On the empirical evidence of asymmetry effects
in the interest rate pass-through in Poland

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Abstract

This paper empirically examines the potential asymmetries in the interest rate pass-through in Poland. We investigate the chosen retail interest rates in commercial banks on deposits and loans denominated in the Polish currency. It is considered whether their adjustment to changes in interbank rates is asymmetric in the long term as well as in the short term. We test for asymmetric cointegration using threshold autoregressive models and momentum-threshold autoregressive models. Next, if it is possible applying the threshold error correction models, we search for asymmetries associated with the direction of change in the money market rate, the level of the economic activity and the level of liquidity in the banking sector. Finally, we test whether using the asymmetric models improves the quality of forecasts of retail bank interest rates.

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1 Introduction

Precise understanding of how the central bank’s rates affect retail bank interest rates is particularly important for conducting efficient monetary policy. Most central banks aim for maintaining a low and stable rate of inflation to provide sustainable economic growth. In order to achieve price stability they adjust their official short term interest rates. In the first stage of the transmission process the official rates affect money market rates. Subsequently, in the second stage, the money market rates influence retail bank interest rates. Finally, the level of deposit and lending rates influences the real economic activity. If the central bank’s rate increases the tendency to consume decreases, as an

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opportunity cost of current consumption increases, and thus, the tendency to save increases. Moreover, the increase of interest rates cause increase of cost of capital and worsens expectations about future spending causing decrease of investment. Whereas when the central bank rate decreases, in contrary, the tendency to consume and invest increases and the tendency to save decreases.

In this study we concentrate on the second stage of the interest rate transmission process in Poland. In the analyzed time period Poland can be viewed as an example of an emerging market economy with fully fledged inflation targeting.\(^1\)

Asymmetries in a response of retail bank interest rates to monetary shocks have been explored in numerous studies\(^2\). Thus, our paper extends the existing literature by providing evidence on threshold effects in the Polish interest rate pass-through in the long term as well as in the short term adjustment process. The threshold error correction models are estimated with the threshold values selected by a grid search over all potential thresholds. Such method has not been used for the Polish data yet. Encompassing the asymmetric elements in the interest rate pass through equation might both give better explanation of the transmission process and improve the forecasting performance of the equation.

The paper is organized as follows. The next section provides rationales for an asymmetric interest rate pass-through in general. Moreover, it presents the specific characteristics of the Polish economy which may cause asymmetries. Section 3 presents our empirical strategy used to investigate the potential asymmetries. Whereas, section 4 describes our dataset and section 5 reports our results. Section 6 tests forecasting properties of the asymmetric and symmetric models. The last section concludes.

\section{Explanations of asymmetric interest rates pass-through}

Empirical studies show that the transmission process from a central bank interest rate to retail bank interest rates is incomplete and may be asymmetric. The changes of certain economic indicators may cause an asymmetric adjustment process. The most important indicators to mention here are the following.

Firstly, it is the level of economic growth. Many authors argue that when high level of economic growth is observed, it is easier for banks to adjust their lending and deposit rates. Then the demand for loans is higher and banks are more inclined to limit

\footnote{Monetary policy framework in Poland is broadly described in Łyziak et al. (2008 and 2010).}

it by greater increases of their credit rates. Moreover, the economic agents are in better financial condition and it is easier for firms to adjust their prices. Thus, the prices are usually adjusted more frequently and more completely in the whole economy, therefore in the banking sector as well. Whereas, during periods of macroeconomic instability and uncertainty, the interest rate pass-through is weaker. When higher interest rate volatility is observed banks wait longer to change their rates.

Also the assessment of credit risk by banks is important. In some periods banks may restrict the supply of loans to riskier borrowers and slow down the adjustment process. Typically credit risk increases in economic slowdown and decreases in economic growth.\(^3\)

On the other hand concerning lending rates banks face asymmetric information and adverse selection problems. Stiglitz and Weiss (1981) argue that increasing lending rates attract customers with a higher risk preference. These borrowers accept higher rates as their projects have higher expected return. Therefore, although it seems to be profitable banks might be unwilling to increase their credit rates.

Secondly, the level of liquidity in the banking sector plays an important role. Angeloni et al. (2003) mention the value of high and low levels of liquid assets as the main factor influencing the interest rate transmission process. Agenor and Aymaoui (2010) show that excess liquidity might cause upward stickiness of deposit rates and an easing of collateral requirements, which might lead to lower lending rates. Moreover, it might provide unwanted stimulus to the economy and the ability of central bank to control this may be constrained when facing reserves shortage (Ganley, 2002).

Similarly, it is worth noting that a significant maturity mismatch of loan and deposit portfolio might cause asymmetries. Banks usually give long term loans and take short term deposits, which involves a high interest rate risk. Therefore, the more long term loans are covered by long term deposits the less pressure banks feel to adjust their lending rates, as their liabilities are less sensitive to market rates.

Thirdly, the level of competition in the economy should be listed. In a competitive market banks may be interested in increasing their market share and maintaining customers by setting favorable rates and borrowing to less risky borrowers. High level of competition among banks appears to cause faster interest rate pass-through (Gropp et al., 2007). Gambacorta and Iannotti (2007), by examining the interest rates in Italy, find out that when the Consolidated Law, which fostered competition, was introduced in Italy in 1993 the speed of interest rate pass through increased and, what is more, the asymmetries concerning the monetary policy regime almost vanished. According to

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\(^3\)Recently so-called risk-taking channel is distinguished, which operates through the impact of monetary policy on the behavior of banks towards risk (Borio and Zhu, 2008; Gambacorta, 2009).
the "structure-conduct-performance hypothesis" the level of concentration is inversely related to the degree of competition, because high level of concentration encourages firms to collude.\footnote{It is questionable, however, if the level of concentration gives banks the market power, due to the monopoly powers in unconcentrated markets or the perfect competition in concentrated ones (as in Canada, Shafer, 1994). Concentrated market might be more competitive when for instance it results from more efficient banks taking over less efficient ones. Therefore the so-called efficient structure hypothesis criticizes the concentration indices.} Sørensen and Werner (2006) show that the level of concentration has a negative impact on the speed of interest rate pass-through in the euro area. Whereas, Corvoisier and Gropp (2001), by investigating the role of concentration in banking sector in the euro area countries, find that when an increase in concentration is observed, banks set less competitive rates (higher interest margins) on loans and demand deposits but not on savings and time deposits.

Another interesting aspect, connected with the level of competition, is a type of bank customers. There can be distinguished sophisticated and unsophisticated customers (Rosen, 1995). The former know all market interest rates, whereas the latter only the current and previous interest rates in their bank. The more unsophisticated customers in the market the more asymmetric behavior of banks is observed, and the less pressure for banks to be competitive. It might be expected that there are more unsophisticated customers for short term deposit and loans than for long term instruments as they usually involve smaller sums of money. Interestingly, the same person can be, for instance, unsophisticated for short term deposits and sophisticated for mortgages.

Lastly, the expectations of market participants might play an important role. Some banks, due to high menu costs, may wait with adjusting their rates for a sequence of small changes to accumulate or for a large change of money market rate. When the managers responsible for setting the interest rate expect higher rates, due to the expected increases of the central bank's rate, they might wait with increasing the deposit rates or, in contrary, when they expect lower rates they might wait with decreasing the credit rates.

\section{A few facts about the Polish banking sector}

The interest rate pass-through is one of the main channels of the transmission process in inflation targeting framework. Lýziak et al. (2010) show that the effectiveness of the interest rate channel in Poland was growing till the recent crisis, due to increasing credibility of the central bank and higher economic maturity.\footnote{Nevertheless, they find out that the exchange rate channel is still the most efficient channel in Poland, however, its efficiency is decreasing and it dropped by half after adopting floating exchange rate regime in 2000.} Below we highlight
certain factors which might possibly disturb or weaken this important channel of the transmission process in Poland.

As far as the analyzed time period is concerned the most important factors are as follows. At the beginning of the analyzed period the European Union accession shock can be observed. An increase of consumer demand, due to expected price increases, as well as an increase of foreign demand, due to reduced trade barriers, were observed. However, it was a short-lived effect, thus assuming the credible monetary policy some of the retail bank interest rates could remain unchanged.\(^6\) \(^7\)

Before the financial crisis, strong growth in banking activities was recorded, mainly concerning credits for house purchases and consumer lending. Also the growing interest in investment funds should be noted, although this trend stopped in the second half of 2007 due to the falling stock market and reappeared in 2009. Obviously, the period of crisis is especially difficult to model. It was characterized by special policies of the central bank and the government to mitigate the crisis.\(^8\) During the crisis, Polish banks reduced their lending actions and focused on retail funding, especially on deposits of households. Therefore competition for consumer deposits intensified. As a result longer term deposit rates are still above the money market rate (see Figure 3 and 4). Hence, in this study we will analyze the period before August 2008 separately. Nevertheless, it is worth noting that Poland is financially less open and developed than euro area and central European countries, what might result in the smaller impact of the crisis on the Polish economy.

The financial system in Poland is dominated by commercial banks (their assets account for 70% of total financial institutions’ assets). Thus, some characteristics of the Polish banking sector are significant for the effectiveness of the interest rate pass-through.

It is worth noting that the banking sector in Poland is affected by the excess liquidity, which is characteristic for transition economies.\(^9\) This excess liquidity might limit incentives for banks to follow increasing money market rates and cause stickiness of deposit rates. Moreover, it seems that the Polish banking sector is not very concentrated comparing to Central and Western Europe, e.g. five largest banks account for

\(^6\)Frequent changes of interest rates are not beneficial for banks because of high menu costs and possibility of breaking their long run relationships with customers.

\(^7\)It might be also worth noting that, in 2004 new members of Monetary Policy Council were appointed and their attitude towards monetary policy seemed to be slightly different than the previous MPC, what might contribute to the decrease of credibility.

\(^8\)See Łyziak et al. 2010.

\(^9\)Transition economies usually experience high capital inflows, due to opening of the market and privatisation, as well as central bank’s interventions to protect the domestic currency (as the prices are too low in comparison to money stock) (Ganley (2002)).
about 44% of total sector assets in the recent years (2008-2011).\textsuperscript{10} Furthermore, the high level of foreign ownership in the banking sector is observed. Almost 70% of total banking assets are controlled by foreign companies. Therefore some banks might follow the guidelines of their foreign partners while adjusting their interest rates. There is also a typical mismatch of loan and deposit portfolio in Poland. The banking sector is dominated by short term deposits (96% of total firms’ deposits and 95% of total households’ deposits in 2010) and long term credits (68% of total firms’ credits and 89% of total households’ credits in 2010). Finally, the Polish banking sector is characterized by quite high share of foreign currencies denominated credits (25% of total firms’ credits and 37% of total households’ credits in 2010). Many households, to capture the lower rates in foreign currencies, have taken mortgage credits in the Swiss franc and more recently in the euro.\textsuperscript{11}

3  Methodology

It is a generally adopted belief that interest rates are non-stationary variables with stationary first differences and that they should be cointegrated. However, not all Polish interest rates seem to follow this rule, especially when cointegration is taken into account. First, we check whether both market and retail bank interest rate are $I(1)$ and test for symmetric and asymmetric cointegration. Secondly, depending on the type of relationship between a retail bank interest rate and a money market rate, we analyse the asymmetries in the short term.

3.1  Asymmetries in long term adjustment

There are a number of models in which the threshold cointegration is applied. The review of some of them can be found in Lo and Zivot (2001). We follow Enders and Siklos (2001) by testing for cointegration with asymmetric error correction term. They presented two approaches: threshold autoregressive (TAR) and momentum-threshold autoregressive (M-TAR) models. As the illustration, Enders and Siklos use these methods to investigate the relation between federal funds rate and a 10-year government bond.

\textsuperscript{10} These and similar indexes ($CR_{10}$, $CR_{15}$) are quite stable since 1996, they increased in 2000, because of banks mergers, and were decreasing since 2001, due to faster development of small and medium banks as well as larger competition after joining the European Union (see Lyziak et al. (2008 and 2010)).

\textsuperscript{11} However, in February 2010 T-recommendation was issued by the Financial Supervisory Commission in Poland (improved version of S-recommendation), which aim for improving a quality of credit risk in banks, setting restrictions for credits in foreign currencies. According to NBP inquiry banks sharpen the criteria for credits to households and loosen the criteria for firms.
in the period from 1964 to 1998. In this study cointegration is detected by M-TAR test, but not by Engle-Granger and TAR tests.

We estimate the long-run relationship between a retail bank interest \(r_t\) rate and a interbank rate \(m_t\) as:

\[
r_t = \alpha_0 + \alpha_1 m_t + ECT_t.
\]  

(1)

Next, we apply TAR and M-TAR models. The residuals from (1) are used to estimate:

\[
\Delta ECT_t = (1 - I_t)\rho_1 ECT_{t-1} + I_t\rho_2 ECT_{t-1} + \sum_{i=1}^{n} \gamma_i \Delta ECT_{t-i} + \epsilon_t,
\]  

(2)

where in TAR:

\[
I_t = \begin{cases} 1 & \text{if } ECT_{t-1} \geq \tau, \\ 0 & \text{if } ECT_{t-1} < \tau, \end{cases}
\]

while in M-TAR:

\[
I_t = \begin{cases} 1 & \text{if } \Delta ECT_{t-1} \geq \tau, \\ 0 & \text{if } \Delta ECT_{t-1} < \tau. \end{cases}
\]

Following number of researchers, such as Chan (1993), Enders and Siklos (2001), Sander and Kleimeier (2004), Payne (2007), we search through \(ECT_t\), or \(\Delta ECT_t\) respectively, discarding the largest and the smallest 15% of \(ECT_t\) and we choose \(\tau\) as the value which minimize the residual sum of squares from the model.

We record the F-statistic for null hypothesis \(\rho_1 = \rho_2 = 0\) and compare it with critical values presented in Enders and Siklos (2001) in Table 1. We require \(\rho_1\) and \(\rho_2\) to be negative and jointly significantly different from zero for stationarity of \(ECT\) and \(\rho_1 \neq \rho_2\) for asymmetric adjustment.

We record also the t-Max statistic (i.e. the larger of t-statistics for \(\rho_1 = 0\) and \(\rho_2 = 0\)), but we are aware that it may not reject the null hypothesis of no cointegration due to low power of the test (see Enders and Siklos, 2001; McMillan, 2008).

Given the existence of asymmetric cointegration, we estimate the following error correction model:

\[
\Delta r_t = \phi_1(1 - I_t)ECT_{t-1} + \phi_2 I_t ECT_{t-1} + \sum_{i=1}^{k} \beta_{r,i} \Delta r_{t-i} + \sum_{i=0}^{n} \beta_{m,i} \Delta m_{t-i} + \epsilon_t.
\]  

(3)

\[\text{It is worth mentioning that the following three-regime Band - threshold error correction model might be considered as well:}\]

\[
\Delta ECT_t = 1_{ECT_{t-1} \leq \tau_1} \rho_1 ECT_{t-1} + 1_{ECT_{t-1} > \tau_2} \rho_2 ECT_{t-1} + \sum_{i=1}^{n} \gamma_i \Delta ECT_{t-i} + \epsilon_t.
\]

Such model allows for no adjustment when \(\tau_1 > ECT_{t-1} \geq \tau_2\), it might be due to some structural breaks or policy modifications. Seo (2006) provides a sup-Wald type test for no linear cointegration for this model. However, it seems that in small samples such as ours the proper tests have very low power (Lo and Zivot, 2006).
3.2 Asymmetries in short term adjustment

Then we move on to short term asymmetries. We use one of the following equations and apply standard information criteria to find out the optimal lag length, setting the maximum lag length to 3.

We estimate the following equations: for interest rates which are I(1) but are not cointegrated:

$$\Delta r_t = \beta_m \Delta m_t + \sum_{i=1}^{k} \beta_{r,i} \Delta r_{t-i} + \sum_{i=1}^{n} \beta_{m,i} \Delta m_{t-i} + \epsilon_t,$$

(4)

for interest rates which are symmetrically cointegrated:

$$\Delta r_t = \beta \text{ECT}_{t-1} + \beta_m \Delta m_t + \sum_{i=1}^{k} \beta_{r,i} \Delta r_{t-i} + \sum_{i=1}^{n} \beta_{m,i} \Delta m_{t-i} + \epsilon_t,$$

(5)

and for interest rates which are asymmetrically cointegrated:

$$\Delta r_t = \phi_1 (1 - I_t) \text{ECT}_{t-1} + \phi_2 I_t \text{ECT}_{t-1} + \beta_m \Delta m_t + \sum_{i=1}^{k} \beta_{r,i} \Delta r_{t-i} + \sum_{i=1}^{n} \beta_{m,i} \Delta m_{t-i} + \epsilon_t.$$

(6)

Next, we search for asymmetries associated with the direction of change in the money market rate, the level of the economic activity and the level of liquidity in the banking sector.

Thus, we test for three sorts of asymmetries concerning:

- increase and decrease of the money market rate \((m)\), setting:

  $$d_t^- = \begin{cases} 1 & \text{if } \Delta m_t < 0, \\ 0 & \text{otherwise}, \end{cases} \quad d_t^+ = \begin{cases} 1 & \text{if } \Delta m_t > 0, \\ 0 & \text{otherwise}. \end{cases}$$

- level of economic activity \((output)\), approximated as the output gap,

- level of liquidity \((operations)\), approximated as the level of own-debt securities of the central bank to retail bank assets, setting:

  $$d_t^- = \begin{cases} 1 & \text{if } T_t < \tau_T, \\ 0 & \text{otherwise}, \end{cases} \quad d_t^+ = \begin{cases} 1 & \text{if } T_t > \tau_T, \\ 0 & \text{otherwise}. \end{cases}$$

where \(T\) denotes \(output/operations\) and where \(\tau_{output}/\tau_{operations}\) are taken as the averages found for each interest rate separately by discarding the largest and the smallest 20\% of \(output/operations\) and minimizing the residual sum of squares from the proper model.
Thus, we add to the equations 4 - 6 the threshold effects, i.e.: for interest rates which are $I(1)$ but are not cointegrated we estimate:

$$
\Delta r_t = \beta_m d_t^- \Delta m_t + \beta_m^+ d_t^+ \Delta m_t + \sum_{i=1}^{k} \beta_{r,i} \Delta r_{t-i} + \sum_{i=1}^{n} \beta_{m,i}^- d_t^- \Delta m_{t-i} + \sum_{i=1}^{n} \beta_{m,i}^+ d_t^+ \Delta m_{t-i} + \epsilon_t. 
$$

(7)

for interest rates which are symmetrically cointegrated:

$$
\Delta r_t = \beta_{ECT} d_t^- \Delta m_t + \beta_{ECT}^+ d_t^+ \Delta m_t + \sum_{i=1}^{k} \beta_{r,i} \Delta r_{t-i} + \sum_{i=1}^{n} \beta_{m,i}^- d_t^- \Delta m_{t-i} + \sum_{i=1}^{n} \beta_{m,i}^+ d_t^+ \Delta m_{t-i} + \epsilon_t. 
$$

(8)

for interest rates which are asymmetrically cointegrated:

$$
\Delta r_t = \phi_1 I_t ECT_{t-1} + \phi_2 (1 - I_t) ECT_{t-1} + \beta_m d_t^- \Delta m_t + \beta_m^+ d_t^+ \Delta m_t + \sum_{i=1}^{k} \beta_{r,i} \Delta r_{t-i} + \sum_{i=1}^{n} \beta_{m,i}^- d_t^- \Delta m_{t-i} + \sum_{i=1}^{n} \beta_{m,i}^+ d_t^+ \Delta m_{t-i} + \epsilon_t. 
$$

(9)

We use the Wald test to jointly and separately test the restrictions: $\beta_m^- = \beta_m^+$, $\beta_{m,i}^- = \beta_{m,i}^+$ for each $i$. We also test if $\beta_m + \sum_{i=1}^{n} \beta_{m,i}^- = \beta_m^+ + \sum_{i=1}^{n} \beta_{m,i}^+$.

4 Data

The study is based on publicly available data on the lending and the deposit rates denominated in the Polish currency. We use monthly data. The analyzed sample starts from January 2004 and ends in April 2012. Due to the substantial change in the methodology of calculating and collecting the retail bank interest rates in the National Bank of Poland it is not possible to extend this period before January 2004. The new statistical framework for the retail bank interest rates has been adjusted to the harmonized ECB requirements, what enables the cross-country comparability.

We divide the sample into two sub-samples. The first one, which includes the observations before the financial crisis, is restricted to August 2008. The second one includes all observations, so the results might be influenced by the crisis.

Relations between the money market rate and the Polish retail bank interest rates are investigated. As the money market rate we take 3-month or 1-month WIBOR (Warsaw Interbank Offered Rate). As far as retail interest rates are concerned, we consider the Polish zloty denominated deposits and loans. We take into account only flows, which are calculated as an average of contracts, which were concluded only during the reporting month, and ignore stocks, which are calculated as an average
of the existing contracts, which were concluded both before and during the reporting month. It seems that for the actual monetary policy and its transmission flows are more important, while stocks might reflect past behaviors.

Output gap is measured as a difference between logarithm of the seasonally adjusted GDP and the trend obtained by Hodrick Prescott filter. We use Fernandez method to disaggregate quarterly data for GDP in to monthly frequencies (cf. Fernandez, 1981). We use a monthly industrial production index to augment the related series. Whereas, the level of liquidity is measured as the level of own-debt securities of the central bank to retail bank assets.

Let us denote:

- deposits of households (see Figure 3):
  I DEP HSH 1M - to 1 month flow,
  I DEP HSH 6M - from 3 to 6 months flow,
  I DEP HSH AVG FLOW - average flow,

- deposits of firms (see Figure 4):
  I DEP FIRMS 1M - to 1 month flow,
  I DEP FIRMS 6M - from 3 to 6 months flow,
  I DEP FIRMS AVG FLOW - average flow,

- credits to households (see Figure 5):
  I CRED HSH HP AVG FLOW - for house purchases average flow,
  I CRED HSH HP AVG STOCK - for house purchases average stock,
  I CRED HSH PI AVG - for sole proprietors average flow,
  I CRED HSH CONS AVG - consumer credit average flow,

- credits to firms (see Figure 6):
  I CRED FIRMS <4M AVG - to 4 million Polish zloty average flow,\textsuperscript{13}
  I CRED FIRMS >4M AVG - above 4 million Polish zloty average flow.

At first glance (see Figures 3-6) we can observe that, during the turbulent period of the crisis, rapid changes of all these rates were observed. It seems that the relations of many of the examined retail bank interest rates with money market rates broke down. Due to the crisis of confidence and fierce competition for deposits, the households’ deposit rates, excluding only the short term rate and the longer term firms’ deposit rates, were exceeding the money market rate. As far as credits for households are concerned they also seem to perform some disturbances, as the spread between them.

\textsuperscript{13}due to the change in the methodology after 05.2010 it is calculated as the average of: credits to firms to 1 million Polish zloty and credits to firms from 1 to 4 million Polish zloty
and money market rate strongly increased. Whereas credits for firms seem to be less affected by the crisis.

We can also notice that after May 2004 the European Union accession shock appeared. The examined interest rates performed slightly smaller changes than it was during the crisis, but their relation with the money market rate remained more stable.

5 Results

5.1 Unit root tests

We test if the analyzed interest rates are non-stationary variables with stationary first differences. If the variables are I(1), then cointegration techniques can be used to model the long-run relations and correct results are obtained when building models with a threshold incorporated to adjustment mechanism.

The obtained results for these tests are not fully consistent with each other, especially the results of the KPSS test differ from the results of the ADF and PP tests. Obviously, all these tests have quite low power with short time spans of data. Moreover, some modifications of the ADF, PP, KPSS tests, as in Virmani (2004)\(^\text{14}\), give ambiguous results. Therefore, we decided to rely on the results indicated by the majority of the tests (i.e. at least two) presented in Table 1.

In the shorter period, all tests show that consumer credit average flow is stationary, so we do not take it into account when analyzing the cointegration. As far as the other rates are concerned, according to all or at least two of the presented tests, the investigated time series are non-stationary with stationary first differences in both periods. Similarly, consumer credit average flow in the longer period contains a unit root. Thus, in the next section, we proceed to test for symmetric and asymmetric cointegration.

5.2 Cointegration tests

During the crisis the long term relation of the analyzes interest rates with the money market rate was greatly disturbed. Nevertheless, it appears that in case of most rates the ECT has returned to its levels observed before the crisis. The two evident exceptions are credits for sole proprietors and consumer credits, for which the ECT is still much higher than before. Hence, the long term relations of these rates seem to be most strongly disturbed.

We apply the Engle-Granger methodology to test cointegration (see Table 2). The

\(^{14}\)Elliott, Rothenberg and Stock - DF-GLS, Perron and Ng, Leybourne and McCabe tests;
Schwartz Criterion is used to choose the lag length. To provide a robustness check, due to a small sample size, we performed also the Johansen tests for cointegration. The cointegration tests indicate that only some of the examined interest rates are cointegrated with 3-month WIBOR and 1-month WIBOR.

In the shorter subsample, according to both tests short term deposits of households (i.e. 1 month and average deposits of households) are not cointegrated with the investigated money market rates. The absence of cointegration is quite surprising. These two rates move almost in line because households prefer short term deposits. Therefore, as far as the deposits of households and firms are concerned, the share of short term deposits has been exceeding 90% in the analyzed period. Further analysis shows that the lack of cointegration in case of these rates is mainly caused by some disturbances in 2004. However, we are uncertain if it is connected with the Polish entry to the European Union or perhaps with a hidden change of the methodology.

The cointegration relation seems to disappear or weaken during the crisis. In the longer subsample the results of the Johansen test are consistent with the results of the Engle-Granger tests. Only deposits to 1 month and average flow deposits of firms as well as credits for house purchases average stock display the cointegrating relation. Their long term relation with the interbank rates seems not to be so strongly affected by the crisis. In contrast the interest rates for deposits from 3 to 6, for which strong competition occurred, as well as credit flows seem to be strongly influenced by the financial crisis.

In the further part of this paper we follow the idea of marginal cost price (see de Bondt, 2005) and for each of the retail bank interest rate we analyse its relation with the money market rate with which it is the most closely related.

5.3 Asymmetric cointegration tests

We determine for each retail bank interest rate whether its long term relationship with the money market rate is asymmetric. We check if the rates are asymmetrically cointegrated using the TAR model and asymmetrically cointegrated using the M-TAR model. Moreover, the TAR and M-TAR models might enable us to show the cointegrating re-

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15 These results can be obtained from the author on request.
16 According to Engle-Granger test also credits for house purchases average stock and credits to firms up to 4 million Polish zloty are not cointegrated in the shorter sample, but the Johansen test shows cointegration.
17 Due to the increase of investment, consumption and significant credit growth banks wanted to attract depositors.
18 For the short term and average flow deposits of firms it is WIBOR 1M and for the rest of rates it is WIBOR 3M (compare with Table 2).
lation between the interest rates which were expected to be cointegrated but standard procedures\textsuperscript{19} did not show the cointegration.

When both TAR and M-TAR models indicate asymmetric cointegration, we choose the best model basing on the standard information criteria (i.e. Akaike info criterion, Schwarz criterion, Hannan-Quinn criterion). In Table 3 the results of asymmetric cointegration tests are presented. It is important to keep in mind that each interest rate is characterized by a different threshold value. Thus, the assessment of the asymmetric effect might differ across the investigated interest rates.

In the shorter period most rates seem to be cointegrated using the M-TAR and TAR models, except: short term deposits of households (to 1 month flow and average flow) and credits for house purchases. In the longer sample, asymmetric cointegration disappears in many cases, but not as many as it was with the symmetric cointegration (compare Tables 2 and 3). It even seems to appear in case of credits for house purchases and deposits of households average flow, which were not cointegrated in the shorter sample.

Below, we will analyze the results of asymmetric cointegration tests, which are used in the next section when analyzing the short-term asymmetries.

Concerning the TAR model:

- deposits of both households and firms from 3 to 6 months flow (in the shorter period),
- deposits of firms to 1 month and average flow (in the longer the period),
- credits to sole proprietors average flow (in the shorter period),
- consumer credit average flow (in the longer period)

adjust quicker when the error correction term is below their threshold value, whereas:

- credits to firms to 4 million Polish zloty average flow (in both periods),
- credits to households for house purchases average stock (in the longer period)

seem to exhibit different adjustment process and react quicker when the error correction term is above their threshold value.

In the case of credits to firms to 4 million Polish zloty and credits to households for house purchases, banks might care more about their long term relations with clients. The competition for such credits is stronger between banks, as large clients are valuable and credits to households have very good collaterals. Thus, banks might be more

\textsuperscript{19}presented in the previous section
inclined to tolerate lower interest rates on such credits. When money market rate increase they tend to adjust these interest rates slowly, whereas, when money market rate decreases, they adjust the interest rates rapidly. Also, according to the adverse selection problem, banks might be aware of the fact that higher rates could attract riskier projects.

On the other hand, although credits to sole proprietors and consumer credits are perceived as more risky in comparison to credits to firms, banks seem to adjust the rates on these credits quicker when they are below their equilibrium level. This result is not consistent with the adverse selection effect. But such behaviour seems to be more profitable for banks. It might also happen that in some cases outside larger cities, individual clients have access to only one quasi-monopolistic bank, where the lending rates are relatively high.

Moreover, also some of the deposit rates react stronger when the error correction term is below the threshold value. It is probably due to high level of competition concerning the longer term deposits and relatively slower adjustment process of firms’ deposits during the financial crisis.

Next, applying the M-TAR model we investigate whether large negative or positive spreads of error correction term force banks to more rapid change of their rates. An increasing spread might be associated with growing risk in relevant credit market segment and banks’ expectations about the occurrence of some unfavorable events. On the other hand it might result from high menu costs. Banks might wait with adjusting their interest rates to avoid high menu costs while introducing small changes.

The results for the M-TAR model are the following. For:

- deposits of households average flow (in the longer period),
- deposits of firms from 3 to 6 months flow (in both periods),
- credits for house purchases (in the longer period),
- credits to firms (i.e. to 4 million Polish zloty average flow (in both periods) and above 4 million Polish zloty average flow (in the shorter period))

the estimates suggest that when the change of the error correction term is below the threshold value, the discrepancies from the equilibrium are eliminated relatively quicker.

Whereas, for:

- deposits of households from 3 to 6 months (in shorter period),

\[\text{It is due to larger asymmetry of information between the bank and the borrower as well as higher probability of collapse of a small firm than of a larger one. In addition, these credits are characterized by a poorer collateral than others (e.g. credits for house purchases).}\]
• deposits of firms to 1 month and average flow (in both periods),
• credits to sole proprietors average flow (in the shorter period),
• consumer credit average flow (in the longer period)

the reversion to the long term equilibrium seems to be quicker when the change of the error correction term is above the threshold value.

However, it seems not to be the most crucial issue whether the quicker reaction appears when the spread of the error correction term is above or below the threshold value. The important fact is that the reaction of these rates is stronger when the large spreads appear. In all cases the threshold level cuts off the time periods with the most outstanding spreads. It seems that during these time periods the speed of adjustment is higher.

Thus, the discrepancies from the equilibrium for the examined rates (in one or both samples) seem to be smoothed out relatively quicker when the sizable changes of the error correction term occur. It is also worth noting that such relation appeared for the credits for house purchases and deposits to households average flow only in the longer sample and was not detected before the crisis. It might be due to the fact that these credits have good collaterals and could be treated by banks as less risky than others. Whereas concerning the short term deposit rates the crisis disturbances were weaker than in case of longer term deposit rates for which the level of competition was relatively high and thus, the long term relation remained more stable.

Enders and Siklos (2001) and McMillan (2008), using the M-TAR model, found that for the analyzed interest rates the reversion to the long-term equilibrium is quicker, when the change of the error correction term is below the threshold value. Enders and Siklos (2001) analyzed the federal funds rate and 10-year rate on government securities. They claim that the quicker reaction is due to the decreases of the federal funds rate or increases in the money market rate. Thus, their result is consistent with the asymmetric policy theory that the Federal Reserve takes stronger measures to mitigate the shocks which are deemed to cause the increases not decreases of inflationary expectations. Similarly, we could expect that the reaction of the Polish banks is quicker when the increases of the money market rate are observed, as it is more profitable for them to increase the lending rates. However, applying the M-TAR models we do not detect such relation for all the lending rates, perhaps due to a small sample size. Nevertheless, such relation might also appear in the short term, what is analyzed in the next section.
5.4 Asymmetries in the short term

This section addresses the results assigned to short term asymmetries. Tables 5-7 report the most important outcomes. We present the sums of coefficients assigned to the changes of the money market rate during one quarter. We decided to concentrate on the one quarter change as the analyzed stage of the monetary transmission process is often considered at such a time horizon.

In the tables we show the results of two tests for asymmetries. Firstly, we look at the equality of sums of respective coefficients - if they are not equal in the statistically significant way, we conclude that the adjustment is asymmetric. Secondly, if there are more lags than one, we look at the equality of each pair of coefficients - the asymmetry in this case means that the adjustment within the investigated time period may be asymmetric, i.e. during the first, the second or the third month.

We analyze the asymmetries with respect to: the direction of the change of the money market rate, the level of the output gap and the level of liquidity.

Concerning the direction of the change of WIBOR, we find only a few significant asymmetries (see Table 5). We find little evidence to support the thesis that all retail bank interest rates react asymmetrically to the positive or negative changes of the money market rate.

The adjustment of deposits of firms (to 1 month and average flows) in the longer period is faster when the money market rate decreases. One of the possible explanations is that it is more profitable for banks to lower their deposit rates than to increase them as well as to increase the lending rates than to decrease them. We do not find any evidence for such relation for the credit rates. Nevertheless, the deposits of firms seem to react almost two times stronger on decreases of the money market rate.

As far as the level of the output gap is concerned, the results are quite varied (see Table 6). It seems that the reaction of some of the interest rates is stronger when the output gap is high. There is evidence that the interest rates for short term deposits of firms and credits for sole proprietors in the shorter period, as well as credits for house purchases and credits to firms to 4 million Polish zloty in the longer sample tend to react stronger when the output gap is high. Hence, these results confirm the claim that when the high level of the economic activity is observed the pass-through of the changes in the money market rate to retail bank interest rates is stronger. There are, however, a number of exceptions, namely in the longer sample short term deposits of firms and in the shorter sample long term deposits of households and credits to firms above 4 million Polish zloty seem to react more aggressively when the level of economic activity is relatively low. It is worth noting that the direction of short term asymmetries seem to change after the financial crisis for short term deposits of firms, which reacted
more strongly when the output gap was high before the crisis and seem to react more strongly when the output gap is low after the crisis, and credits to firms above 4 million Polish zloty. But it is mainly due to the change of the threshold values (see Table 6) and it indicates high sensitivity to the results on the level of threshold value. Thus, it is difficult to judge about the character (and direction) of these asymmetries.

Concerning the level of liquidity the results also indicate asymmetric adjustment of the interest rates, namely in most cases weaker reaction to the changes of the interbank rate when the level of liquidity is low. It is true for most of the deposit rates in both samples, relatively risky credits for sole proprietors and consumer credits as well as credits to firms above 4 million Polish zloty in the longer sample. The periods of low level of liquidity contain the recent financial crisis as well as the European Union accession shock. Thus, the turbulences of the interest rate adjustment process might stem from high level of uncertainty during these time periods (as it was in the beginning of the financial crisis). There are two exceptions. Longer term deposits for households in the longer period and credits for firms to 4 million Polish zloty, in contrary, seem to react stronger when low level of liquidity is observed. This result is consistent with the theory that in an economy characterized by a structural excess liquidity an interest rate pass-through is greater when the level of liquidity is lower.

Furthermore, it is worth noting that we repeated the estimations for both the long and the short term asymmetries for different time periods and it turns out that while the assessment of long term asymmetries is very stable over different samples the assessment of short term asymmetries is quite variable and changes across different time periods.

6 Forecasting the retail bank interest rates with nonlinear model

One of an important application of nonlinear models is forecasting. Nevertheless, the relevant literature shows that there is no clear evidence that the forecasting performance of these models is better than linear ones. Clements et al. (2004) state that due to many unknowns and complexity of the economic system adding some nonlinearities might not improve forecasts. In this section we test whether adding simple asymmetries in the long and short term improves the quality of forecasting the retail bank interest rates. We take into account four retail bank interest rates:

- deposits of households to 1 month flow (I DEP HSH 1M ),
- deposits of firms to 1 month flow (I DEP FIRMS 1M),
• credits to households for house purchases flow (I CRED HSH HP AVG FLOW),
• credits to firms above 4 million Polish zloty flow (I CRED FIRMS > 4MLN AVG),

which represent the most important categories of the investigated interest rates.

We compare the results of out-of-sample forecasting from the error correction model (ECM) with asymmetries \(^{21}\) and ECM without asymmetries. We chose the models with all statistically significant coefficients.

As far as the short term asymmetries are concerned we consider the threshold variables for which the strongest short term asymmetries were revealed. For the two deposits rates it is the level of liquidity and for the two credit rates it is the level of output gap. M-TAR model is used to account for long term asymmetries.

We concern the forecasts based on the period from January 2004 to February 2008, that is before the financial crisis occurred, and forecasts based on the period from January 2004 to October 2011.

The root mean squared errors for both symmetric and asymmetric models are presented in Table 8. The forecasts are made for one and six steps ahead for the longer sample and for one, six and fifty steps ahead for shorter sample.

The forecast errors for the deposit rates are similar for both symmetric and asymmetric models. It appears that for the period 01:2004 - 02:2008 the asymmetric models seem to perform better in case of longer term (fifty steps ahead) forecasts for deposit rates of households and shorter term (one and six steps ahead) forecasts for deposit rates of firms. Whereas for the period 01:2004 - 05:2011 the asymmetric model is better for forecasts of credit rates to firms both one and six steps ahead and forecasts for the deposit rates for six steps ahead. In the other cases the symmetric model performs better than the asymmetric one.

Thus, the forecasting performance of the asymmetric models turns out to be very case dependent. The recent turbulent times make us very uncertain about the persistence of the revealed asymmetries. However, if the asymmetries are properly diagnosed than the usage of symmetric models might lead to significant errors.

7 Concluding remarks

In this study we examine the asymmetries in the response of retail bank interest rates to the changes of the money market rate in Poland in the time period from 2004 to 2012. We apply the obtained asymmetric models to test the forecasting performance of the asymmetric versus symmetric models.

\(^{21}\)presented in the previous section
Firstly, we consider the long term relations of the chosen lending and deposit rates with the money market rate. We find out that many of the rates are not cointegrated in the examined period. Next, we investigate the asymmetric cointegration applying the TAR and M-TAR models, testing whether the chosen retail bank interest rates respond asymmetrically according to the value of the disequilibrium as well as the change in the disequilibrium. It turns out that more than half of examined rates seem to exhibit an asymmetric long-term adjustment.

Secondly, we analyze the short term relations. In the short term we consider three possible sorts of asymmetries. There is little evidence that the response of the examined interest rates to positive and negative changes in the money market rate. Only the short term deposits of firms react significantly stronger to decreases of the money market rate. The results for the level of economic activity are ambiguous, as the interest rates seem to react stronger when different values of this characteristic is observed. Concerning the level of liquidity the results indicate weaker reaction to the changes of the interbank rate when the level of liquidity is low. Nevertheless, many different factors probably influence the interest rate transmission process and it is difficult to separate just one of them.

Finally, it is unclear if the revealed asymmetries improve the quality of forecasting retail interest rates in Poland. It seems that they give better results in a few cases. But the shortness of the sample, on the one hand, and the uncertainty if the asymmetries will survive to the subsequent time periods, on the other hand, make it difficult to draw any final conclusions.
References


[33] Virmani V. (2004), Unit root tests: results from some recent tests applied to select Indian macroeconomic variables, Indian Institute of Management Ahmedabad, Research and Publication Department, IIMA Working Papers WP2004-02-04.
Table 1: Unit Root Tests

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<td>WIBOR 3M</td>
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The null hypothesis is rejected at: *** 1% significance level, ** 5% significance level, * 10% significance level.
Table 2: Engle-Granger Cointegration Test (t-statistics)

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<td>-5.09*</td>
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Critical values for cointegration: -3.73 1% significance level, -3.17 5% significance level, -2.91 10% significance level, see Enders (1995); * denotes cointegration.
Table 3: Asymmetric cointegration

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<tr>
<td>CRED FIRMS &gt; 4MLN AVE</td>
<td>5.70</td>
<td>0.06</td>
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For critical values see Enders, Siklos (2001), we present only those for 10% significance level for F statistic:

In the shorter sample: for TAR model 6.05 (no lagged changes), 6.20 (one lagged change), 6.79 (four lagged changes); for M-TAR model 5.92 (no lagged changes), 5.99 (one lagged change), 5.99 (four lagged changes); in the longer sample: for TAR model 5.95 (no lagged changes), 6.02 (one lagged change), 6.35 (four lagged changes); for M-TAR model 5.73 (no lagged changes), 5.76 (one lagged change), 5.52 (four lagged changes);
### Table 4: Asymmetric cointegration and optimal lag length

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<td>M-T AR or TAR n + 1 k</td>
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<td>I CRED HSH CONS AVG</td>
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* statistically insignificant; in 4, 5, 8, 9 columns p-value for Wald statistic, red color for asymmetries;
Table 7: Asymmetries concerning the level of liquidity

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<td>( \beta_m + \sum_{i=1}^n \beta_i )</td>
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<table>
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* statistically insignificant; in 4, 5, 9, 10 columns p-value for Wald statistic, red color for asymmetries.

Table 8: Out-of-sample forecasts - Root Mean Squared Errors (multiplied by 10^3)

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<thead>
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<td>2.132</td>
<td>2.876</td>
</tr>
<tr>
<td>50 steps ahead</td>
<td>10.161</td>
<td>13.176</td>
</tr>
<tr>
<td>I CRED FIRMS &gt; 4MLN AVG</td>
<td>0.513</td>
<td>1.980</td>
</tr>
<tr>
<td>six steps ahead</td>
<td>2.941</td>
<td>3.940</td>
</tr>
<tr>
<td>50 steps ahead</td>
<td>7.514</td>
<td>7.820</td>
</tr>
</tbody>
</table>

Asymmetric model - ECM with asymmetries in both the long and the short term.
Figure 1. The relevant characteristics of the economy

Figure 2. NBP reference rate and WIBOR

Figure 3. Deposits of households

Figure 4. Deposits of firms

Figure 5. Credits to households

Figure 6. Credits to firms