjustment of WIBOR 3M, WIBOR 6M and WIBOR 9M is fully captured by the immediate pass-through coefficient. The shorter the maturity of the interest rates, the higher their immediate adjustment.[25]

Table 15. Results of the estimation of error correction models for monthly data for the period from January 2005 to June 2013

	immediate pass-through	long term adjustment coefficient	Is adjustment complete?	Speed of transmission (months)
POLONIA	0.90	0.99	yes	0.21
WIBOR 1W	1.04	1.01	yes	0.27
WIBOR 1M	1.07	1.04	no	0.30
WIBOR 3M	0.96	-	-	-
WIBOR 6M	0.91	-	-	-
WIBOR 9M	0.88	-	-	-

Notes: speed of adjustment may be interpreted as the number of months needed to return to long-term equilibrium after a change in the monetary policy rate; the dummy variable equal 1 since September 2008 was added for POLONIA.

[25] Additionally, we estimated similar error-correction models for the longer sample between January 1998 and June 2013. The results for the longer sample seem to be quite similar. The transmission is a bit faster for all of the analysed money market interest rates. It is probably because of the lower weight of the crisis disturbances. For WIBOR 6M and WIBOR 9M we are not able to detect the long-term adjustment and the immediate pass-through appears to be lower for the longer sample. It may show that the transmission for these rates improved slightly over time.

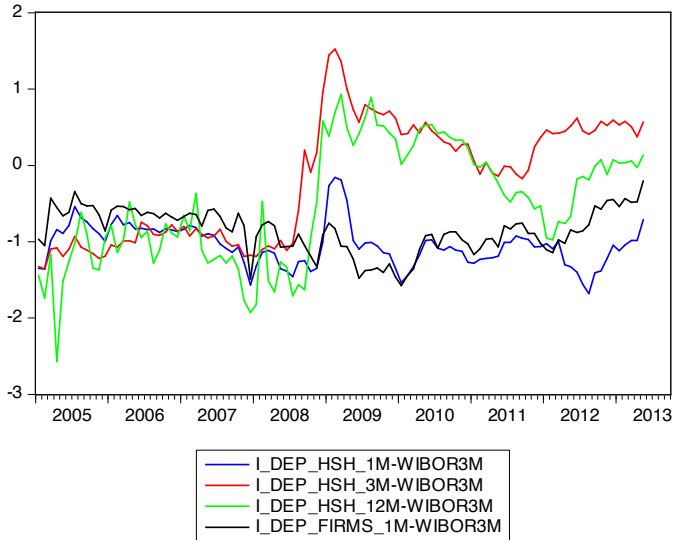
3.1.2. Transmission to deposit and lending rates in commercial banks

3.1.2.1. Analysis of short- and long-term reactions on aggregated data

To estimate a long-run relationship between retail rates and money market rates (either WIBOR 1M or WIBOR 3M) we have used Vector Error Correction Models (VECM). In this approach disequilibrium between deposit/loan rates and money market rates is eliminated through an adjustment of the retail rate. In some cases, i.e. if there is a considerable share of competing products in foreign currencies (in the Polish case this mostly concerns loans to households and enterprises), we have added the foreign interest rate (EURIBOR 3M) to the cointegrating space. Taking into account disturbances in the interest rate pass-through after the Lehman Brothers collapse in September 2008, we use a dummy (which takes 0 up to August 2008 and 1 thereafter). In most cases this variable turned out statistically significant.

We start our analysis of pass-through showing spreads between the money market rate (WIBOR 3M) and selected rates on new deposits and loans. As is clear from Figure 14 and Figure 15, spreads have not returned to the pre-crisis level. There is even some increase in spreads observed recently and apparently due to the second phase of the financial crisis, worse macroeconomic conditions in Poland and increased perception of risk (deposits of households up to 3 and 12 months, loans for consumption and housing).

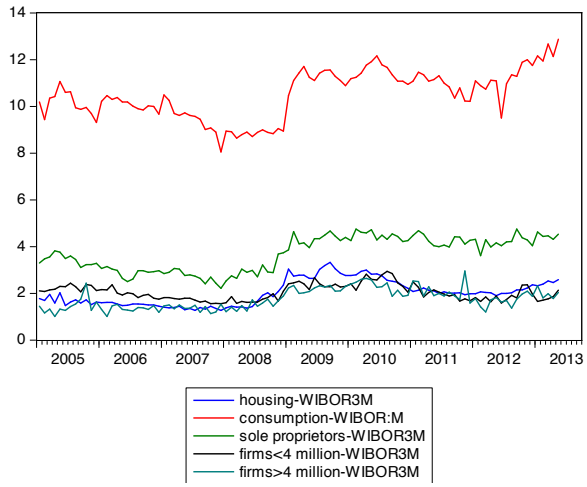
Figure 14. Spreads between WIBOR 3M and interest rates on households and firms deposits



Notes: *I_DEP_HSH_xM* (*I_DEP_FIRMS_xM*) denotes rates on deposits from households (firms) with maturity up to x months.

Source: NBP data.

Figure 15. Spreads between WIBOR 3M and interest rates on credits to households and firms



Source: NBP data.

We analyze interest rates on deposits of households of maturities: up to 1 month, from 1 to 3 months, from 6 to 12 months. For the corporate sector we investigate only deposits up to 1 month, since they consitute the predominant portion of new deposits of firms (see Table 12). Then we pass to interest rates on loans and estimate pass-through to loans for consumption and housing, for individual producers, for the corporate sector up to 4 million PLN and on big loans (above 4 million PLN). The results are presented in Table 16.

There is a full interest rate pass-through to the average interest rate of deposits of households (we cannot reject the restriction that the coefficient of long-term adjustment equals 1). This is mainly due to the reaction of deposits of a shorter term to maturity (deposits of maturity of 12 months adjust to a lower level). On the other hand, deposits from 1 month to 3 months seem to overreact (we obtain a long-term adjustment coefficient higher than 1). This results from banks' behaviour after the Lehman Brothers collapse: banks tended to search for liquidity of maturies exceeding 1 month and therefore increased interest rates on deposits to the level above the respective money market rate (Figure 14). We expect that this coefficient will fall with time and with a gradual absorption of these disturbances (compared with the last estimate (Demchuk *et al.*, 2012) it is already lower by almost 0.3 p.p.).

It is worth noting that the dummy which was to capture the increase in the retail rates due to the financial crisis is statistically significant for households' deposits of maturity from 1 to 3 months, average households' deposit rates, loans for housing purposes and loans to sole proprietors (small firms included in the household sector). It was statistically insignificant in the case of deposits of maturity up to 1 month of both househods and enterprises, deposits of households from 6 to 12 months and loans to the enterprise sector. As mentioned before, in the initial phase of the financial crisis banks looked for liquidity for maturities exceeding 1 month, short-term liquidity was provided by NBP, thus banks increased interest rates on short-term deposits much less than deposits of maturity of 3 months. Coefficients obtained at the dummy variable varied from 0.8 in the case of the average rate on household deposits, 1.1 in the case of loans for housing to 1.9 in the case of loans to the sole proprietors. Based on this estimate, we conclude that

banks perceived a higher risk with respect to loans to the sole proprietors than households for housing purposes.

Disequilibrium between money market rates and deposit rates tends to be eliminated rather slowly, slower than in the case of deposits of the enterprise sector. The speed of adjustment of loan rates is more diversified and it is difficult to find clear-cut regularities.

There is a complete pass-through of money market rates to the average rate on loans for both households and the enterprise sector. In the case of the pass-through process to the rates on loans for housing and to rates on loans up to 4 million PLN for the enterprise sector, not only domestic, but also foreign interest rates (EURIBOR 3M) were found statistically significant. For example, in the model of the rate on housing loans when we do not impose a restriction of a full pass-through, both coefficients standing at WIBOR 3M and EURIBOR 3M equal 0.6. With the complete pass-through restriction the latter falls to 0.17. There is a similar situation in the case of a pass-through to the rates on loans up to 4 million PLN to the corporate sector, i.e. banks include EURIBOR in their pricing model.

We have not found a long-term relationship between money market rates and rates on loans for consumption. This is probably due to the fact that unlike other loans, loans for consumption do not have collateral and therefore in their case pass-through is significantly affected by risk, both macroeconomic and idiosyncratic.

Table 16. Estimates of long-run adjustment coefficients of transmission from money market rates to deposit and lending rates, 2005:01-2013:05, aggregated data

Interest rate	Long run adjustment coefficient	Is adjustment complete?	Loading coefficient
Households' deposits			
total	1.08	yes	-0.16
up to 1 month	1.07	yes[(1)]	-0.09
from 1 to 3 months	1.4	no	-0.08
from 6 to 12 month	0.87	no[(2)]	-0.37
Firms' deposits			
up to 1 month	1.02	yes[(3)]	-0.33
Credits to households			
total	1.02[(4)]	yes	-0.48
for consumption		no cointegration	
for housing purposes	0.61[(5)]	yes	-0.12
to sole proprietors	1.35[(6)]	no	-0.22
Credits to firms			
total	1.02	yes	-0.36
up to 4m PLN	0.59[(5)]	no	-0.14
above 4m PLN	0.94[(7)]	yes	-0.51

Notes:
(1) complete pass-through restriction disturbed in 2008;
(2) formal tests do not reject hypothesis of complete pass-through, but test on stability of restriction indicate quite long periods when it did not hold;
(3) complete pass-through restriction unstable in years 2008-2009;
(4) cointegrating relation unstable in the period 2009-2011;
(5) significant role of EURIBOR;
(6) cointegrating relation unstable in the period 2007-2008;
(7) cointegrating relation exists on condition of including demand variable in the cointegrating space;

3.1.2.2. Analysis of short- and long-term reactions on individual commercial bank data

The analysis of the long run pass through is based on an estimation of the cointegrating equation between the given type of retail rates and market rate[26] on the full sample (i.e. from January 2005 to July 2013) and on two sub-samples delimited by the beginning of the severe phase of the financial crisis. It is assumed that for a given bank product the long run multiplier is the same for all banks, while long run margins are set individually by each bank.

Table 17 presents estimates of the long run pass through for these interest rate types of households' and firms' deposits and credits, for which tests confirmed the existence of a cointegration relationship.[27] In esti-

[26] In the case of deposits with maturity up to 1 month WIBOR 1M is employed and for all other interest rate categories – WIBOR 3M.
[27] Statistical tests indicated cointegrating relations for all interest rate types except rates on consumer credit in the full and post crisis sample.

mations on the full sample, a shift in the spread in the period after the outbreak of the financial crisis was taken into consideration.[28]

The full sample results indicate that in the long run market rates are fully transmitted to the rate on firms' deposits (total and in division to different maturities) and to some rates on households' deposits (with maturity from 1 to 3 months and from 3 to 6 months). In the case of other households' deposit rates the long run multipliers are significantly lower than one and range from 0.79 to 0.84. When it comes to lending rates, for households' the adjustment in the long run is complete while for firms it amounts only to about 80%.

Estimates of the long run multipliers on shorter samples imply that in the period after the outbreak of the financial crisis, the scale of the long run adjustment of rates on households' total deposits has increased, which resulted from a stronger transmission to rates on deposits with maturity from 1 to 3 months (Table 17). The strength of long run reaction has also increased in the case of rates on firms' deposits, and except for those with the shortest maturity, it exceeded one in the last few years. In the case of lending rates, coefficients of long run adjustment have decreased.[29]

It should be noted that the changes refer not only to the scale of adjustment, but also to levels to which the interest rates converge. As shown in Figure 14 and Figure 15, the spreads between retail rates and money market rates have shifted since the beginning of the crisis. For the interest rate transmission, the fact that they have not returned to their pre-crisis levels may be of greater importance than changes in the scale of adjustment.

Moreover, changes in the interest rate pass-through do not necessarily result from the impact of the financial crisis on the interbank market, but from asymmetry in retail rates adjustment with regard to the direction of the market rate changes. Banks might be more willing to transmit to deposit rates decreases of market rates than increases, and more willing to transmit increases than decreases to lending rates. Therefore, it would be desirable to have samples with similar a proportion of interest rate falls and rises. This condition is not fulfilled in this analysis. In the first subsample (ending in August 2008) the scale of cumulated falls and increases is similar (equal to, respectively, -2.8 p.p. and 2.7 p.p.), while in the second subsample interest rate decreases prevailed (they amounted to -6.0 p.p. compared to increases of 2.7 p.p.). The previous analyses of asymmetries in the interest rate pass-through suggest rather stronger adjustment to market rate increases than decreases for both deposits and credits (see: Sznajderska, 2013b).

[28] By adding a dummy variable.

[29] These changes are not confirmed in analysis of the aggregated level. Due to the short sample and scale of distortions related to the financial crisis, the uncertainty of estimates is high, and in a few cases there are problems with identifying cointegrating relations.

Table 17. Estimates of the long run pass through to deposit and lending rates*

Interest rate type	2005-2008		2009-2013		2005-2013	
	Long run adjustment coefficient	Is adjustment complete?	Long run adjustment coefficient	Is adjustment complete?	Long run adjustment coefficient	Is adjustment complete?
Households deposits						
total	0.82	no	0.97	yes	0.92	no
up to 1 month	0.85	no	0.82	no	0.84	no
from 1 to 3 months	0.85	no	1.03	yes	0.99	yes
from 3 to 6 months	0.91	no	0.89	yes	0.95	yes
from 6 to 12 months	0.78	no	0.73	no	0.79	no
Firms deposits						
total	0.88	no	1.10	no	0.96	yes
up to 1 month	0.93	no	1.05	yes	0.98	yes
from 1 to 3 months	0.84	no	1.18	no	1.01	yes
from 3 to 6 months	0.79	no	1.11	no	0.95	yes
Credit to households						
total	1.39	no	0.48	no	0.99	yes
for consumption	1.16	yes	x	x	x	x
for housing purposes	1.00	yes	0.74	no	0.87	yes
to sole proprietors	1.08	yes	0.76	no	1.02	yes
Credit to firms						
total	0.93	yes	0.67	no	0.77	no
up to 4 million PLN	0.96	yes	0.70	no	0.81	no
above 4 million PLN	0.95	yes	0.76	no	0.81	no

* Estimates based on individual banks' data from NBP interest rate statistics.

Source: Stanisławska (2013).

The process of interest rates adjustment in the short run may be described with the use of error correction models (ECM), employing residuals from the cointegrating equations. It allows an assessment of the scale of immediate reaction (i.e. within first month) and coefficient determining the speed of return to the equilibrium, describing how much of disequilibrium is eliminated in each month (Table 18). Both parameters govern the speed of adjustment of retail rates to their equilibrium levels.

The full sample estimates indicate that the short-term reaction of interest rates on households' total deposits and firms' total deposits is almost the same. In the first month about 52% of the market rate change is transmitted to deposit rates and in each successive month about 12% of disequilibrium is eliminated. However, if more detailed deposit categories are taken under consideration, the results suggest that due to stronger immediate reaction, adjustment of firms' deposit rates is to some degree faster than that of households' deposit rates.

The transmission to households' lending rates is very slow (the slowest of all analysed interest rates). The immediate reaction is statistically insignificant, and the loading coefficient is close to zero. Also rates on credit to sole proprietors react weakly to the market rate changes. On the contrary, the transmission to firms' lending rates proceeds quickly. As much as 66-74% of market rate change is transmitted in the first month and about 20-30% of disequilibrium is eliminated in each following month.

Summing up, the interest rate transmission is faster in the case of interest rates on firms' deposits and credits than in the case of households' deposits and credits. Firms' lending rates adjust most quickly, while households' lending rates – most sluggishly.

The analysis conducted on two subsamples suggests a slightly stronger immediate reaction of deposit rates and weaker reaction of credit rates in the period after the outbreak of the financial crisis, but taking into consideration the remaining parameters affecting the speed of adjustment, differences in this regard seem not to be significant (Figure 16)[30].

[30] In the case of households' deposits the greatest difference is noticed for total deposits, but is not visible for their detailed categories.

Table 18. Estimates of parameters describing interest transmission in short run(+)

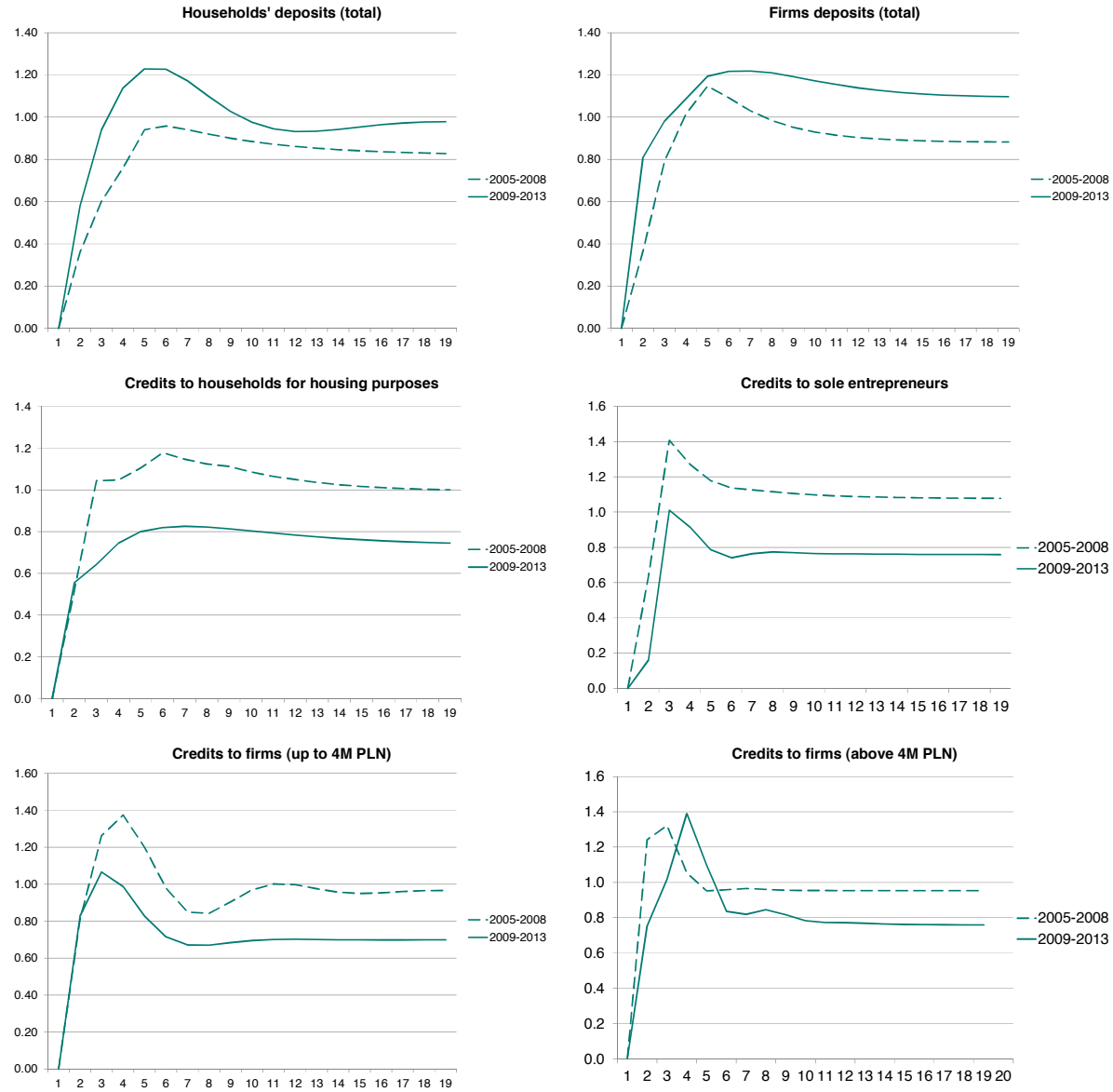
Interest rate	2005-2008		2009-2013		2005-2013	
	Immediate reaction	Loading coefficient	Immediate reaction	Loading coefficient	Immediate reaction	Loading coefficient
Households' deposits						
total	0.36***	-0.15**	0.58***	-0.27***	0.52***	-0.12***
up to 1 month	0.38***	-0.14**	0.64***	-0.15***	0.41***	-0.08***
from 1 to 3 months	0.43***	-0.20**	0.54***	-0.21***	0.40***	-0.11***
from 3 to 6 months	0.53***	-0.19**	0.40***	-0.17***	0.33***	-0.10***
from 6 to 12 months	0.24**	-0.17***	0.43***	-0.19***	0.33***	-0.14***
Firms' deposits						
total	0.37***	-0.26***	0.81***	-0.17***	0.53***	-0.11***
up to 1 month	0.39***	-0.23***	0.83***	-0.18***	0.53***	-0.13***
from 1 to 3 months	0.65***	-0.13*	0.77***	-0.27***	0.59***	-0.09**
from 3 to 6 months	0.44***	-0.27***	0.90***	-0.33***	0.50***	-0.11**
Credit to households						
total	0.57	-0.20***	0.46***	-0.11**	0.32	-0.06***
for consumption	-0.10	-0.17***	x	x	x	x
for housing purposes	0.52***	-0.18**	0.56***	-0.11***	0.39***	-0.07***
to sole proprietors	0.64**	-0.29**	0.16	-0.24**	0.25	-0.11***
Credit to firms						
total	1.19***	-0.42***	0.57***	-0.33***	0.66***	-0.20***
up to 4 million PLN	0.81***	-0.53***	0.83***	-0.42***	0.70***	-0.21***
above 4 million PLN	1.24***	-0.47**	0.75***	-0.44***	0.74***	-0.29***

(+) Estimates based on individual banks' data from NBP interest rate statistics.

*/ ** / *** denotes statistical significance at 10% / 5% / 1% level.

Source: Stanisławska (2013).

Figure 16. Response function of selected interest rates to sustained change of money market rate (1 p.p. increase)



Source: Stanisławska (2013).

3.1.2.3. Assessment of heterogeneity in interest rate pass-through according to individual banks' characteristics

The process of interest rate transmission varies not only across economies (e.g. Borio, Fritz, 1995; Sørensen, Werner, 2006), but also across banks (e.g. Weth, 2002; Gambacorta, 2004; Chmielewski, 2004; De Graeve et al., 2007; Horvath, Podpiera, 2012), which might be explained by differences in the structure of their balance sheets.

As a potential source of heterogeneity we have considered various financial indicators related to the credit channel theory (size of assets, capital adequacy ratio, liquidity), to financing strategy, these reflecting kinds of relationship with clients as well as the quality of credit portfolio.

Like in the previous section, the analysis of heterogeneity in the process of interest rate transmission to retail rates has been conducted for new deposits and new credits to non-financial sector, divided into several categories, in the period from January 2005 to July 2013. The inference on links between banks' features and interest rates transmission is based on estimates of parameters of ECM model in two subgroups of banks classified by value of this characteristic (see Weth, 2002)[31]. It is assumed that the interest transmission process is the same in all banks within a given group except for individual margin reflected by bank individual effect.

Table 19, due to limited space, presents only difference in estimated immediate reaction coefficients, loading coefficients and long run multipliers between the two groups of banks and the results of test on their statistical significance.[32]

The obtained results indicate faster adjustment of rates on firms' credit in bigger banks along with no differences in the scale of long term adjustment. It might be related to the observation that bigger banks usually lend to bigger firms, which have access to alternative sources of financing. This may induce faster adjustment of interest rates in these banks to the market rate (see Weth, 2002). The impact of banks size on deposit rates is less clear. On one hand, for some deposits categories, banks with larger assets have lower long run multipliers and react to disequilibrium less, which would suggest weaker transmission of money market rates. On the other hand, the immediate reaction of deposit rates (especially of households) is in these banks stronger.

The credit channel view suggests weaker interest rate transmission in bigger, more liquid and better capitalised banks[33]. The presented results are in line with these predictions only to a limited extent and only in the long run. They suggest that banks' capital position (measured by capital adequacy ratio) does not affect the scale of long run adjustment, while higher liquidity (measured by ratio of liquid assets to total assets) contributes to a lower long run multiplier only for deposit rates. In the short run banks with higher capital adequacy ratio and higher liquidity ratio adjust their deposit and/or lending interest rates quicker (the difference is statistically significant only for few categories of bank products).

Greater importance of non-financial sector deposits in financing and relying on relationship banking might contribute to weakening of interest rate transmission.[34] Greater scale of long term relations with clients,

[31] Each bank characteristics is analysed separately.

[32] Estimates of parameters for each group of banks are to be found in Stanisławska (2013).

[33] In case of assets, the empirical evidence on their influence on interest rate transmission is ambiguous, while for liquidity and capital position, theoretical predictions based on credit channel view are confirmed in empirical studies. An exception is found in study on Czech banking sector, where higher liquidity of banks is connected to higher long run multiplier, and higher capital adequacy ratio with faster adjustment (see Horvath, Podpiera, 2012).

[34] Greater degree of financing from non-financial sector deposits and greater scale of relationship banking should be related to ability of bank to smooth interest rates on its products (see: Berlin, Mester, 1999; Weth, 2002; de Grauve *et al.*, 2007). As a proxy for relationship banking a share of long term (above 1 year) receivables and obligations to non-financial sector to total assets is used.

used as a proxy for the relationship banking, is associated with stronger smoothing of rates on large credits and slower pace of adjustment, while stronger deposit base is linked to weaker transmission in the long run to lending rates on credits for housing purposes, and stronger transmission to rates on credit to individual proprietors. Both features have greater impact on deposit rates and influence them in direction of slower adjustment (in banks with greater share of non-financial sector deposits and greater share of long term businesses).

The last individual bank feature considered, quality of credit portfolio, affects interest adjustment in Polish banks only to a limited extent. In case of short term reaction, statistically significant difference, indicating faster adjustment in banks with higher share of non-performing loans, was noticed only for two categories of firms' deposits. When it comes to lending rates, banks with credit portfolio of lower quality transmit interest rate changes to rates on credit to sole proprietors in smaller degree than banks with credit portfolio of better quality.

Summing up, the obtained results suggest that individual bank characteristics affect the interest rate pass through only to a limited extent. The greatest role seems to be played by bank's size, its liquidity and strength of deposit base. The influence of individual bank characteristics refers rather to the speed of adjustment than strength of the long term reaction, which stays in line with most empirical studies (e.g. Weth, 2002; Gambacorta, 2008)[35]. Moreover, more differences in transmission are observed in the case of disaggregated than aggregated categories of interest rates[36], and in the case of deposit rates than lending rates. It should be stressed that the results might be to some degree deformed by distortions in transmission mechanism linked to the financial crisis.

[35] The analysis conducted under assumption that individual bank characteristics affect only short-run adjustments lead to similar conclusions (Stanisławska 2013). The only exception is banks' assets which seem to not affect interest rate transmission in a significant way.

[36] It happens that results point out on different direction of influence of a given characteristics on various interest rate categories.

Table 19. Summary of results on the heterogeneity of interest rate pass through in commercial banks in Poland in the period from 2005-01 to 2013-07

Bank's characteristic:	Assets			Capital adequacy ratio			Liquidity		
Parameter:	α_2-α_1	β_2-β_1	LT_2- LT_1	α_2-α_1	β_2-β_1	LT_2- LT_1	α_2-α_1	β_2-β_1	LT_2- LT_1
Households' deposits									
total	**0.283*** **	**0.046**	**-0.14**	**0.019**	**-0.041**	**0.10**	**0.251****	**-0.034**	**-0.25**
up to 1 month	0.245**	-0.010	-0.67*	-0.067	-0.010	0.21	0.175**	-0.066*	-0.46
from 1 to 3 months	0.287*	0.094***	0.02	0.120	-0.079**	0.04	0.228**	-0.037	-0.25*
from 3 to 6 months	0.185	0.037	0.26*	0.284**	-0.035	0.02	0.328***	-0.038	0.10
from 6 to 12 months	0.137	-0.007	0.12	0.142	-0.035	0.28	0.096	-0.028	0.29
Firms' deposits									
total	**0.200****	**0.062**	**-0.32***	**-0.091**	**0.001**	**0.14**	**0.128**	**0.048**	**-0.41****
up to 1 month	0.058	-0.015	-0.43*	-0.047	0.038	0.18	0.099	-0.024	-0.31
from 1 to 3 months	0.065	0.090**	0.30	0.118	-0.111**	-0.19	0.048	-0.099**	-0.34*
from 3 to 6 months	0.015	0.045	0.13	0.034	-0.129***	0.17	0.151	-0.120***	-0.33
Credits to households									
total	**0.110**	**0.013**	**1.69****	**-0.319**	**0.006**	**-0.97**	**0.126**	**0.027**	**0.00**
for housing purposes	0.146	-0.019	0.49	-0.180	-0.011	-0.62	0.224	0.019	-0.10
to sole proprietors	0.212	-0.005	0.35	0.012	-0.072	-0.40	0.047	-0.148**	-0.10
Credits to firms									
total	**0.363**	**-0.115***	**0.09**	**-0.122**	**0.022**	**0.049**	**0.073**	**-0.140****	**-0.12**
up to 4 million PLN	0.343*	-0.042	0.11	-0.058	0.047	-0.014	0.073	-0.058	0.08
above 4 million PLN	-0.300	-0.121*	0.16	-0.121	-0.071	0.046	0.073	-0.096	0.07

Estimates based on individual banks' data from NBP interest rate statistics.

Subscript 1 refers to the group of banks with a lower value of the given indicator and subscript 2 refers to the group of banks with a higher value of the given indicator. */**/*** denotes statistical significance at the level 0.10/0.05/0.01.

Statistical significance of difference between estimates of parameters α_2-α_1, β_2-β_1, LT_2- LT_1 means that there is heterogeneity in immediate reactions, loading coefficients and long run multiplier, respectively. Positive sign of difference α_2-α_1 means *stronger* immediate reaction of the interest rate in banks with a higher value of the given indicator, positive sign of difference β_2-β_1 means a *weaker* reaction to disequilibrium in banks with a higher value of the given indicator, and positive sign of difference LT_2- LT_1 means a *higher* long run multiplier in banks with a higher value of the given indicator.

Source: Stanisławska (2013).

Table 19. Summary of results on heterogeneity of interest rate pass through in commercial banks in Poland in period from 2005-01 to 2013-07 (continued)

Bank's characteristic:	Share of non-financial sector deposits in liabilities			Relationship banking proxy			Share of non-performing loans in total loans		
Parameter:	α_2-α_1	β_2-β_1	LT_2- LT_1	α_2-α_1	β_2-β_1	LT_2- LT_1	α_2-α_1	β_2-β_1	LT_2- LT_1
Households' deposits									
total	**-0.063**	**0.031**	**0.02**	**-0.040**	**0.067****	**-0.08**	**-0.037**	**-0.038**	**0.20**
up to 1 month	-0.108	0.018	0.15	-0.014	-0.003	-0.26	0.001	0.011	0.24
from 1 to 3 months	-0.097	0.056	-0.05	-0.192*	0.074**	-0.06	0.091	-0.040	0.12
from 3 to 6 months	-0.238*	0.045	-0.47	-0.212*	0.045	0.00	0.138	-0.025	0.24
from 6 to 12 months	-0.307***	0.034	-0.35**	-0.073	0.032	-0.16	0.093	-0.018	0.27*
Firms' deposits									
total	**-0.043**	**0.001**	**-0.07**	**0.066**	**-0.011**	**-0.15**	**-0.144**	**-0.026**	**0.26**
up to 1 month	-0.152	0.017	-0.03	-0.006	-0.036	-0.13	-0.018	0.030	0.26
from 1 to 3 months	-0.190**	0.091*	0.37*	-0.192**	0.106**	0.07	0.229**	-0.070	-0.19
from 3 to 6 months	-0.047	0.112**	-0.03	-0.089	0.177***	-0.21	-0.084	-0.123**	-0.10
Credits to households									
total	**0.044**	**-0.058**	**1.36**	**0.320**	**0.023**	**0.27**	**-0.377**	**0.019**	**-0.82**
for housing purposes	-0.284	0.033	-1.27**	0.107	0.028	0.19	-0.092	-0.005	1.27
to sole proprietors	0.083	0.045	0.69***	0.006	0.049	0.38	-0.198	-0.093	-0.51*
Credits to firms									
total	**-0.288**	**-0.059**	**-0.04**	**-0.031**	**0.002**	**-0.20**	**0.067**	**0.029**	**0.11**
up to 4 million PLN	-0.214	0.007	0.09	0.050	-0.032	-0.06	0.016	0.027	0.08
above 4 million PLN	-0.074	0.011	-0.07	0.182	0.155**	-0.27**	-0.044	-0.091	0.03

3.1.3. Credit response to monetary policy impulse

To obtain reactions of volumes of loans to the monetary policy shock, we use once again VAR models (monthly data) presented in chapter 2.1. We plug in various types of loans one by one, and use Cholesky decomposition (the loans are ordered last).

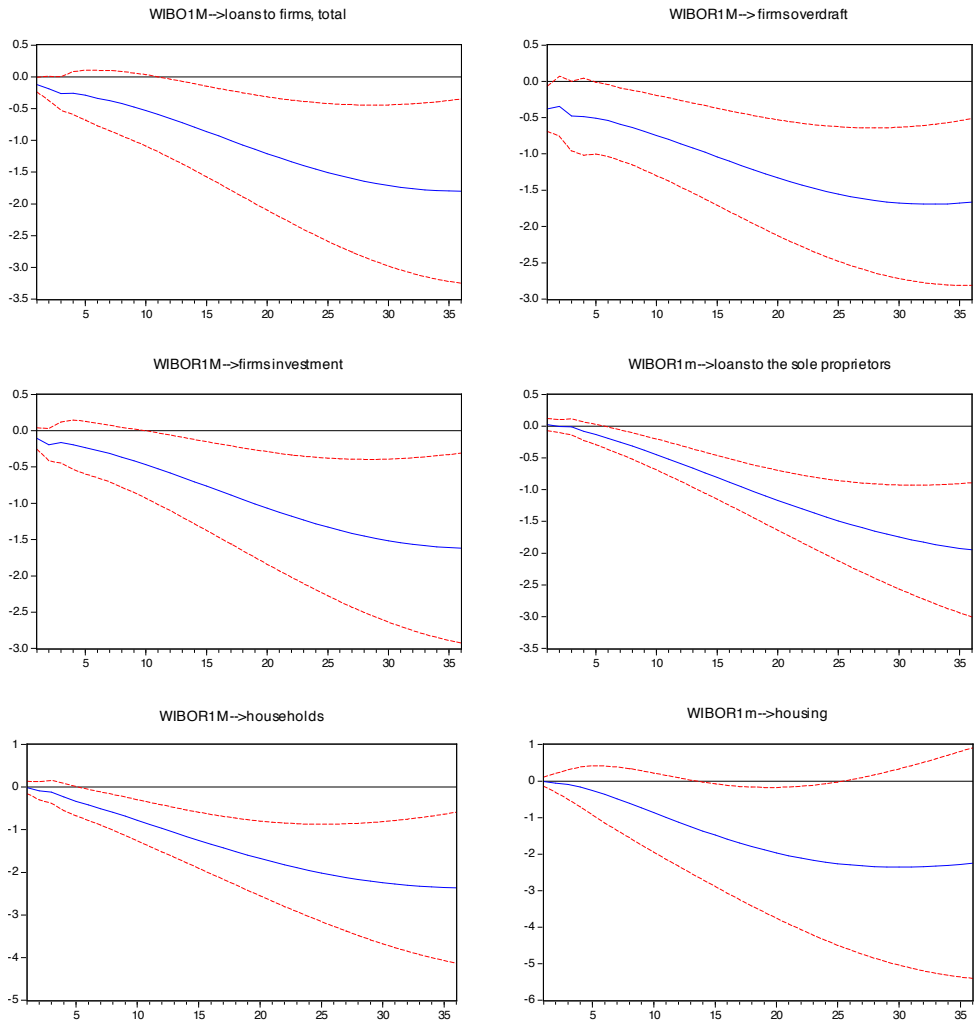
Reactions of loans in the domestic currency have not changed much as compared to the previous report (Demchuk *et al.*, 2012). Loans tend to react relatively quickly, which is most evident in the case of bank overdrafts and loans to sole proprietors. Statistically significant reactions appear 3-5 months after the shock. We note a relatively stronger reaction of loans to sole proprietors, which may indicate credit channel operation[37].

Loans for households also tend to fall after monetary tightening. Loans for housing, having good collateral, react a bit slower than the total volume of loans to households.

[37] In credit channel literature, after monetary policy shock, banks reduce quicker the loan supply to small units and households, trying to shield loans to the biggest borrowers.

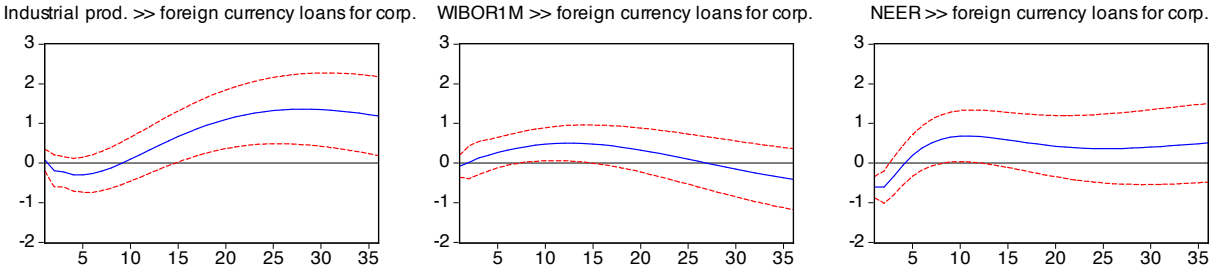
The decrease in loans in the domestic currency after the interest rate shock is partially offset by access of the enterprise sector and households to foreign currency loans. In the case of loans for non-financial corporations, after 8-14 months from WIBOR1M rate increase, there occurs an 0.4-0.5 % increase in foreign currency loans (the data was adjusted for exchange rate changes). Following an industrial production shock, a statistically significant increase in foreign currency loans occurs after 15 months and the largest influence takes place after 27-29 months. After 9-12 months foreign currency loans are also increased by exchange rate appreciation. However, in the beginning (to the 2nd month) the loans decrease, due to the negative impact of the appreciation on industrial production. In the case of loans for households, an interest rate increase (as well as exchange rate appreciation) has no statistically relevant impact on foreign currency loans. However, these loans tend to increase in the aftermath of the industrial output shock (with a lag of 8-24 months).

Figure 17. Response functions of loans in PLN to firms and households (in nominal terms) to (positive) interest rate shock



Source: own calculations.

Figure 18. Impulse responses of foreign currency loans for corporations to (positive) industrial production, interest rate and exchange rate shock



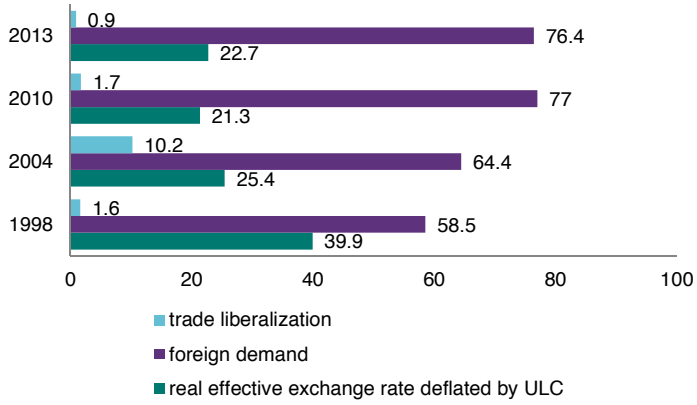
Source: own calculations.

3.2. Exchange rate channel

3.2.1. The impact of the exchange rate on aggregate demand

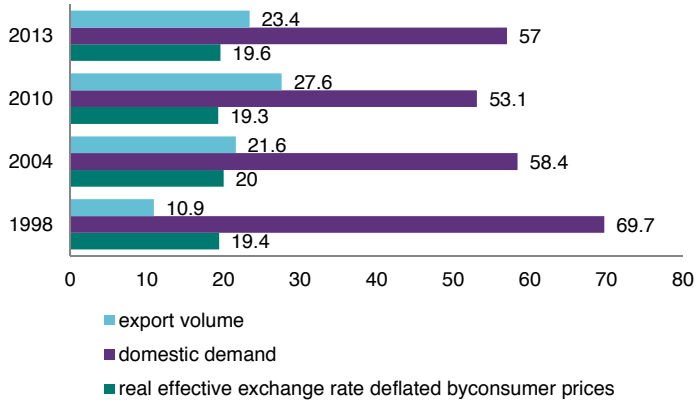
Changes in the exchange rate affect relative prices and modify the competitiveness of Polish goods in international markets and imported goods in the Polish market. This influences growth rates of export and import volumes and directly affects aggregate demand. To estimate the impact of the exchange rate on aggregate demand we use the quarterly model of transmission (QMOTR), presented in section 2.2.1, and to calculate the weight of factors explaining changes of export and import volumes – the NATREX model (Przystupa, 2009). In the latter, the effects of intra-industry trade and integration-related effects (trade liberalization) modify the impact of external demand and price/cost competitiveness. Figure 19 and Figure 20 present the estimated weights of individual components explaining export and import volumes in Poland.

Figure 19. Factors explaining changes in export volume (sum of weights of all factors =100.0)



Source: own calculations.

Figure 20. Factors explaining changes in import volume (sum of weights of all factors =100.0)



Source: own calculations.

Among determinants of the growth rate of export volume, special attention should be paid to the exchange rate. Its role was decreasing until 2009 (from almost 40% in 1998 to 20.1% in 2009), and has been growing slightly since the beginning of the financial crisis. We attribute the diminishing role of the exchange rate to changes in intra-corporate ties and intra-industry trade[38]. International corporations make settlements within a capital group, treating output in a subsidiary as a part of the group output. In these circumstances, exchange rate changes determine the movements in import prices or changes in the size of import input. An increase (decrease) of the intra-industry trade causes a respective decrease (increase) of the significance of the exchange rate.

[38] This observation can be supported by the study analysing the impact of the economic crisis on intra-industry trade in the automotive industry (Ambroziak, 2012). The author proved that the intensity of the intra-industry trade in Poland has considerably diminished during the crisis after earlier rapid growth related to EU accession.

The estimated drop of the importance of the trade liberalization index leads to the same conclusion. Statistical data show a fall of Polish export growth in the GVC (*global value chains)*, as compared both to other export categories and to the GVC exports of the EU[39]. This means that there is a significant slowdown in this form of international cooperation compared to the previous decade, i.e. the subsidiary companies of the international corporations located in Poland do not intensify the Polish exports to the extent they did before[40].

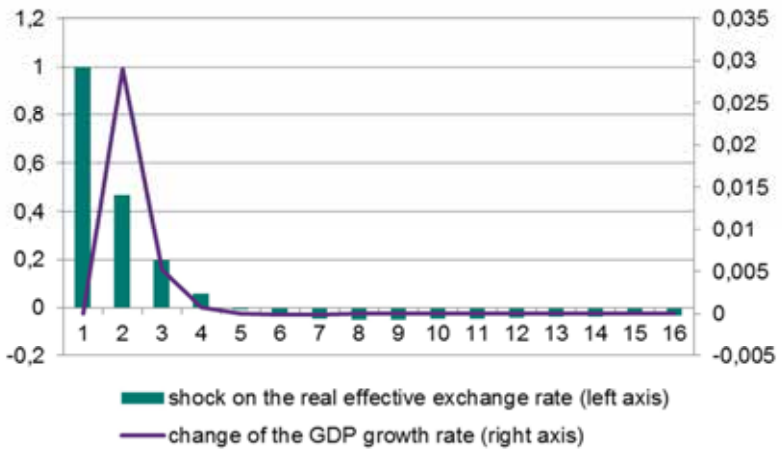
Declining dynamics in intra-industry trade and in the GVC trade entailed a slight decrease in the role of foreign demand (by 0.6 p.p.). However, foreign demand explains changes in the volume of exports in more than 75%, by 12 p.p. more than in the time of Poland's accession to the EU.

Domestic demand still plays a crucial (and even growing by 4 p.p.) role in the dynamics of the volume of imports. Domestic demand explains this part of imports, which is directly related to production of the international corporations sold abroad, including the sale within the GVC. Changes in the volume of exports, correlated with changes in foreign demand, are the best approximation of the import input to production sold abroad. This is due to the high import intensity of exports manufactured in Poland by international companies, particularly for goods with a significant high-tech component. A decline in external demand, affecting the dynamics of the volume of exports, reduces direct import needs. The greater the decline in sales of the most import-intense groups of goods, the stronger the reduction of direct import needs.

Figure 21 presents the impact of the exchange rate shock on the GDP growth rate. The exchange rate shock in the QMOTR model is generated as the risk premium shock that results in the exchange rate depreciation by 1% (the increase of the real exchange rate means depreciation of the domestic currency). Such depreciation accelerates the annual GDP growth rate by 0.03 p.p. with a lag of one quarter.

[39] In 2012 the GVC exports growth rate in Poland (0.4%) was considerably lower than the GVC exports of the EU (2.8%).
[40] See: IBRKK (2013).

Figure 21. Shock on the real effective exchange rate deflated by consumer prices and reaction of the GDP growth rate to the shock



Source: own calculations.

3.2.2. Pass-through effect

The latest estimations of the exchange rate pass-through effect (P-T)[41] to consumer prices carried out for Poland with various methods and models show its significant drop during the last five years – from over 0.21 in 2008 to 0.18 in 2010 and 0.06 in 2013 on average (Table 20).

Table 20. The exchange pass-through effect

Pass-through effect	after 2 quarters		after 4 quarters		after 8 quarters	
	estimation 1998-2008	estimation 2000-2013	estimation 1998-2008	estimation 2000-2013	estimation 1998-2008	estimation 2000-2013
Import transaction prices (PM)	0.50	0.67	0.65	0.70	0.73	0.74
Sold production prices (PPI)	0.24	0.21	0.44	0.23	0.51	0.25
Consumer prices (CPI)	0.11	0.02	0.19	0.04	0.21	0.06

Source: own calculations.

From the point of view of the monetary transmission, the key question is whether the significant drop of the magnitude of the P-T is structural (permanent) or cyclical (transitory). On the one hand, experience of the industrialized countries in the late 80's and early 90's, irrespective of the business cycle, shows a permanent

[41] Textbooks define exchange rate pass-through effect into domestic prices as the 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 currency exchange rate. They analysed the pass-through effect in developed countries in 1971-2004 and 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 inflation targeting regime was implemented in the 1990s, the decline was even larger: from 0.18 to 0.03.

decline in the P-T of a magnitude similar to the Polish one. On the other hand, the studies for Greece, Ireland, Italy, Spain and Portugal[42] indicate a temporary nature of the P-T decline. Growing macroeconomic instability and the loss of confidence increased the sensitivity of CPI inflation to exchange rate movements in these economies to almost 0.2, i.e. to the level observed in the first half of the 80's, after an earlier drop of the P-T to almost zero in the late 90's.

Hence, what is the interpretation of the currently observed fall in the exchange rate pass-through in Poland? Table 21 shows faster effects of the exchange rate pass-through to import and producer prices: according to 2013 estimates, during the first two quarters 89% and 82% of the exchange rate shock are built in those prices, while according to 2008 estimates the figures are 66% and 47% respectively. At the same time the P-T for the import prices remains almost unchanged, while for producer prices it is reduced by half. This may indicate a structural change in the production process and lead to a permanent reduction of the P-T. The described effect may be due to a growing share of international companies in the production process (e.g. Ambroziak, 2012).

In 2003 consumer prices respond to exchange rate movements with a magnitude three times lower than in 2008, but the speed of reactions remains almost the same (about 40% of the total effect occurs during the first two quarters). Taking into account that over the last years about 20% of total imports (corresponding to 15% of the total consumption) was assigned to retail sales and that for this part of imported goods the P-T effect is equal to 0.74, the estimated decline in the exchange rate pass-through to CPI to 0.06 seems to be excessive. It signals that it is rather transitory and can be explained by asymmetries of the P-T. Differences between the linear and the asymmetric impact of exchange rate movements on CPI are primarily evident in periods of economic instability with the pass-through in the contraction lower than in the recovery. This is due to the fact that in periods of contraction companies seeking to maintain market share are rather more likely to maintain or reduce prices than to raise them.

At the same time, the structural nature of a fall in the P-T effect to producer prices suggests that even during a recovery of the P-T to the consumer prices, it will not return to its previous level, the average P-T effect may be slightly over 0.1.

Table 21. 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 transaction prices (PM)	48 (17)	41 (49)	5 (25)	3 (4)	3 (5)
Sold production prices (PPI)	55 (12)	27 (35)	7 (29)	6 (10)	5 (14)
Consumer prices (CPI)	10 (10)	38 (42)	29 (31)	11 (7)	12 (10)

Note: In parentheses are given the values consistent with 2008 estimates.
Source: own calculations.

[42] See: Ben Cheikh (2013).

3.3. Credit channel

There are a few premises for the credit channel operation in Poland. Bank assets account for a major part of the financial sector assets, bank loans are an important source of external financing of the enterprise sector, whereas the corporate bond market is not very important (see Table 1, Table 3 and Table 9 in chapter 1.2). On the other hand, the structural surplus liquidity of the banking sector, access to loans in foreign currencies and loans from abroad, as well as a considerable share of foreign ownership in the banking sector (see Table 5, Table 6, Table 7 and Table 9 in chapter 1.2) may weaken the operation of the credit channel.

Impulse responses of loans presented in section 3.1.3 do not allow to conclude whether the credit channel operates or not, i.e. whether monetary policy has an impact on the loan supply[43]. To extract the long-run supply function from the loan data, we have used a model, in which some variables affect loan supply and others – loan demand.

These are the following variables in the model: loans for households and the enterprise sector in real terms[44], real sector activity measured by GDP, the interest rate acting as a proxy of banks' refinancing costs (WIBOR 1M), the interest rate on loans, inflation (q/q)[45] and the capital adequacy ratio. We assume that loan supply positively depends on the interest rate on loans, and negatively on the WIBOR rate. We expect that the coefficient obtained at these two rates will be equal in absolute terms, i.e. that the spread between the two rates has an impact on the loan supply. Another factor which is supposed to negatively affect the supply function is the risk of bank assets portfolio. Due to statistical reasons, we use the capital adequacy ratio as a proxy for this variable[46]. If portfolio risk increases, banks need to increase capital and, in order to do so, they incur costs (e.g. a higher risk premium in the case of external refinancing). Thus, we expect that banks will be less willing to extend new loans, increase the interest rate on loans and/or tighten credit conditions. It should be stressed, however, that in the case of Poland, the evaluation of a coefficient standing at the capital adequacy ratio may be somewhat mis-estimated due to the fact that since the Lehman Brothers collapse, the Polish Financial Supervision Authority (KNF) has been recommending banks to retain a certain part of profits to build a strong capital position.

Besides identification of the loan supply, we also identify the loan demand function. We assume that loan demand depends positively on GDP (scale variable), and negatively on the loan rate. On the other hand, it should not depend either on the refinancing rate (WIBOR 1M) nor on the capital adequacy ratio. Addition-

[43] Loan supply and loan demand functions are not observable. The amount of loans observed is a resultant of supply and demand, thus after a monetary policy shock, one does not know whether the loan reaction was mostly due to the operation of the interest rate channel or the credit channel, or maybe whether they have operated simultaneously. Before the financial crisis, the verification of the credit channel existence used to bring mixed results, some works confirmed its existence, but some did not succeed or concluded that it was a channel of minor significance.

[44] We have used a weighted average of consumption and investment deflators to obtain total loans in real terms. By the same token, in the case of loans for households, we have used a consumption deflator to obtain credit in real terms, and for the loans to the enterprise sector – an investment deflator.

[45] Test ADF suggests that $\pi_t = \log(p_t)-\log(p_{t-1})$, where p_t is a seasonally adjusted CPI index, is a series containing a unit root ADF test without trend: -1.51 (prob. 0.52); with trend and constant: -1.04, (prob. 0.93).

[46] We are conscious that other variables, especially a share of non-performing loans in total assets might be less disputable as a proxy for the risk in the banking sector than the capital adequacy ratio. However, it seems that the share of non-performing loans is a stationary variable, thus cannot be used here.

ally, we expect that the inflation rate is important for both borrowers and creditors, but we do not impose any particular restriction.

First, we have analysed total loans, then loans for the enterprise sector and finally loans for households. To obtain normally distributed residuals (or at least to avoid excessive skewness) we have used dummy variables, eliminating the Y2K problem, the impact of the Russian crisis on inflation, and higher inflation due to the EU entry, that is, the same set as in the case of VAR models. Determining the number of cointegrating relations, we have assumed a deterministic trend in the data. The number of lags has been determined by the information criterion (Schwarz), but we have taken into account the distribution of residuals as well.

We have obtained cointegrating relations[47] for all categories of loans (3 for total loans and for loans to the corporate sector[48] and 2 for the household sector), then we have imposed restrictions. Restrictions have been formally tested and not rejected. The selected results are presented in Table 22.

Demand for total loans strongly depends on GDP, according to our estimates the coefficient is equal to about 2.4. In mature economies it tends to be lower. Fase (1995) and Kakes (2000) obtained a similar result for the Netherlands. In our case, high elasticity results from the behaviour of households (their demand elasticity with respect to GDP is 2.5). On the other hand, demand elasticity of firms is similar to that obtained in the euro area. The high demand elasticity of households may 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 loans of households in the domestic currency to the disposable income increased from about 46% in 2000 to 137% in 2012).

Also, households exhibit a higher semi-elasticity of demand with respect to the interest rate and inflation. Taking into account the average interest rate on loans (10.8) and the estimated coefficient of semi-elasticity of demand for total loans, we get elasticity of demand with respect to the interest rate equal to about -0.4[49].

Rising inflation tends to increase demand for loans, probably to adjust credit volume to the expected price developments. With average inflation close to 1%, we obtain elasticity of demand for total loans with respect to inflation close to the one obtained for the interest rate, i.e. -0.4.

Supply functions obtained for the enterprise sector and households also tend to exhibit some differences. The supply function of total loans resembles that obtained for households. Semi-elasticity of supply to households with respect to spread is about two times higher than in the supply to the corporate sector. The same is true for the capital adequacy ratio. This means that if banks need to increase capital, they will rather reduce credit supply to households than to enterprises. Nonetheless, it should be bore in mind, that the coefficient at the capital adequacy ratio can be overestimated owing to the interventions of KNF.

[47] For the enterprise sector we limited the sample to the period starting from the year 2000. For the sample starting in 1998 we did not obtain cointegrating vectors.

[48] We interpret the third cointegration relationship as the interest rate pass-through to the loan rate. GDP is a variable which affects the transmission, however, it rather proxies demand than risk (its impact is positive).

[49] Hülsewig *et. al.* (2005) shows that for Germany this elasticity is about -0.7. Other empirical works show it in a range from -0.2 to -1.1 (see: Kakes, 2000).

Taking into account sample averages of spread and the coefficient of the capital adequacy ratio, the elasticity of total loan supply is about 1.8[50] and -3.0, respectively. Increasing inflation tends to reduce supply as banks can be afraid of an increasing macroeconomic risk.

Disturbances of the demand function tend to be absorbed very slowly (see Table 22), and once again this is mostly a result of features of the function obtained for households. Disequilibrium in the market for loans to the enterprise sector is eliminated much faster, over one quarter diminishes by 24%. Disturbances on the supply side are eliminated even slower and once again, the process is faster in the enterprise sector than the household sector.

Our results confirm the operation of the credit channel in Poland[51].

Table 22. Estimated coefficients of credit (in PLN) demand and supply function, 1998:Q1-2013:Q1

Function	GDP	Lending interest rate	WIBOR rate	Inflation	Capital adequacy ratio	α
Credit in PLN (total)						
credit demand	2.39 (11.71)	-0.04 (5.52)	x	0.28 (10.56)	x	-0.09 (7.02)
credit supply	x	0.85 (26.50)	-0.85 (26.50)	-0.36 (8.73)	-0.22 (9.97)	-0.06 (6.93)
Credit in PLN to firms						
credit demand	1.66 (14.89)	-0.04 (7.97)	x	0.23 (13.09)	x	-0.24 (8.15)
credit supply	x	0.4 (15.10)	-0.4 (15.10)	-0.45 (12.36)	-0.14 (10.20)	-0.14 (8.05)
Credit in PLN to households						
credit demand	2.5 (6.40)	-0.07 (4.95)	x	0.57 (10.39)	x	-0.04 (5.20)
credit supply	x	0.90 (13.20)	-0.90 (13.20)	-0.31 (4.68)	-0.32 (7.03)	-0.01 (3.20)

Notes: in parenthesis absolute values of t-statistics are reported; parameter α shows the speed of adjustment toward equilibrium after shock to credit demand or supply function.

Source: own calculations.

[50] It is much less than given in Hulsewig *et. al.* (2005). For Germany this value amounts to 0.06. According to our estimates, elasticity of supply with regard to spread in the case of firms is equal to about 0.8, so it is more than ten times higher than estimated for Germany.

[51] Marzec and Pawłowska (2011) also indicate that the credit channels operate in Poland. They show, based on panel data covering the period 2001-2009, that banks tended to be more restrictive for smaller than larger companies.

3.4. Features of inflation expectations significant from the point of view of monetary transmission

The process of formulating inflation expectations in the economy is of great significance for the transmission of monetary policy. To analyse the main characteristics of inflation expectations in the Polish economy we refer to direct measures of consumers', corporates' and financial sector analysts' inflation expectations. The expectations relate to a one-year time horizon. The sample includes observations from the beginning of 2001 through mid-2013.

3.4.1. Remarks on the measurement of inflation expectations

Inflation forecasts of the financial sector analysts are based on Reuters surveys. Additionally, we use inflation forecasts of a broad group of professional forecasters provided by the NBP Survey of Professional Forecasters. In this case, however, the sample of available observations is significantly shorter than in the case of Reuters survey data and starts in late 2011.

Inflation expectations of consumers and enterprises are quantified on the basis of qualitative survey data. Taking into account survey methodology (number of respondents, phrasing of survey questions), we treat the survey conducted by the Central Statistical Office (GUS) since 2004 on a monthly basis as our preferable source of consumer survey data (see Łyziak 2012). For the earlier period (2001-2003) we extrapolate the balance statistic needed to quantify inflation expectations with the probability method. Due to the form of the survey question, the probability quantification method applied requires the assumption concerning consumer perception of price changes during last 12 months. In this respect we form two assumptions, obtaining as a result two measures of consumer inflation expectations. In quantifying the first one – called 'objectified' – it is assumed that the current CPI inflation constitutes the reference point for consumers in selecting the response option to the question on predicted price changes. In the case of the second measure of inflation expectations – called 'subjectified' – we refer to subjectively perceived price dynamics, so-called Consumer Perceived Price Index (CPPI) (Hałka and Łyziak 2013). It exceeds CPI inflation significantly (5.0% vs. 3.0% on average in 2001-2013) due to the fact that in their perceptions of price developments Polish consumers focus on prices of frequently purchased goods and services and seem to pay no attention to price reductions of these items.

Inflation expectations of Polish enterprises are measured on the basis of quarterly surveys conducted by Narodowy Bank Polski (NBP's Quick Monitoring). Since the 3rd quarter of 2008, the survey question has been qualitative. It provides the respondents with the most recent CPI inflation figure, so we treat it as a scaling factor in the quantification of enterprises' inflation expectations. Earlier, i.e. since the 1st quarter of 2001 till the 2nd quarter of 2008, the survey question on expected price changes was quantitative. Except for the main measure of enterprise inflation expectations, being a combination of the results from the quantitative question (2001Q1-2008Q2) and expectations quantified on the basis of qualitative survey data (since 2008Q3), we calculate an alternative measure, different from the main one in the first sub-period. Having quantitative expectations of individual enterprises we translate them into implied (individual) responses to the qualitative survey question, and then we aggregate them and use them to quantify inflation expectations with the probability method (see Łyziak 2013a for details).

Table 23 and Figure 22 present all the measures of inflation expectations used in this report. Their detailed characteristics are discussed in Łyziak (2013a).

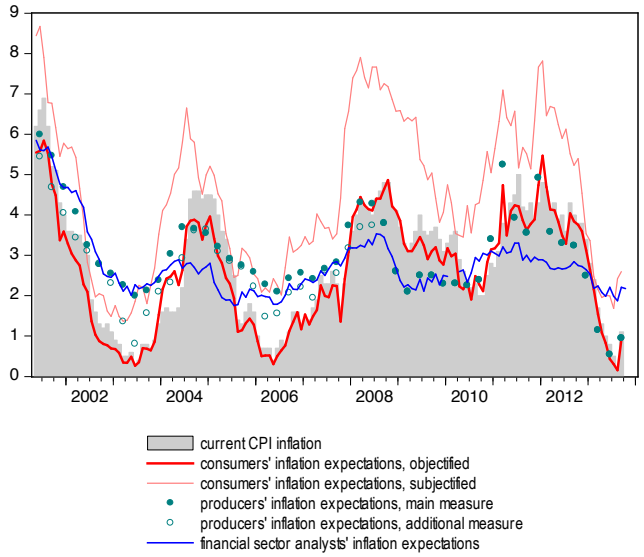
Table 23. Inflation expectations in Poland, 2001-2013

Category	Data source, measure	Average (%)	Standard deviation	Coefficient of variation
Consumer inflation expectations[(1)]	GUS, objectified	2.8	1.6	59.1
	GUS, subjectified	4.7	2.0	43.6
Producer inflation expectations[(2)]	NBP, main	3.1	1.2	38.7
	NBP, alternative	2.9	1.2	41.4
Financial sector analysts' inflation expectations[(1)]	Reuters	2.9	1.0	34.5
Current inflation (known while setting expectations)	GUS	3.0	1.7	56.7

Notes: (1) – monthly data, 2001:01-2013:08; (2) – quarterly data, 2001Q1-2013Q2.

Source: own calculations on the basis of GUS, NBP and Reuters data (Łyziak 2013a).

Figure 22. Inflation expectations in Poland, 2001-2013



Source: own calculations on the basis of GUS, NBP and Reuters data (Łyziak 2013a).

3.4.2. Are inflation expectations in Poland rational?

The results of the recent research (Łyziak 2013a) confirm that inflation expectations in Poland do not satisfy the hypothesis of rational expectations.

Errors of consumers', enterprises' and financial sector analysts' inflation expectations (Table 24) are not of a random nature, which means that expectations do not meet the condition of unbiasedness. In terms of the mean absolute error (MAE), the accuracy of expectations formulated by financial sector analysts and enterprises is better than the accuracy of random forecasts, relatively bigger errors characterize consumer inflation expectations.

In spite of the fact that inflation expectations in Poland are biased, economic agents under consideration efficiently process a part of available information. The degree of macroeconomic efficiency is diversified among analysed groups of agents. It is relatively low in the case of consumers, who efficiently use information on the exchange rate, oil prices in international markets and industrial output. At the same time interest rates, the unemployment rate and current inflation systematically affect inflation expectational errors (are not processed in an efficient manner). Financial sector analysts efficiently process all the pieces of information mentioned above excluding interest rates and current inflation. It seems that the inflation expectations of Polish enterprises display the highest degree of macroeconomic efficiency. It should be noted however that enterprises – similarly as remaining groups of agents – face difficulties while assessing the impact of interest rates on future inflation. In contradiction to the results of previous research (Łyziak 2012), our new results indicate that short-term interest rates are not interpreted efficiently by enterprises. However, the magnitude of inflation expectational errors caused by inadequate perception of the monetary transmission mechanism seems limited.

3.4.3. The degree of forward-lookingness of inflation expectations

Inflation expectations of the analysed agents are characterised by a different degree to which they are forward-looking (Table 24). Consumer inflation expectations are determined by the past inflation to the greatest extent but even they are not formulated on the basis of past observations only. Financial sector analysts' inflation expectations are characterised by a larger weight of the forward-looking factor, and enterprises' inflation expectations – by the largest weight. Depending on the measure of expectations used, as many as 32-36% of enterprises seem to formulate their inflation expectations in a rational way.

3.4.4. The degree to which inflation expectations are anchored in Poland

When formulating inflation expectations, consumers, corporates and financial sector analysts assign a different weight to the NBP inflation target (Table 24). It has a strong influence on the inflation expectations of financial sector analysts and enterprises, and only a slight impact on consumer inflation expectations. It is interesting to note that when the central bank inflation projection deviates from the NBP inflation target,

financial sector agents set their inflation expectations closer to the NBP target than to the NBP inflation projections (Łyziak 2013b).[52]

Different measures of anchoring of probability inflation forecasts of professional forecasters (based on the NBP Survey of Professional Forecasters) – such as deviations of long-term inflation forecasts from the NBP inflation target, sensitivity of long-term inflation forecasts to changes in current inflation or short-term inflation forecasts or the probability of future inflation being within the interval of permitted deviations from the NBP inflation target – confirm the high degree of anchoring of inflation forecasts set by professional economists (Kowalczyk *et al.* 2013).

Table 24. Selected features of inflation expectations in Poland, 2001-2013

Category	Data source, measure	ME	MAE	Degree of forward-lookingness[(1)]	Degree of anchoring[(2)]
Consumer inflation expectations[(3)]	GUS, objectified	0.18	1.80	0.08	0.12
	GUS, subjectified	2.15	2.60	0.10	0.15
Producer inflation expectations[(4)]	NBP, main	0.60	1.63	0.36	0.64
	NBP, alternative	0.32	1.61	0.32	0.50
Financial sector analysts' inflation expectations[(3)]	Reuters	0.29	1.41	0.25	0.90
Naive forecast	-	0.40	1.96	-	-

Notes: [(1)] – estimated weight of future inflation in the formation of inflation expectations; [(2)] – estimated weight of the NBP inflation target in the formation of inflation expectations, [(3)] – monthly data, 2001:01-2013:08; [(4)] – quarterly data, 2001Q1-2013Q2.

Source: own calculations on the basis of GUS, NBP and Reuters data (Łyziak 2013a).

3.4.5. Analysis of inflation expectations under assumption of adaptive learning

For the last two decades, there has been a growing role of the hypothesis of adaptive learning in the expectations literature[53]. In this approach it is assumed that economic agents, similarly to econometricians, estimate parameters of equation describing their beliefs about given economic phenomenon and employ them to formulate forecasts. Estimates of these parameters are revised every time when new information is available. The scale of correction depends on forecast error and value of gain parameter, which might be constant or decreasing over time. Accepting a model with a decreasing gain parameter ($1/t$) means that param-

[52] The results presented in this study also suggest that inflation projections published by Narodowy Bank Polski have played an important role in making interest rate decisions more predictable, supporting the process of building central bank credibility.

[53] A general introduction to the adaptive learning approach and a review of its application is to be found e.g. in Evans, Honkapohja (2009). In the Polish literature, Cierkoński (2008) wrote on the implications of this approach for conducting and assessing monetary policy, while Stanisławska (2008) evaluated the process of expectations formation by Polish consumers and banking sector analysts from the point of view of this concept.

eters of the forecasting equation undergo smaller and smaller revisions with time and, under certain conditions, might converge to a model of rational expectations. In other words, new observations have a smaller and smaller (approaching zero) impact on estimated parameters of the forecasting equation. In the case of a model with a constant gain parameter (taking values from 0 to 1), economic agents in estimating the forecasting equation put more weight on more recent observations and their influence does not disappear with time. The higher value the gain parameter takes, the stronger the influence of new data on the estimated parameters of the forecasting equation. For this kind of adaptive learning, no convergence to rational expectations is typical, and it is known as permanent learning.

A comparison of the quantified measure of consumer inflation expectations[54] (over the period from the beginning of 1997 to mid-2013) with expectations consistent with various models of adaptive learning, suggests that Polish consumers use a simple forecasting rule, which contains only past inflation and a constant term (Table 25). Moreover, our expectations measure is more in line with a constant gain model than decreasing gain model. This would suggest that consumers have noticed changes that took place in the economy and formulated expectations with use of a model which faster incorporated changes in economic relations into the parameters of the forecasting equation. The best fitting value of gain parameter amounts to 0.030-0.037 in the case of autoregressive forecasting equations and 0.050-0.054 for the remaining ones. This means that consumers in the process of forming inflation expectations (i.e. estimating parameters of the forecasting equation) take into consideration a relatively short period of past data (4.5-5.5 years in the case of autoregressive rules and 3.1-3.3 years in the case of the remaining). For all forecasting rules, the best fitting values of gain parameter are lower than optimal, i.e. giving the smallest forecasting errors. This indicates that consumers could improve forecast accuracy if they put even more weight to more recent observations.

Theoretical considerations suggest that the value of the gain parameter might depend on general conditions of the economy, especially on the intensity of structural changes. If we assume that consumers in Poland change the value of this parameter from time to time and split the sample into a few shorter ones, it turns out that the value of best fitting parameter has decreased (Table 26). This suggests that consumers consider a longer period of historical data while making forecasts and this contributes to a more stable process of formulating inflation expectations.

[54] The objectified measure based on Ipsos survey.

Table 25. Fit of the gain parameter of the adaptive learning algorithm to survey data on consumer inflation expectations (1996:01-2013:07)

	Variables considered by consumers in forecasting equation			
	Inflation (one lag)	Inflation (one and two lags)	Inflation Industrial prod.	Inflation Industrial prod. Interest rate
Adaptive learning with constant gain				
best fitting value of gain parameter	0.037	0.030	0.050	0.054
mean square comparison error	0.158×10^3	0.136×10^3	0.372×10^3	0.278×10^3
optimal value of gain parameter	0.081	0.074	0.100	0.060
Adaptive learning with decreasing gain				
mean square comparison error	0.398×10^3	0.271×10^3	0.780×10^3	0.673×10^3

Source: own calculations based on Ipsos and GUS data.

Table 26. Best fitting values of gain parameters in sub-periods*

Period	Best fitting value of gain parameter	Number of years taken under consideration
Change of gain parameter every 4 years		
1997 – 2000	0.063	2.6
2001 – 2004	0.043	3.9
2005 – 2008	0.019	8.8
2009 – 2012	0.001	166.7
Change of gain parameter every 8 years		
1997 – 2004	0.050	3.3
2005 – 2012	0.015	11.1

* Results for learning rule with only constant and lagged inflation.

Source: own calculations based on Ipsos and GUS data.

3.5. Effectiveness of major channels of the monetary policy transmission mechanism

The effectiveness of the main channels of the monetary transmission mechanism is calculated based on the vector autoregression models. It depends on both the parameter estimates of the variables creating the individual channels in the model and on their statistical significance. The method for assessing effectiveness of transmission channels is presented in Annex 3.

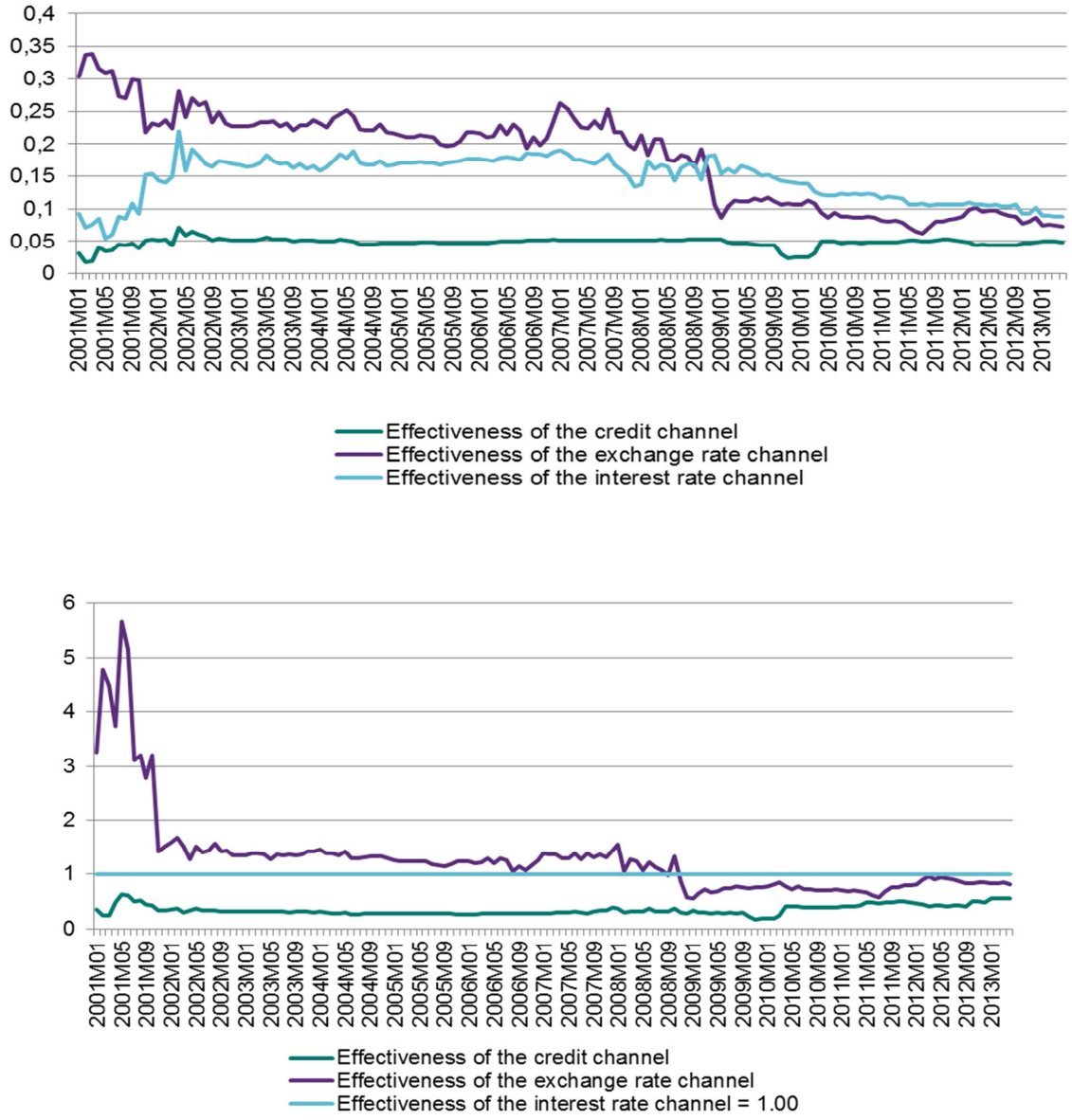
The analysis of the effectiveness of monetary transmission channels in Poland shows that up to November 2008 the exchange rate was the most effective channel (Figure 23). However, this effectiveness decreases steadily under the influence of structural shocks and varies across the business cycle. The adoption of a floating exchange rate regime in 2000 was a structural shock. Over the next two years the effectiveness of the exchange rate channel decreased by half. On the other hand, accession to the EU (with unchanged exchange rate regime) was a shock disrupting the economic situation, which led to only transitory disturbances in the effectiveness of the exchange rate. In turn, the sharp phase of the financial crisis reduced it by 55% (October 2008-January 2009). Since then, it has remained at this new level – with some cyclical oscillations – and nothing suggests any changes in this respect. This may prove the structural nature of the change and can be explained both by the fall in the P-T effect and by a slight impact of the exchange rate on the real economy (the growth rates of the volumes of exports and imports have been explained in more than 80% by the foreign and domestic demand respectively).

The effectiveness of the interest rate channel increased significantly after the implementation of inflation targeting, reflecting the increased maturity of the Polish economy in terms of its monetization, scale of financial intermediation, as well as central bank credibility. Since 2002 until the collapse of the Lehman Brothers the effectiveness of the interest rate channel practically did not change and its slight fluctuations were caused by the business cycle. However, from December 2008 to May 2013 the efficiency of this channel fell by almost 50%. This drop, contrary to changes in the effectiveness of the exchange rate channel, can be assigned to cyclical factors: the persistence of the low economic activity in the developed countries combined with increased uncertainty discourages firms from investment despite the accommodative monetary policy[55]. Hence, a stronger economic growth will lead to an increase of the effectiveness of the interest rate channel.

The indicator of the credit channel effectiveness (understood in the narrow sense: inflation is influenced by aggregate demand that depends on credit supply) behaves in a very similar way to the effectiveness of the interest rate channel. Until the outbreak of the financial crisis, it was more than three times smaller than the effectiveness of the interest rate channel. It should be noted that the response of the credit channel effectiveness to the financial crisis was far more significant than the response of the interest rate channel. In the first stage of the crisis banks responded by contracting lending significantly, against the conducted monetary policy. However, from the middle of 2010 the effectiveness of the credit channel increased and nowadays it is two times lower than the effectiveness of the interest rate channel.

[55] A slight fall of the interest rate channel effectiveness may also be related to placing the monetary policy focus differently in the period of the financial crisis, i.e. attaching more importance by the central bank to shaping liquidity measures in the banking sector than to changes in the POLONIA rate, cf. Łyziak *et al.* (2012).

Figure 23. Effectiveness of the monetary transmission channels in Poland



Source: own calculations.

3.6. Asymmetric effects in the monetary policy transmission mechanism

Numerous studies point out that asymmetric effects should be incorporated in models of monetary transmission. The recent estimations confirm that these effects are significant also in the Polish monetary transmission mechanism.

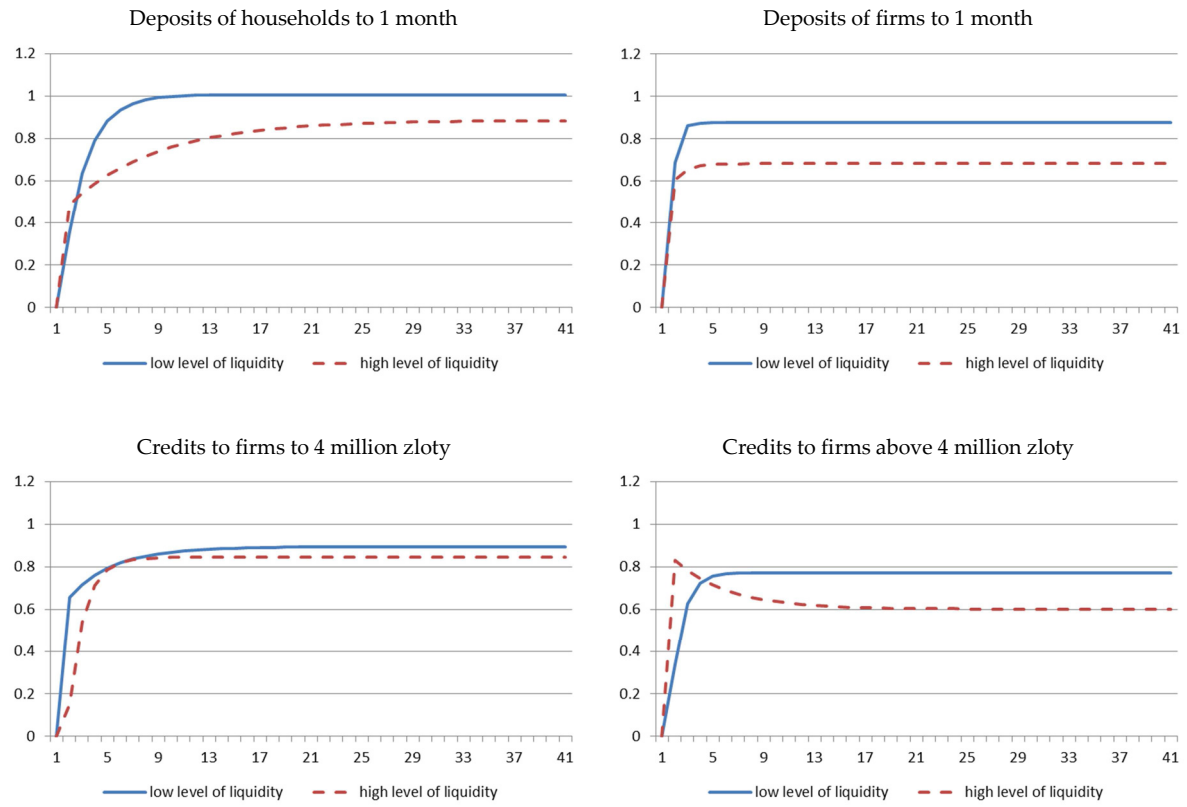
The interest rate pass-through seems to be diversified not only across different banks (see section 3.1.2.2), but is also asymmetric across different characteristics of the Polish economy (Sznajderska, 2013b). In the long term the adjustment is faster when sizable discrepancies from the long-term equilibrium appear. Also there appear certain asymmetric effects according to the direction of change of the money market rate, the level of economic activity, the level of liquidity in the banking sector, the level of expectations about money market rates, the level of competition in the banking sector, and the level of credibility of the central bank.

Interest rates for deposits of households, deposits of firms, and credits to firms seem to adjust more strongly and fully when the level of liquidity in the banking sector[56] is low (see Figure 24). This is because when the level of liquidity is relatively high the banks are less dependent on NBP policy, being less inclined to raise their deposit rates and more inclined to accept lower collaterals.

Additionally, the adjustment of deposit and credit rates, if asymmetric, is stronger in the periods of increases than decreases of money market rates. The results indicate such asymmetry in the case of almost all deposit rates, credits for house purchases, consumer credits, and credits to firms below 4 million Polish zloty.

[56] The level of liquidity is calculated as the ratio of highly liquid assets (the securities issued by the general government sector and monetary financial institutions) to total banking sector assets. The threshold value is estimated as the value that minimalizes the sum of square errors from the relevant equation.

Figure 24. Reaction of selected retail interest rates to an increase in money market rates by 1 p.p. in periods of high and low liquidity



Source: own calculations

Also the models for the pass-through from the money market rate to exchange rate that include certain asymmetric effects seem to fit the data better than the linear ones (see Sznajderska, 2013a). According to the calculations for the period between 1998 and 2012, interest differentials for the rates with maturity below six months tend to affect the exchange rate more strongly, when the interest differentials are relatively lower than higher. Low interest differentials and a stable exchange rate reflect strong economic fundamentals and a low level of risk premium. In such situations an increase in the domestic interest rate should, *ceteris paribus*, cause larger capital inflows and larger exchange rate appreciation than in the periods of higher interest differentials.

Estimating the asymmetry of the exchange rate pass-through effect to the CPI in Poland (Przystupa and Wróbel, 2011), it is demonstrated that the magnitude of this effect varies depending on the phase of the business cycle, the direction of changes in the exchange rate and its volatility (**Table 27**). During economic booms the exchange rate pass-through to CPI is on its average level, it declines in the recession to almost zero and increases during the recovery. During appreciation the pass-through effect declines to almost zero and during depreciation it may slightly exceed its average level. Low exchange rate volatility implies a pass-through effect twice as large as the average; a high volatility reduces the effect to the average level.

The structural nature of the fall in the pass-through of exchange rate changes on producer prices suggests that even during the recovery the P-T effect on consumer prices will not increase significantly (see section 3.2.2). Then the asymmetric effects will be reduced proportionately in all phases of the business cycle, and the differences between linear and asymmetric impact of the exchange rate on the price will be relevant only when rapid changes of the exchange rate occur.

Table 27. Asymmetry of the exchange rate pass-through to CPI

Asymmetry of the exchange rate pass-through to CPI related to:	τ	Threshold models (τ = threshold)		Nonreversible linear models	
		variable > τ	variable ≤ τ	$t_1 > t_0$	$t_1 \leq t_0$
output gap	0.08% (0.24%)	0.06 (0.192)	0.06 (0.179)	0.09 (0.274)	0.03 (0.091)
change of NEER (increase-appreciation)	0.7% (2.08%)	0.02 (0.065)	0.08 (0.239)	0.01 (0.18)	0.08 (0.238)
volatility of NEER	1.44% (4.32%)	0.08 (0.247)	0.18 (0.549)	0.05 (0.139)	0.05 (0.141)
CPI inflation	τ = official inflation target	0.06 (0.195)	0.07 (0.201)	0.05 (0.160)	0.06 (0.183)

Note: The values in parentheses are consistent with estimates from 2011

Source: own calculations – updated estimates of Przystupa and Wróbel (2011), p. 41.

The analysis of other inflation determinants shows that the influence of monetary policy is stronger during periods of a high level of economic activity as a result of more forward-looking inflation expectations. Moreover, in these periods the level of economic activity seems to influence CPI inflation more strongly than during periods of a low level of economic activity[57]. Such results might stem from downward nominal wage rigidities or capacity constraints of firms in times of expansion.

It is important to note, however, that taking into account the shortness of the sample and possible crisis distortions, further studies are needed to confirm the significance of the asymmetric effects and assess the need to incorporate them in the analysis of monetary policy, mainly in the comprehensive models of the monetary transmission mechanism and in studies on optimal monetary policy rules[58].

[57] For CPI inflation two out of three estimations methods show convexity of the Phillips curve, but for base inflation excluding foodstuffs and energy the results seem to indicate concavity of the curve.

[58] The Narodowy Bank Polski monetary policy rule seems to be asymmetric between 1998 and 2012 (see Sznajderska, 2014). The bank reacted more strongly to the inflation gap when the inflation gap was relatively higher than lower.

Conclusions

The report presents a picture of the monetary transmission mechanism in Poland emerging from an analysis of the structural features of the Polish economy and from new model estimates.

Analysis of the structural features of the Polish economy suggests that the monetary policy transmission mechanism in Poland is similar to a transmission mechanism typical for more advanced economies on a comparable stage of development of the financial intermediation system and with similar monetary policy regimes. Research on the influence of monetary policy on the Polish economy, conducted recently at NBP, allowed us to confirm many features of this mechanism presented in the previous report (Demchuk *et al.*, 2012), connected to, *inter alia*, assessment of the most important channels of central bank`s influence on the economy and lags in the response of inflation to changes in short-term interest rates. At the same time, recent results have extended our knowledge on the functioning of selected elements of the transmission mechanism in Poland – such as, e.g. pass-through of the money market interest rates to deposit and lending rates at commercial banks or functioning of the credit channel – leading us to formulate new conclusions. Here we would like to point out the two most important of them.

Firstly, in the last few years we observe a substantial decrease in impact of the exchange rate on consumption prices (CPI), leading to impairment of the relative strength and efficiency of the exchange rate channel of the monetary policy transmission mechanism. In our opinion, the reduction of the exchange rate pass-through is to a large degree of a structural nature, reflecting changes in the production process, related to the growing share of production by international firms.

Secondly, it seems that the inflation response to changes in the central bank interest rates is stronger than the result arising from our previous assessments. It might stem from faster and slightly stronger influence of demand pressure on prices and from increased degree of forward-lookingness in the economy.

Considerations presented in the report suggest, however, that the changes we observed in the particular characteristics of the monetary policy transmission mechanism result from at least four overlapping factors. Evolution of the monetary transmission mechanism, related to trends typical for the Polish economy, such as the growing scale of financial intermediation or growing openness of the economy, is the first of them. The second factor is constituted by cyclical properties of the monetary policy transmission mechanism and asymmetries present at some of its stages, emerging under certain macroeconomic conditions. The next factor is related to disturbances of the transmission mechanism – especially of the interest rate channel – resulting from the global financial crisis. The combination of the above-mentioned factors motivates us to develop research methods employed in the analysis of the monetary policy transmission mechanism, and related changes in the research methodology constitute another factor which possibly shapes our perception of economic relations in the chain of the monetary policy transmission.

Attaching the observed changes in the transmission mechanism to the above-mentioned factors in an objective manner is rather impossible; therefore our interpretations are characterized to a large degree by subjectivism.

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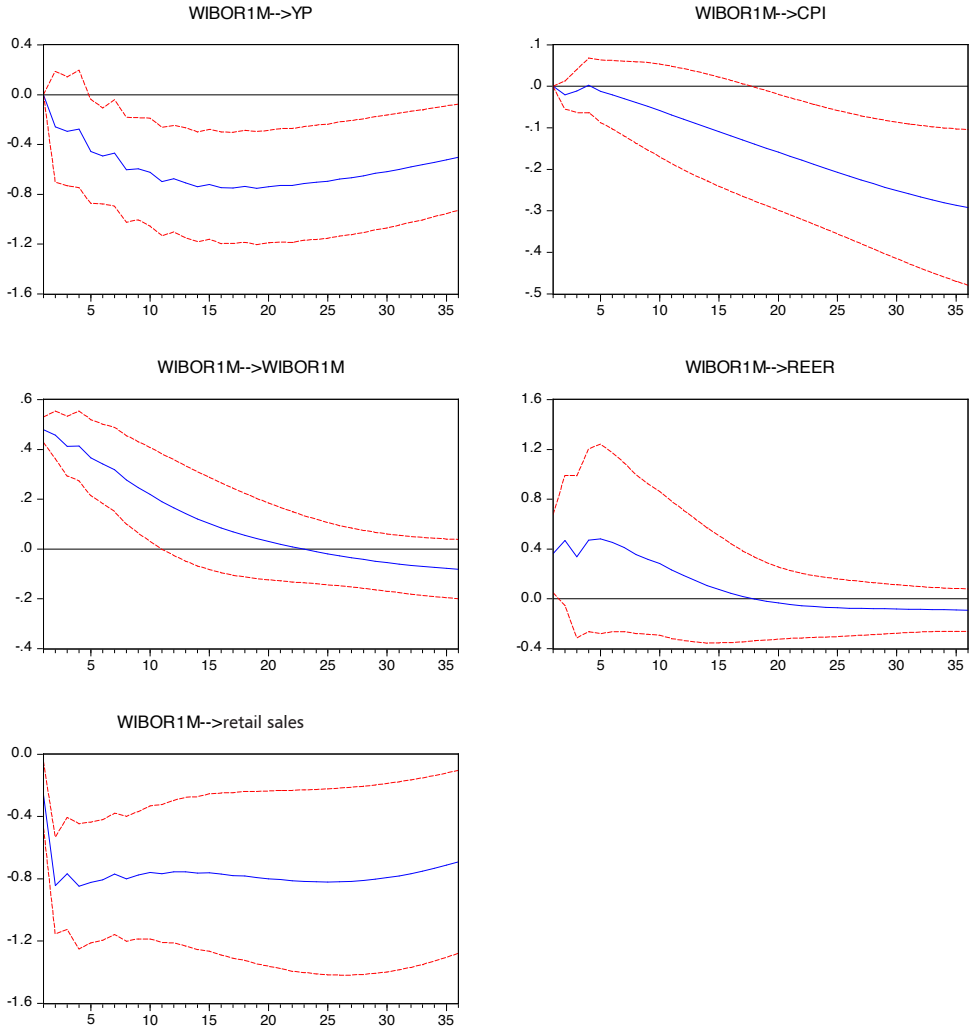
Appendix 1

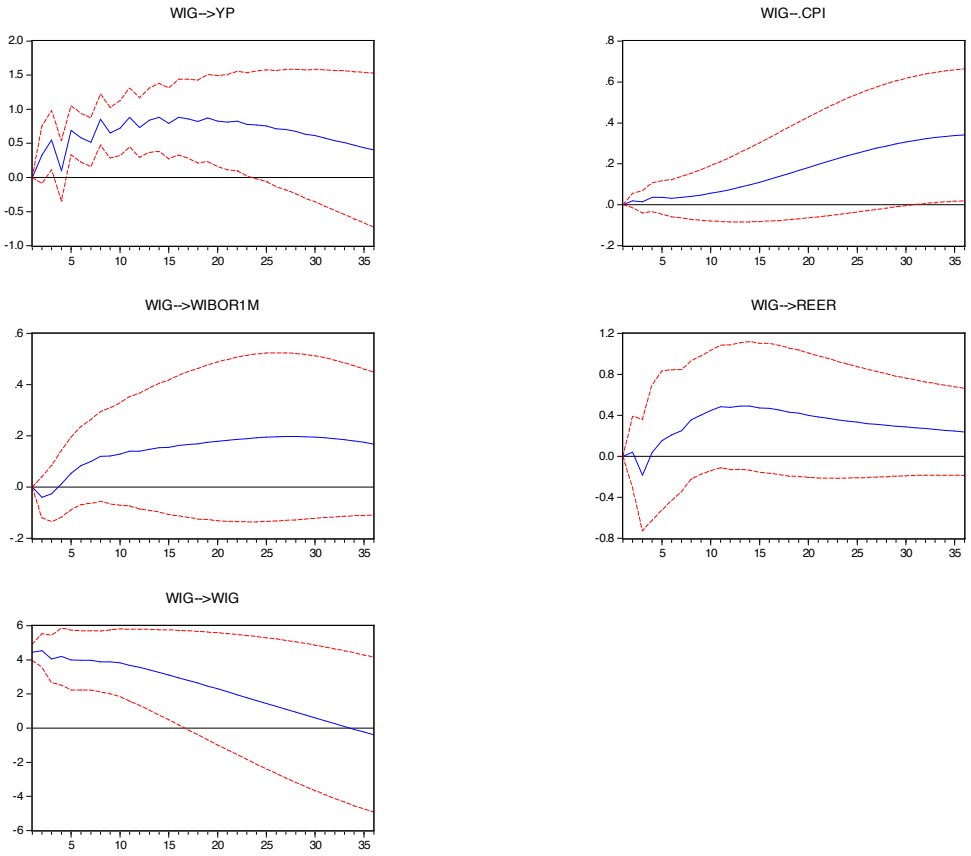
Additional reaction functions from vector autoregression type models (VAR)

Figure 25. Response functions to interest rate shock, Cholesky decomposition – VAR model including retail sale, monthly data



Source: own calculations

Figure 26. Response functions to other financial assets shock (WIG), Cholesky decomposition



Source: own calculations

Appendix 2

New models of the monetary policy transmission mechanism in Poland

Authors of the Appendix:

Jan Przystupa (QMOTR)
Ewa Wróbel (MMT 2.0)

Quarterly Model of Transmission (QMOTR)

Specification of the model

1. Objective: To create a relatively simple model, useful in analyzing the monetary transmission mechanism, with the structure more flexible than DSGE models and more resistant to Lucas critique than classical macroeconometric models. Such an intermediate type of model, named by the authors 'semi-structural' models, was developed in the International Monetary Fund by a team led by D. Laxton and operates under the name GPM (Global Projection Models; see Carabenciov *et al*. 2008[59]).
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.
3. QMOTR enlarges the set of entities represented in the standard model for the banking sector (block of transmission in the banking sector) and for the government sector (block of government spending). Further plans aim to include the block which will merge monetary policy (interest rate) and macroprudential policy (capital adequacy ratio).
4. 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.
5. 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 calibrate the parameters (a subjective judgment of experts) or Bayesian estimation, allowing

[59] Carabenciov I., Ermolaev I., Freedman C., Juillard M., Kamenik O., Korshunov D., Laxton D. (2008), *A Small Quarterly Projection Model of the US Economy*, IMF Working Paper, 08/278.

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 observed variables. It gives the possibility to introduce a set of variables describing potential (equilibrium) which are consistent with the model.

6. The introduction of expert knowledge to the model is carried out by an appropriate choice of parameters of distributions of explanatory variables. These parameters are provided by the MMT 2.0 model.

7. MMT 2.0, thanks to its flexibility, is a useful tool for a relatively simple testing of new arrangements which are in the next step employed in the QMOTR model.

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 QMOTR all real variables are expressed by the difference between the current and potential state (gaps). Gaps are stationary. It provides 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 (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 a random disturbance (e.g. shock in the forex market).
    - All potential (equilibrium) levels of real variables are model-consistent. This concerns: 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 (LIBOR, EURIBOR).

2. The main players in the model 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 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 exported. Exports depend on foreign demand and on the exchange rate of the zloty against the euro and the U.S. dollar.
    - Consumers (households) derive utility from domestic and foreign products. Consumers can 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.

- Banks, like companies, operate under monopolistic competition. They determine the interest rate on loans taking into account the money-market rate (the cost of refinancing) and the demand for credit. In the long run, the money market rate and interest rates on loans are in equilibrium. Banks may allocate households' savings in loans or treasury bills. Loans are granted for production and consumption purposes.

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. Non-fixed expenditure is pro-cyclical and floating in line with the business cycle.

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 actual GDP and its potential level) is explained by its expected future value and the value delayed, the difference between the expected real interest rate on loans and the equilibrium 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 output gap in the euro zone.

   Entities 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 (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).

   Interest on loans depends on the money market rate and on the expected domestic economic situation. 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 difference between domestic and the euro area prices.

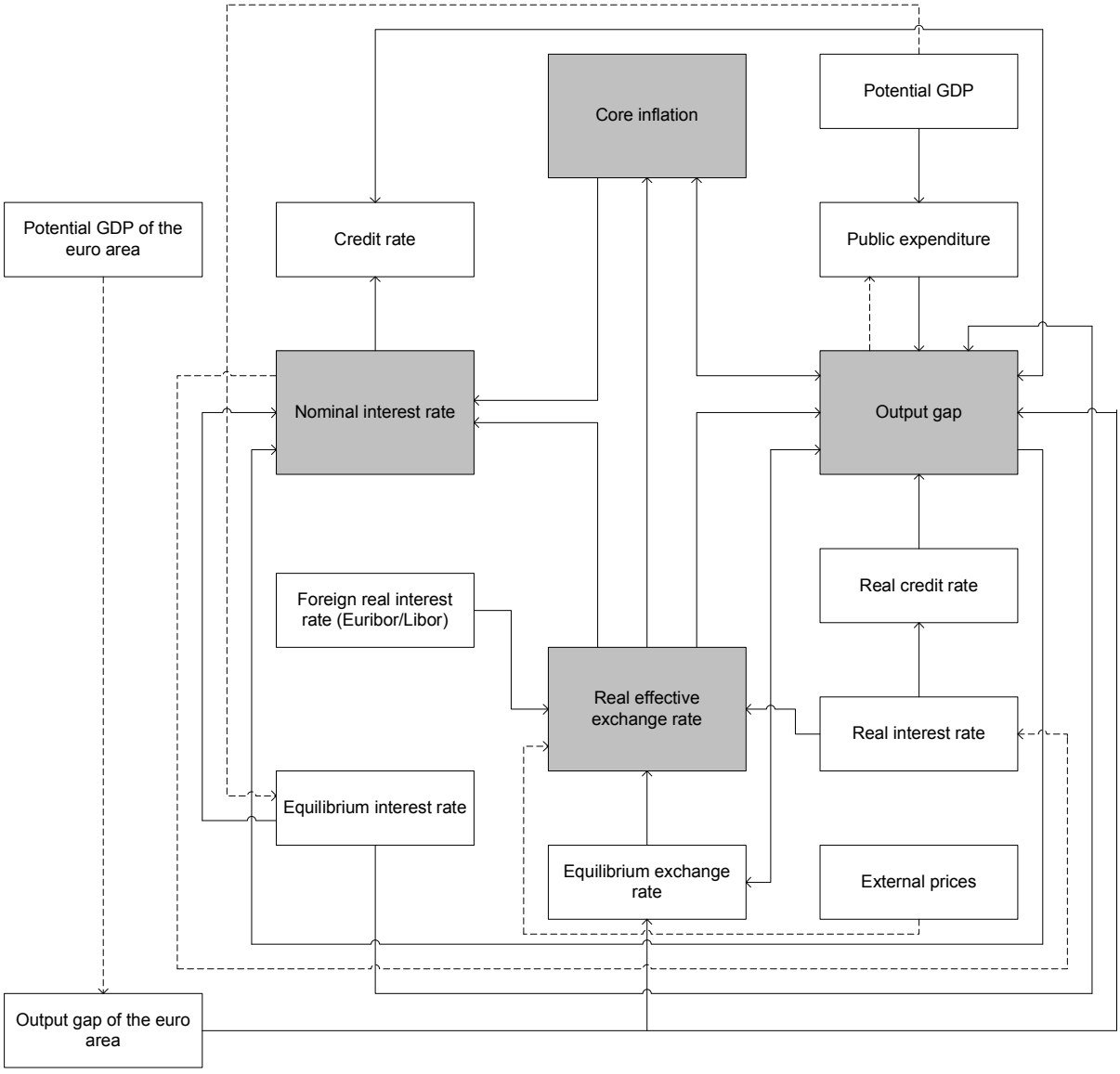
2. **The Phillips curve.** Inflation (HICP q/q without unprocessed food and energy[60]) depends on its delayed and expected value, the output gap and the real exchange rate (pass-through effect). Alternatively to the output gap, the unemployment gap is used in the Phillips curve. The unemployment gap is linked with the output gap via Okun's law, and the natural rate of unemployment is described by the state space model.

[60] The decision to use such a price index in the QMOTR and MMT 2.0 models was briefly motivated in the main part of the report.

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. Expected change in the real exchange rate depends on the real interest rate disparity and the difference between the natural rate in the home country and abroad (i.e. from the "equilibrium" risk premium). This means that the 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 risk premium on foreign exchange 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. This initiates the return to equilibrium.

4. **Monetary policy 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 perturbation factor allows the central bank compensate for reactions that do not arise directly from the interest rate equation. The dependence of the current level of interest rates from its past values (smoothing) prevents excessive fluctuations of interest rates.

Scheme of the QMOTR model



Dynamic properties of QMOTR

In order to approximate the dynamics of the model we present in the graphs below the reactions of selected variables on the following impulses:

- Impulse of the domestic interest rate – an increase by 1 percentage point for one quarter (Figure A1);
- Impulse of the exchange rate – depreciation of the domestic currency by 10% for one quarter (Figure A2);
- Impulse of foreign demand – an increase of the output gap in the euro zone by 1 percentage point for one quarter (Figure A3).

Figure A1. Reaction to the impulse of the domestic interest rate

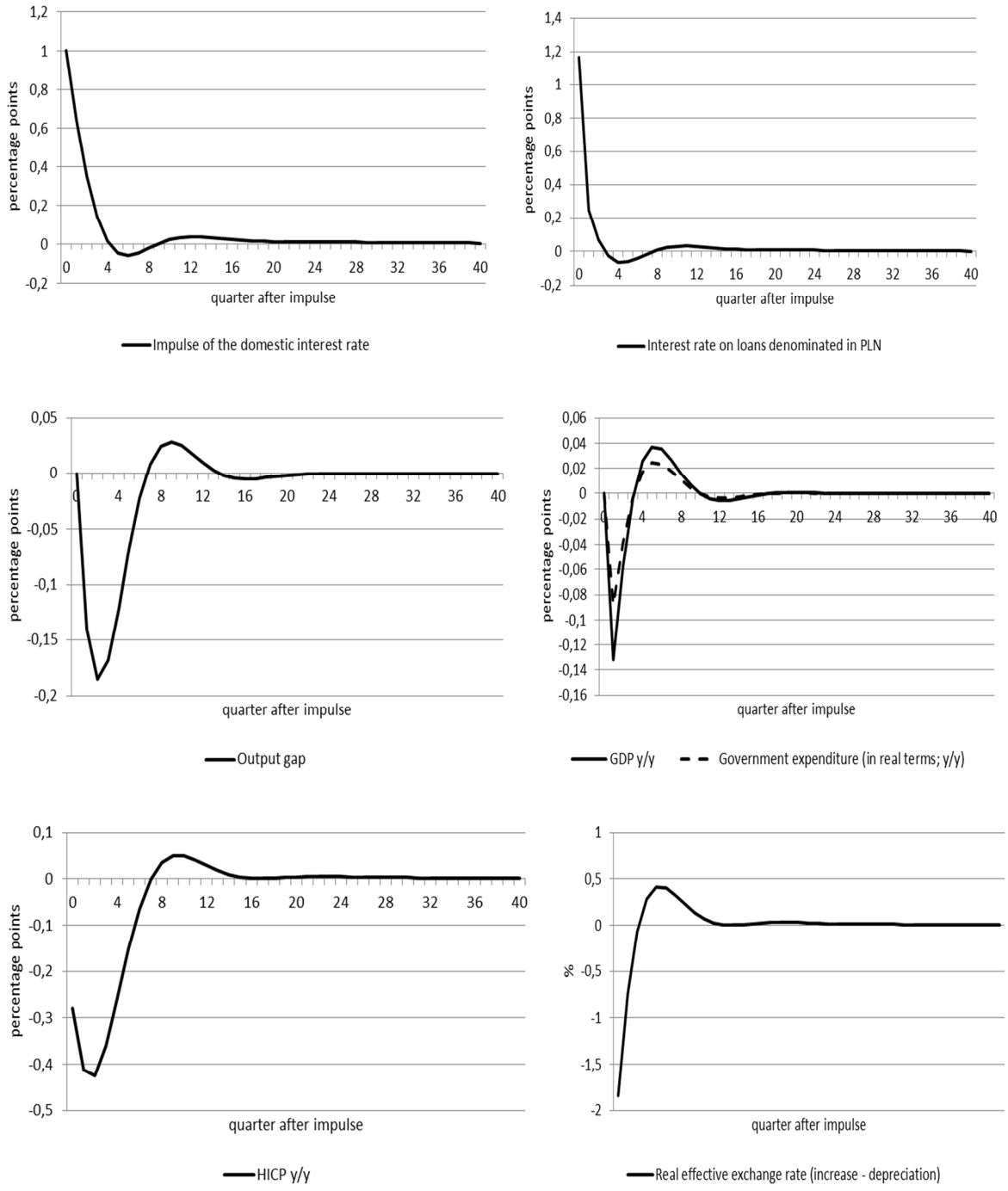


Figure A2. Reaction to the impulse of the exchange rate

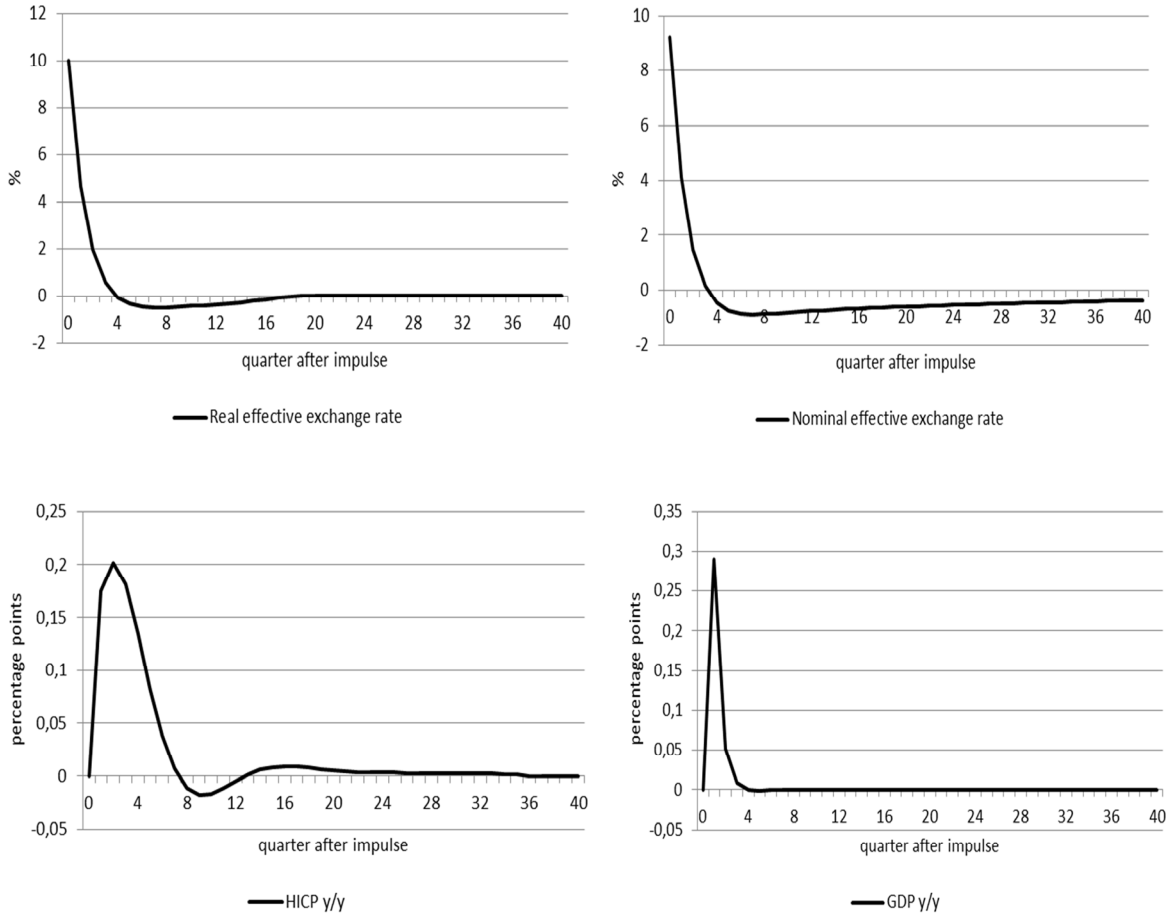
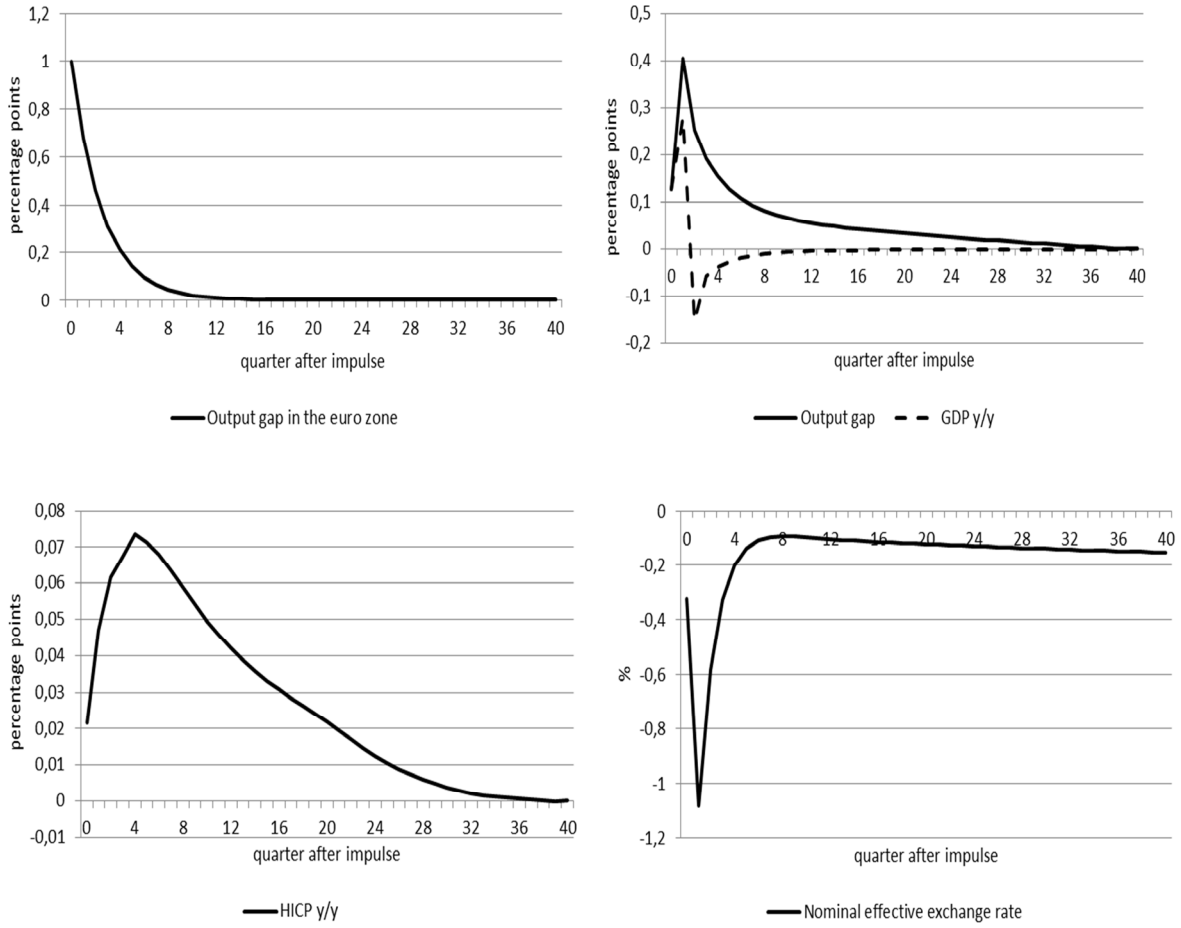


Figure A3. Reaction to the impulse of foreign demand



Small Model of Monetary Transmission (MMT 2.0)

Model description

1. Small Model of Monetary Transmission (MMT 2.0) is a modified version of the MMT model used in the previous edition of Monetary Transmission Report. It serves to analyse monetary policy transmission, including transmission in the banking sector (interest rate pass-through and credit channel), reactions of main macroeconomic variables such as output gap, inflation or loans (in the domestic currency) to domestic and foreign interest rates, foreign demand and prices, as well as oil prices. The main addition of this version is the inclusion of loans and public expenditures and "potential" levels of real variables (although they are estimated outside the model).
   - Current works on the model include making it possible to analyse feedbacks between monetary policy (short-term interest rate) and supervision (capital adequacy ratio) toolkits.
   - MMT 2.0 provides priors to QMOTR. Also, thanks to its relatively flexible structure, it serves as an experiment field for the QMOTR. MMT 2.0 belongs to a class of new-Keynesian models. It is built around four principal relationships: IS curve, Phillips curve, exchange rate equation inspired by the UIP and PPP concepts and interest rate rule.
2. As in the case of MMT, MMT 2.0 was estimated using OLS and GMM. Equations were estimated separately and only afterwards the whole system was simulated.

Model assumptions

1. 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 impacts the real effective exchange rate, the real sector and inflation. The impact of the nominal interest rate on real variables is only transitory, in the long-run real variables return to their equilibria (or "potentials"). All real variables are expressed as a "gap" between its current and potential level. Gaps are stationary and were obtained using the Hodrick-Prescott filter. The HP filter assures stationarity, but on the other hand, it is a purely statistical method of dividing a series into a cyclical component and the trend. Moreover, there is a well-known end of the sample problem. On the other hand, in a small model it is impossible to use the production function (it should be stressed that to some extent it also uses filtering). The end of the sample problem was alleviated through the use of forecasted levels of variables. Moreover, multi-dimensional filtering, or a structural approach, supposed to bring more accurate estimations of gaps (and in particular the output gap), can be vulnerable to misspecifications. As it is pointed out by Borio et al. (2013)[61], deriving information on the output gap solely from inflation can be misleading, since it omits other potentially important variables (e.g. bank credit). In MMT 2.0 the "potentials" obtained from the Hodrick-Prescott filter in the next step are endogenised through autoregressive processes.
2. In the model there exist the following agents: domestic and foreign producers, domestic and foreign consumers, the central bank, the banking sector and the government.

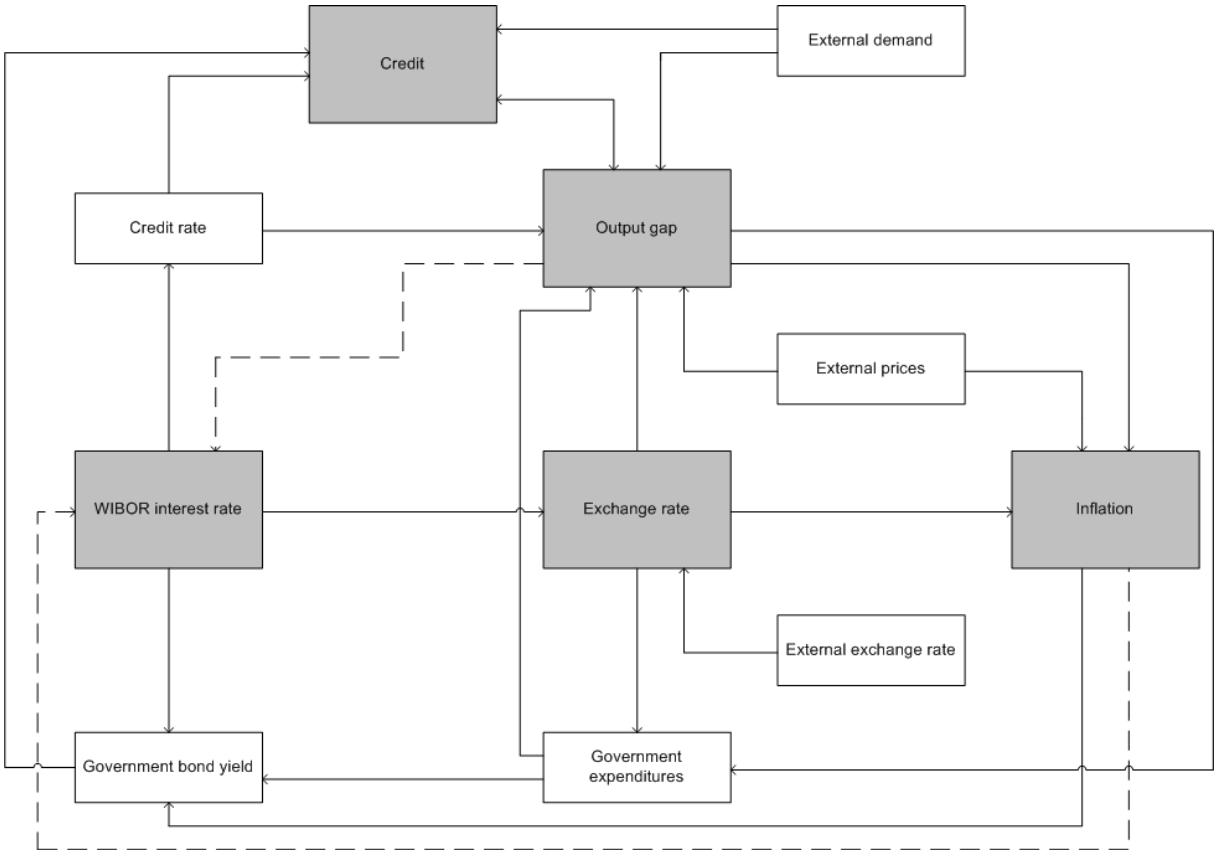
[61] Borio C., Disyatat P., Juselius M. (2013), *Rethinking potential output: Embedding information about the financial cycle*, Working Paper No 404, BIS.

- Domestic producers act under monopolistic competition. Thus, there are many firms producing goods which differ in such a way that producers can set their prices. To produce, firms use domestic and foreign inputs. They sell their products both on the domestic and foreign market. Exports depend on foreign demand and the exchange rate with respect to the euro and the US dollar.
- Consumers (households) derive utility from domestic and foreign goods. They save by purchasing domestic and foreign assets. The allocation of savings between the domestic and foreign market depends on the domestic and foreign interest rate differential, expected exchange rate changes and the risk premium reflecting macroeconomic risk, domestic and foreign.
- Like producers of goods, banks act under monopolistic competition. They set interest rates on loans, taking into the account money market rate (refinancing cost) and demand for loans. In the long-run, the money market rate and loan rate stay in equilibrium (cointegration). Banks can allocate consumers' savings into loans or treasury bonds. They extend loans for consumption and production.
- The government sector runs fiscal policy with the revenues from treasury bonds and taxes. From its revenue, the government finances the public sector, expenditures for social policies and co-finances EU related projects. Expenditures stipulated by law (e.g. pensions) have a constant share in GDP. The rest of expenditures depend on the state of the business cycle.

Main equations of the MMT 2.0

1. **IS curve.** The output gap (i.e. the difference between actual and potential GDP) depends on its lag, the real ex ante interest rate gap (we use the interest rate on loans), the real effective exchange rate gap (the nominal exchange rate is a weighted average of bilateral rates with respect to the euro and the US dollar, with weights respectively 80% and 20%), the government expenditures gap and the loan gap (loans are in real terms). Thus, the output gap is mainly led by demand factors and frictions in the credit market.
2. **The real effective exchange rate** is a behavioural equation with elements of the uncovered interest rate parity and purchasing power parity concepts. The expected change in the real exchange rate depends on the disparity between real domestic and foreign interest rates, as well as the disparity of their potential (or natural) levels. In addition, the macroeconomic risk premium is proxied by the weighted average of the domestic and foreign output gap. An increase in the domestic interest rate should result, all other things being equal, in the appreciation of the domestic currency.
3. **The Phillips curve.** The inflation rate (HICP without energy and unprocessed food, q/q) depends on its past and expected value, the output gap and the real exchange rate (the pass-through effect).
4. **The interest rate rule.** The interest rate depends on its past value (smoothing), inflation expected in time t+3 and the current output gap.
5. The model also contains equations for the loan interest rate, yields on Treasury bonds of maturity of one year, loan demand, the public expenditure gap and the capital adequacy ratio.

Scheme of the MMT 2.0 model



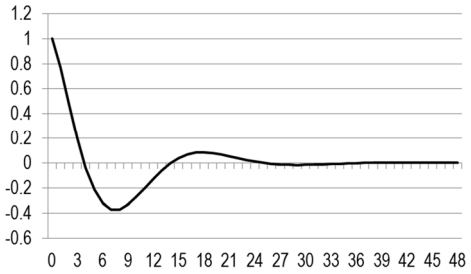
Model's dynamics

To demonstrate the dynamic properties of the model we show the reactions of its basic variables to three impulses:

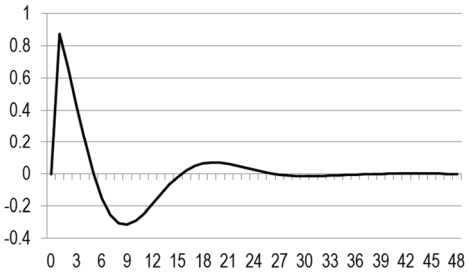
- an increase in the domestic interest rate (by 1 pp. for 1 quarter, figure A4)
- an increase in foreign demand (an increase in the EU area output gap by 1 pp. for 1 quarter, figure A5)
- an increase in the foreign interest rate (by 1 pp. for one quarter, figure A6).

Figure A4. Domestic interest rate (WIBOR 3M) impulse, on the horizontal axis – quarters after the impulse

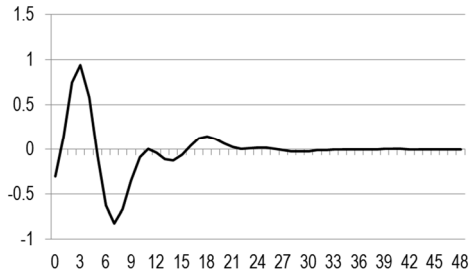
Interest rate (WIBOR 3M), in pp.



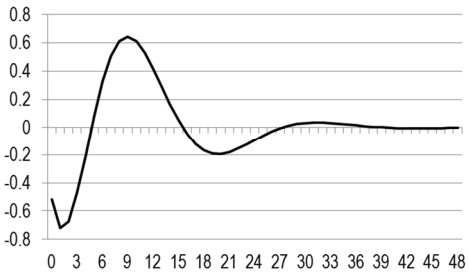
Loan rate, in pp.



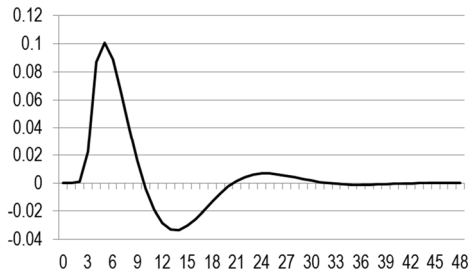
Yields in Treasury Bonds (1Y), in pp.



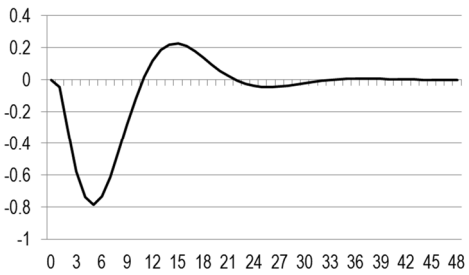
REER, in %



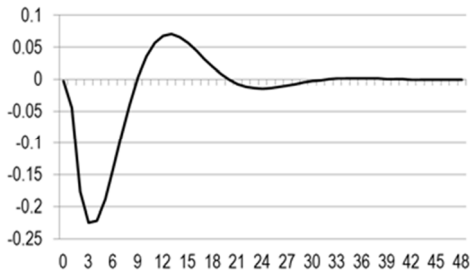
Capital adequacy ratio, in pp.



Loans in PLN (real), in pp.



Output gap, in pp



Inflation HICP y/y, in pp.

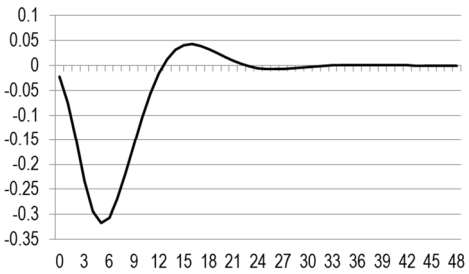
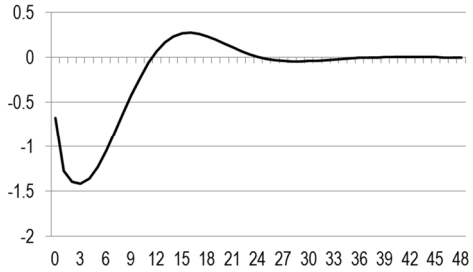
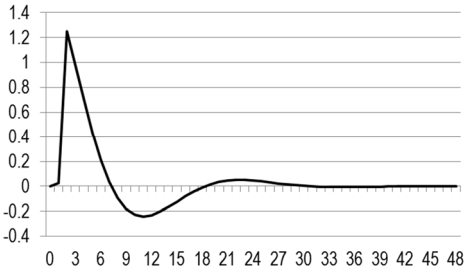


Figure A5. Foreign demand impulse, on the horizontal axis – quarters after the impulse

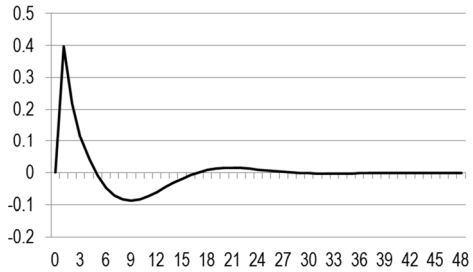
REER, in %



Loans in PLN, real in pp.



Output gap, in pp.



Inflation HICP y/y, in pp.

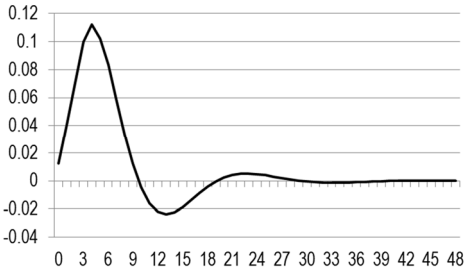
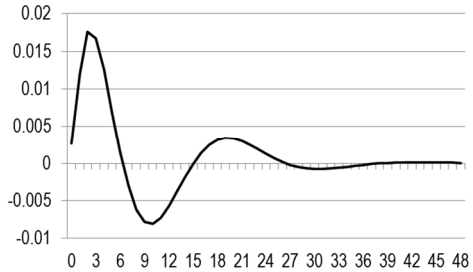
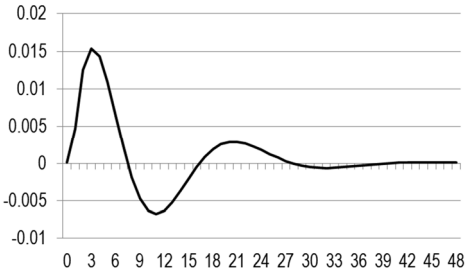


Figure A6. Foreign interest rate impulse, on the horizontal axis – quarters after the impulse

Interest rate (WIBOR 3M), in pp.

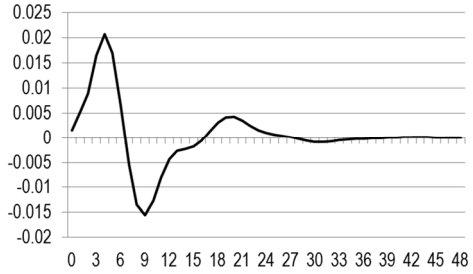


Loan rate, in pp.

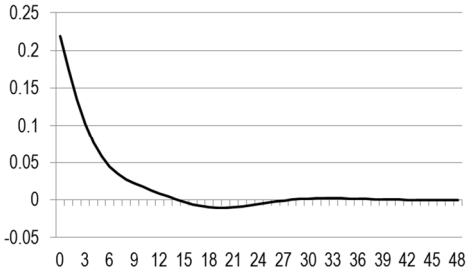


Yields in Treasury Bonds (1Y), in pp.

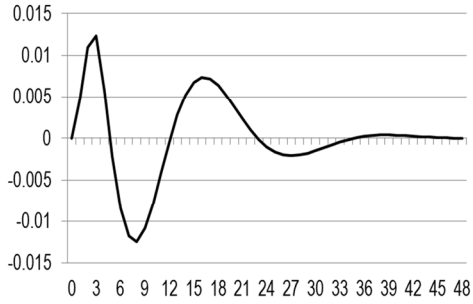
REER, in %

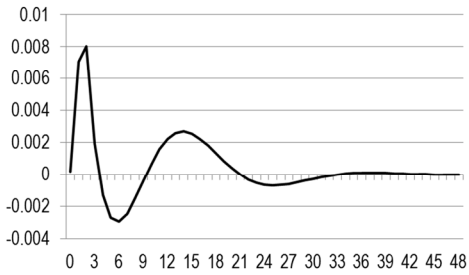


Loans in PLN, real in pp.

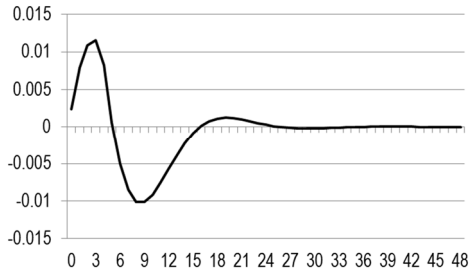


Output gap, in pp.





Inflation HICP y/y, in pp.



Appendix 3

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). Out estimations of the effectiveness of transmission are based on the monthly vector autoregression model (VAR), presented in section 3.1.3 of the report. The number of lags, determined on the basis of the Schwartz information criterion and analysis of autocorrelation of residuals, is 4. The model is estimated on levels to capture the long-term relationships between variables.

The channels of the monetary policy transmission mechanism are defined by the adequate ordering of variables, namely:

- the exchange rate channel: WIBOR 1M – the nominal effective exchange rate – industrial production – loans and credits (in zloty) to enterprises and households – CPI ;
- the interest rate channel: WIBOR 1M – industrial production – loans and credits (in zloty) to enterprises and households – CPI ;
- the credit channel: WIBOR 1M – loans and credits (in zloty) to enterprises and households – industrial production – CPI.

The effectiveness of monetary policy transmission (MTE) for the individual channel is defined as standardized elasticity ($e_{y2/y1,yA}$) between instrumental (y_1) and target (y_2) variables with intermediation of the y_A variable, if the parameters at respective variables are significant at the p-value (pv) level and fulfil Wald restriction tests:

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

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 models were re-estimated with the number of lags larger by one with respect to their optimal number (i.e. for 5 lags in our case). The overparametrization allows for using the OLS estimator (e.g. Harvey, 1991).

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