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# 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, the level of liquidity in the banking sector, the central bank's credibility and the economic agents' expectations. Finally, we test whether using the asymmetric models improves the quality of forecasts of retail bank interest rates.

**Keywords:** interest rate pass-through, asymmetries, threshold models, forecasting

# 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 (consumption and investment).

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.

[1] Monetary policy framework in Poland is broadly described in Łyziak et al. (2008 and 2010).

[2] see for instance: Becker et al. (2010) for the UK, Cecchin (2011) for Switzerland, De Graeve et al. (2007) for Belgium, Égert et al. (2007) for CEE, Gambacorta (2007) for Italy, Karagiannis et al. (2010) for the euro area and the USA, Payne (2007) for the USA, Sander and Kleimeier (2002, 2004, 2006) for European and SACU countries.

## 2 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 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 Aynaoui (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.

[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).

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 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.[4] 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.

Fourthly, the expectations of market participants might play an important role. Becker et al. (2010) point out that some banks 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.

[4]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, Shaffer, 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.

Lastly, certain individual characteristics of banks are important factors. In this context the Polish interest rate pass-through for bank-level data is investigated by Chmielewski (2003)[5]. The author argues that some individual bank-specific variables might determine the interest rate adjustment process. Banks which are more profitable seem to adjust their credit and long-term deposit rates faster. While, less profitable banks seem to widen their credit-deposit spreads when a decrease of money market rate is observed. The author suggest that it may be because they want to defend their interest margin or just because their pricing strategy is less competitive. Moreover, banks with low quality loans seem to decrease corporate lending rates faster and stronger, perhaps to attract safer borrowers. As far as a capital adequacy ratio is concerned, the banks with a lower capital adequacy ratio seem to adjust their lending rates more effectively, as they usually have more risky assets.

Whereas, Gambacorta and Marques-Ibanez (2011), basing on bank-specific data from 15 countries, provide a paper on bank lending channel prior to and during the financial crisis. The authors describe the new bank lending channel, which emerged due to: greater reliance of banks on market sources of funding (i.e. bond market) and less on deposits, financial innovations (such as securitisation), presence of internal capital markets (multi-bank holding companies) and greater diversification in banks' activities (non-interest income revenues). They point out that the type of bank funding, i.e. the amount of short-term funding and securitisation, is of a key importance for the effectiveness of the transmission mechanism; whereas the standard characteristics such as: size, liquidity and capitalisation, are not sufficient to explain the functioning of new and evolving bank lending channel.

## 2.1 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. Łyziak 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.[6] 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

[5] his analysis included the period from January 1998 until August 2003

[6] 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.

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[7] [8].

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[9]. 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.[10] This excess liquidity might limit incentives for banks to follow decreasing 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 about 44% of total sector assets in the recent years (2008-2011).[11] Furthermore, the

[7] 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.

[8] 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.

[9] See Łyziak et al. 2010.

[10] 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)).

[11] 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 Łyziak et al. (2008 and 2010)).

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 (98% of total firms' deposits and 94% of total households' deposits in 2009) and long term credits (68% of total firms' credits and 88% of total households' credits in 2009). Finally, the Polish banking sector is characterized by quite high share of foreign currencies denominated credits. Many households, to capture the lower rates in foreign currencies, have taken mortgage credits in the Swiss franc and more recently in the euro.[12]

[12]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.

# 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 (i.e. 3-month WIBOR), 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 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:

$$r_t = \alpha_0 + \alpha_1 m_t + ECT_t. \tag{1}$$

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

$$\Delta ECT_t = (1 - I_t)\rho_1 ECT_{t-1} + I_t \rho_2 ECT_{t-1} + \sum_{i=1}^{n} \gamma_i \Delta ECT_{t-i} + \epsilon_t, \tag{2}$$

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: [13]



$$\Delta r_t = \phi_1(1 - I_t)ECT_{t-1} + \phi_2 I_t ECT_{t-1} + \sum_{i=1}^{k} \beta_{r,i}\Delta r_{t-i} + \sum_{i=0}^{n} \beta_{m,i}\Delta m_{t-i} + \epsilon_t. \quad (3)$$

## 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:

$$\Delta r_t = \beta_m \Delta m_t + \sum_{i=1}^{k} \beta_{r,i}\Delta r_{t-i} + \sum_{i=1}^{n} \beta_{m,i}\Delta m_{t-i} + \epsilon_t, \quad (4)$$

for interest rates which are symmetrically cointegrated:

$$\Delta r_t = \beta ECT_{t-1} + \beta_m \Delta m_t + \sum_{i=1}^{k} \beta_{r,i}\Delta r_{t-i} + \sum_{i=1}^{n} \beta_{m,i}\Delta m_{t-i} + \epsilon_t, \quad (5)$$

and for interest rates which are asymmetrically cointegrated:

$$\begin{aligned} \Delta r_t = &\phi_1(1 - I_t)ECT_{t-1} + \phi_2 I_t ECT_{t-1} + \beta_m \Delta m_t + \\ &+ \sum_{i=1}^{k} \beta_{r,i}\Delta r_{t-i} + \sum_{i=1}^{n} \beta_{m,i}\Delta m_{t-i} + \epsilon_t. \end{aligned} \quad (6)$$

[13] 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).

Next, we search for asymmetries associated with the direction of change in the money market rate, the level of the economic activity, the level of liquidity in the banking sector, the central bank's credibility and the economic agents' expectations. Thus, we test for five sorts of asymmetries concerning:

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

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

- 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,

- the CPI deviations from the the central bank's inflation target[14] as well as the absolute value of the CPI deviations from the inflation target ($CPI^*$) , setting:

$$d_t^- = \begin{cases} 1 & \text{if } T_t < \tau^T, \\ 0 & \text{otherwise,} \end{cases} \qquad d_t^+ = \begin{cases} 1 & \text{if } T_t > \tau^T, \\ 0 & \text{otherwise,} \end{cases}$$

where T denotes $output/operations/CPI^*$ and where $\tau^{output}/\tau^{operations}/\tau^{CPI^*}$ are taken as the averages found for each interest rate separately by discarding the largest and the smallest 20% of $output/operations/CPI^*$ respectively, 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:

$$\begin{aligned} \Delta r_t =& \beta_m^- d_t^- \Delta m_t + \beta_m^+ d_t^+ \Delta m_t + \\ &+ \sum_{i=1}^{k} \beta_{r,i} \Delta r_{t-i} + \sum_{i=1}^{n} \beta_{m,i}^- d_t^- \Delta m_{t-i} + \sum_{i=1}^{n} \beta_{m,i}^+ d_t^+ \Delta m_{t-i} + \epsilon_t. \end{aligned} \tag{7}$$

for interest rates which are symmetrically cointegrated:

$$\begin{aligned} \Delta r_t =& \beta ECT_{t-1} + \beta_m^- d_t^- \Delta m_t + \beta_m^+ d_t^+ \Delta m_t + \\ &+ \sum_{i=1}^{k} \beta_{r,i} \Delta r_{t-i} + \sum_{i=1}^{n} \beta_{m,i}^- d_t^- \Delta m_{t-i} + \sum_{i=1}^{n} \beta_{m,i}^+ d_t^+ \Delta m_{t-i} + \epsilon_t. \end{aligned} \tag{8}$$

[14] Since 2004 the inflation target is set at the level of $2,5\%$.

for interest rates which are asymmetrically cointegrated:

$$\begin{aligned}\Delta r_t =&\phi_1 I_t ECT_{t-1} + \phi_2(1-I_t)ECT_{t-1} + \beta_m^- d_t^- \Delta m_t + \beta_m^+ d_t^+ \Delta m_t + \\ &+ \sum_{i=1}^{k} \beta_{r,i} \Delta r_{t-i} + \sum_{i=1}^{n} \beta_{m,i}^- d_t^- \Delta m_{t-i} + \sum_{i=1}^{n} \beta_{m,i}^+ d_t^+ \Delta m_{t-i} + \epsilon_t.\end{aligned} \tag{9}$$

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 end in November 2011. 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 12M - from 6 to 12 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 12M - from 6 to 12 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 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,[15]
  I CRED FIRMS >4M AVG - above 4 million Polish zloty average flow,
  I CRED FIRMS AVG FLOW - 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 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.

[15] 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

# 5 Results

## 5.1 Unit root tests

First, we use standard tests: Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Philips-Schmidt-Shin (KPSS) to detect if the variables are non-stationary with stationary first differences. As the null hypothesis: ADF and PP tests have unit root, whereas KPSS has stationarity. The results are presented in Table 1. Critical values for ADF and PP are taken from MacKinnon (1996), while for KPSS from Kwiatkowski, Philips, Schmidt, Shin (1992).

Test equations for levels include a constant but they do not include a trend, which is not meaningful for interest rates [16]. Whereas, test equations for first differences for ADF and PP do not include any deterministics and for KPSS include a constant.

In the ADF test, the Schwartz Criterion is used to indicate the lag length. Whereas for the PP and KPSS tests we use the Bartlett kernel estimation method and the Andrews bandwidth selection method. As suggested by Jönsson (2006), while performing the KPSS test for small samples using the Bartlett kernel is the best choice.



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)[17], 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.

[16] At least it is not meaningful for the examined interest rates in the analyzed period. For example, if we considered the period starting from 1990s and completing in 2003 in Poland we would observe the downward trend in the money market rates, what is characteristic for the disinflation phase.

[17] Elliott, Rothenberg and Stock - DF-GLS, Perron and Ng, Leybourne and McCabe tests;

Table 1: Unit Root Tests

| | 01.2004 - 08.2008 | | | 01.2004 - 11.2011 | | |
|---|---|---|---|---|---|---|
| Level | ADF | PP | KPSS | ADF | PP | KPSS |
| I DEP HSH 1M | 0,51 | 0,74 | 2,56*** | 0,16 | 0,33 | 0,38* |
| I DEP HSH 6M | 0,56 | 0,83 | 1,05*** | 0,32 | 0,40 | 0,28 |
| I DEP HSH 12M | 0,29 | 0,36 | 0,15 | 0,12 | 0,14 | 0,12 |
| I DEP HSH AVG FLOW | 0,34 | 0,71 | 1,37*** | 0,15 | 0,26 | 0,36* |
| I DEP FIRMS 1M | 0,89 | 0,82 | 0,58** | 0,41 | 0,42 | 0,38* |
| I DEP FIRMS 6M | 0,23 | 0,77 | 1,36*** | 0,45 | 0,43 | 0,34 |
| I DEP FIRMS 12M | 0,59 | 0,65 | 0,17 | 0,26 | 0,31 | 0,10 |
| I DEP FIRMS AVG FLOW | 0,41 | 0,81 | 0,61** | 0,37 | 0,37 | 0,38* |
| I CRED HSH HP AVG FLOW | 0,26 | 0,82 | 4,07*** | 0,16 | 0,37 | 0,41* |
| I CRED HSH PI AVG | 0,69 | 0,90 | 0,61** | 0,52 | 0,52 | 0,16 |
| I CRED HSH CONS AVG | 0,02 | 0,00 | 0,21 | 0,49 | 0,00 | 0,34 |
| I CRED FIRMS < 4MLN AVG | 0,67 | 0,78 | 0,57** | 0,50 | 0,40 | 0,42* |
| I CRED FIRMS > 4MLN AVG | 0,73 | 0,79 | 0,19 | 0,31 | 0,34 | 0,09 |
| I CRED FIRMS AVG FLOW | 0,84 | 0,84 | 0,39** | 0,45 | 0,42 | 0,17 |
| WIBOR 1M | 0,49 | 0,72 | 0,78*** | 0,25 | 0,32 | 0,38* |
| WIBOR 3M | 0,44 | 0,71 | 1,20*** | 0,18 | 0,30 | 0,41* |

| | 01.2004 - 08.2008 | | | 01.2004 - 11.2011 | | |
|---|---|---|---|---|---|---|
| First difference | ADF | PP | KPSS | ADF | PP | KPSS |
| I DEP HSH 1M | 0,01*** | 0,00*** | 0,22 | 0,00*** | 0,00*** | 0,07 |
| I DEP HSH 6M | 0,00*** | 0,00*** | 0,31 | 0,00*** | 0,00*** | 0,07 |
| I DEP HSH 12M | 0,00*** | 0,00*** | 0,14 | 0,00*** | 0,00*** | 0,05 |
| I DEP HSH AVG FLOW | 0,04** | 0,00*** | 0,20 | 0,00*** | 0,00*** | 0,06 |
| I DEP FIRMS 1M | 0,00*** | 0,00*** | 0,32 | 0,00*** | 0,00*** | 0,08 |
| I DEP FIRMS 6M | 0,00*** | 0,00*** | 0,27 | 0,00*** | 0,00*** | 0,11 |
| I DEP FIRMS 12M | 0,00*** | 0,00*** | 0,23 | 0,00*** | 0,00*** | 0,08 |
| I DEP FIRMS AVG FLOW | 0,00*** | 0,00*** | 0,30 | 0,00*** | 0,00*** | 0,09 |
| I CRED HSH HP AVG FLOW | 0,12 | 0,00*** | 0,37* | 0,00*** | 0,00*** | 0,08 |
| I CRED HSH PI AVG | 0,00*** | 0,00*** | 0,53** | 0,00*** | 0,00*** | 0,11 |
| I CRED HSH CONS AVG | 0,00*** | 0,00*** | 0,11 | 0,00*** | 0,00*** | 0,05 |
| I CRED FIRMS < 4MLN AVG | 0,00*** | 0,00*** | 0,47** | 0,00*** | 0,00*** | 0,10 |
| I CRED FIRMS > 4MLN AVG | 0,00*** | 0,00*** | 0,25 | 0,00*** | 0,00*** | 0,10 |
| I CRED FIRMS AVG FLOW | 0,00*** | 0,00*** | 0,38* | 0,00*** | 0,00*** | 0,11 |
| WIBOR 1M | 0,00*** | 0,00*** | 0,27 | 0,00*** | 0,00*** | 0,07 |
| WIBOR 3M | 0,00*** | 0,00*** | 0,26 | 0,00*** | 0,00*** | 0,07 |

The null hypothesis is rejected at: *** 1% significance level, ** 5% significance level, * 10% significance level;

## 5.2 Cointegration tests

In Figures 8 and 9, the error correction terms (ECT) for the examined deposit and lending rates are presented. It is easy to notice that during the crisis the long term relation of these rates with the money market rate was greatly disturbed. Indeed, in all charts the rapid change of the ECT at the end of 2008 is visible. 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.

First, we apply the Engle-Granger methodology to test cointegration (see Table 2). As previously in the ADF test, the Schwartz Criterion is used to chose the lag length. The Engle-Granger cointegration test indicates that only some of the examined interest rates are cointegrated with 3-month WIBOR and 1-month WIBOR. In the shorter subsample, deposits of households (1 month and average) and credits to firms up to 4 million Polish zloty are not cointegrated with the investigated money market rates.

It is quite surprising that short term and average deposit flows for households are not cointegrated with the money market rate. 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 (see Table 15). However, we are uncertain if it is connected with the Polish entry to the European Union[18] or perhaps with a hidden change of the methodology.

According to the Engle-Granger tests, the cointegration relation seems to disappear or weaken during the crisis. In the longer subsample only deposits to 1 month and average flow and from 6 to 12 months deposits of firms display the cointegration 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.

To provide a robustness check, due to a small sample size, we perform also the Johansen tests for cointegration. We present the outcomes of the Johansen test for the 1 and 2 lag length due to non conclusive results. In Appendix in Tables 11-14 the results are reported. We analyze the periods starting from January 2004 as well as from January 2005 because of the uncertainty about the correctness of some data in

[18]Due to the increase of investment, consumption and significant credit growth banks wanted to attract depositors.

2004. In some cases in the shorter subsample the results obtained from these tests differ significantly from the results obtained while applying the Engle-Granger methodology.

In the shorter period ending before the financial crisis, the main differences are as follows. In contrast to the previous test, for deposits from 3 to 6 months flows of households, deposits from 3 to 6 and from 6 to 12 months of firms as well as credits to firms above 4 million Polish zloty average flow, the Johansen test does not indicate the cointegrating relation. Therefore, in case of these rates it is difficult to judge about the cointegration in the shorter subsample. We presume that the ambiguous results for the shorter subsample stem from its shortness.

While in the longer subsample both tests indicate only a few cointegration relations. Moreover, for the credit rates the results of the Johansen test are consistent with the results of the Engle-Granger tests. As far as deposit rates are concerned the Johansen test does not indicate the cointegration relation for deposits of firms.

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. For the short term and average flow deposits to firms it is WIBOR 1M and for the rest of rates it is WIBOR 3M (compare with Table 2).



Table 2: Engle-Granger Cointegration Test (t-statistics)

| | 01.2004 - 08.2008 | | 01.2004 - 11.2011 | |
|---|---|---|---|---|
| | WIBOR 3M | WIBOR 1M | WIBOR 3M | WIBOR 1M |
| I DEP HSH 1M | -1,91 | -2,22 | -3,02* | -2,48 |
| I DEP HSH 6M | -3,00* | -2,98* | -1,58 | -1,57 |
| I DEP HSH 12M | -5,44* | -5,29* | -2,95* | -2,68 |
| I DEP HSH AVG FLOW | -2,07 | -2,23 | -2,25 | -1,91 |
| I DEP FIRMS 1M | -3,92* | -5,20* | -3,17* | -5,83* |
| I DEP FIRMS 6M | -4,98* | -3,17* | -1,22 | -1,37 |
| I DEP FIRMS 12M | -6,53* | -5,59* | -2,64 | -2,37 |
| I DEP FIRMS AVG FLOW | -3,95* | -5,35* | -3,35* | -6,05* |
| I CRED HSH HP AVG FLOW | -2,21 | -5,43* | -1,22 | -1,28 |
| I CRED HSH PI AVG | -2,87 | -3,76* | -1,93 | -1,67 |
| I CRED HSH CONS AVG | $n/a$ | $n/a$ | -1,62 | -2,35 |
| I CRED FIRMS < 4MLN AVG | -2,81 | -2,27 | -1,71 | -1,16 |
| I CRED FIRMS > 4MLN AVG | -5,84* | -5,09* | -2,22 | -2,15 |
| I CRED FIRMS AVG FLOW | -2,80 | -5,55* | -2,07 | -1,83 |

critical values for cointegration: -3,73 1% significance level, -3,17 5% significance level, -2,91 10% significance level, see Enders (1995); * denotes cointegration;

### 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 relation between the interest rates which were expected to be cointegrated but standard procedures[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 (with 3-month WIBOR) are presented.[20]

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), credits to house purchases, and credits to firms average flow. 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 credits to firms average flow, which were not cointegrated in the shorter sample.

In Figures 8 and 9, threshold values for the deposit and lending rates which are asymmetrically cointegrated are presented. It is important to keep in mind that each rate is characterized by a different threshold value. We also show the error correction term and the differenced error correction term when the M-TAR model operates.

Below, we will analyze the results of asymmetric cointegration tests for the lending rates. In Tables 3, 4 and Figure 8, we also present the results for deposit rates, which are used in the next section when analyzing the short-term asymmetries. However, we do not discuss them in detail.

Concerning the TAR model:

- 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)

[19] presented in the previous section

[20] We do not present the results for 1-month WIBOR, as they are similar to those for 3-month WIBOR.

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, 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. Thus banks might be more 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[21], 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.



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:

- 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:

- credits to sole proprietors average flow (in the shorter period),
- consumer credit average flow (in the longer period)

[21] 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).

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. As it is presented in Figure 9 (dashed lines) 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 credits to firms 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 a good collateral and could be treated by banks as less risky than others.

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.

Table 3: Asymmetric cointegration

| **January 2004 - August 2008** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | TAR | | | | M-TAR | | | | lags |
| | F-statistic | p-value | t-statistics | | F-statistic | p-value | t-statistics | | |
| | $\rho_1 = \rho_2 = 0$ | $\rho_1 = \rho_2$ | $\rho_1$ | $\rho_2$ | $\rho_1 = \rho_2 = 0$ | $\rho_1 = \rho_2$ | $\rho_1$ | $\rho_2$ | |
| I DEP HSH 1M | 2,05 | 0,49 | -1,87 | -0,78 | 3,33 | 0,10 | -0,91 | -2,41 | 0 |
| I DEP HSH 6M | 6,86 | 0,04 | -3,49 | -0,08 | 6,18 | 0,08 | -0,95 | -3,52 | 4 |
| I DEP HSH 12M | 14,53 | 0,85 | -3,71 | -3,91 | 20,19 | 0,01 | -5,23 | -3,62 | 0 |
| I DEP HSH AVG FLOW | 2,54 | 0,37 | -2,19 | -0,54 | 5,31 | 0,02 | -0,17 | -3,25 | 0 |
| I DEP FIRMS 1M | 14,09 | 0,31 | -4,78 | -2,30 | 20,50 | 0,00 | -1,85 | -6,13 | 0 |
| I DEP FIRMS 6M | 6,54 | 0,08 | -3,54 | -0,94 | 8,00 | 0,02 | -3,64 | -2,97 | 4 |
| I DEP FIRMS 12M | 26,43 | 0,02 | -2,98 | -6,63 | 22,68 | 0,16 | -4,96 | -4,56 | 0 |
| I DEP FIRMS AVG FLOW | 15,06 | 0,25 | -4,97 | -2,33 | 21,27 | 0,00 | -1,95 | -6,22 | 0 |
| I CRED HSH HP AVG FLOW | 4,67 | 0,05 | -0,85 | -3,03 | 4,16 | 0,08 | -2,79 | -1,17 | 1 |
| I CRED HSH PI AVG | 8,97 | 0,01 | -4,19 | -0,59 | 11,21 | 0,01 | -0,36 | -4,72 | 0 |
| I CRED HSH CONS AVG | *n/a* | *n/a* | *n/a* | *n/a* | *n/a* | *n/a* | *n/a* | *n/a* | *n/a* |
| I CRED FIRMS < 4MLN AVG | 6,13 | 0,05 | -0,82 | -3,40 | 13,09 | 0,00 | -5,10 | -0,42 | 0 |
| I CRED FIRMS > 4MLN AVG | 16,92 | 0,63 | -3,37 | -4,74 | 19,31 | 0,08 | -5,28 | -3,28 | 0 |
| I CRED FIRMS AVG FLOW | 5,15 | 0,14 | -2,98 | -1,72 | 4,77 | 0,21 | -2,94 | -1,51 | 1 |

| **January 2004 - November 2011** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | TAR | | | | M-TAR | | | | lags |
| | F-statistic | p-value | t-statistics | | F-statistic | p-value | t-statistics | | |
| | $\rho_1 = \rho_2 = 0$ | $\rho_1 = \rho_2$ | $\rho_1$ | $\rho_2$ | $\rho_1 = \rho_2 = 0$ | $\rho_1 = \rho_2$ | $\rho_1$ | $\rho_2$ | |
| I DEP HSH 1M | 5,41 | 0,21 | -1,43 | -2,99 | 4,94 | 0,38 | -2,46 | -1,94 | 1 |
| I DEP HSH 6M | 3,16 | 0,06 | -2,46 | -0,56 | 2,17 | 0,18 | -0,98 | -1,85 | 1 |
| I DEP HSH 12M | 6,80 | 0,04 | -3,39 | -1,44 | 6,19 | 0,07 | -1,81 | -3,02 | 0 |
| I DEP HSH AVG FLOW | 2,92 | 0,37 | -1,80 | -1,62 | 6,09 | 0,01 | -3,48 | 0,01 | 1 |
| I DEP FIRMS 1M | 19,73 | 0,06 | -5,63 | -2,78 | 30,68 | 0,00 | -2,56 | -7,40 | 0 |
| I DEP FIRMS 6M | 1,22 | 0,33 | -0,21 | -1,55 | 5,64 | 0,00 | -3,36 | 0,16 | 0 |
| I DEP FIRMS 12M | 3,99 | 0,32 | -1,25 | -2,54 | 5,51 | 0,05 | -1,67 | -2,87 | 0 |
| I DEP FIRMS AVG FLOW | 20,62 | 0,02 | -6,28 | -1,35 | 26,20 | 0,00 | -2,43 | -6,82 | 0 |
| I CRED HSH HP AVG FLOW | 1,54 | 0,39 | -0,32 | -1,72 | 10,57 | 0,00 | -4,57 | 0,48 | 0 |
| I CRED HSH PI AVG | 2,01 | 0,12 | -0,32 | -1,99 | 3,89 | 0,01 | -2,79 | -0,11 | 1 |
| I CRED HSH CONS AVG | 11,40 | 0,00 | -4,68 | -1,44 | 18,50 | 0,00 | -1,55 | -6,02 | 4 |
| I CRED FIRMS < 4MLN AVG | 7,42 | 0,04 | -0,60 | -3,80 | 17,53 | 0,00 | -5,82 | -1,11 | 0 |
| I CRED FIRMS > 4MLN AVG | 2,95 | 0,33 | -1,22 | -2,17 | 5,16 | 0,03 | -1,44 | -2,98 | 1 |
| I CRED FIRMS AVG FLOW | 2,96 | 0,21 | -2,23 | -1,09 | 7,18 | 0,00 | -0,95 | -3,72 | 1 |

for critical values see Enders, Siklos (2001), we present only these 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

| | January 2004 - August 2008 | | | January 2004 - November 2011 | | |
|---|---|---|---|---|---|---|
| | M-TAR or TAR | $n+1$ | $k$ | M-TAR or TAR | $n+1$ | $k$ |
| I DEP HSH 1M | - | 1 | 1 | symmetric | 1 | 2 |
| I DEP HSH 6M | TAR / M-TAR | 1 | 0 | - | 3 | 0 |
| I DEP HSH 12M | M-TAR | 1 | 0 | TAR / M-TAR | 1 | 0 |
| I DEP HSH AVG FLOW | - | 3 | 0 | M-TAR | 3 | 1 |
| I DEP FIRMS 1M | M-TAR | 1 | 0 | TAR / M-TAR | 1 | 0 |
| I DEP FIRMS 6M | TAR / M-TAR | 1 | 0 | - | 2 | 1 |
| I DEP FIRMS 12M | TAR | 2 | 0 | - | 1 | 1 |
| I DEP FIRMS AVG FLOW | M-TAR | 1 | 0 | TAR / M-TAR | 1 | 0 |
| I CRED HSH HP AVG FLOW | - | 2 | 0 | M-TAR | 2 | 2 |
| I CRED HSH PI AVG | TAR / M-TAR | 1 | 0 | - | 2 | 1 |
| I CRED HSH CONS AVG | $n/a$ | 3 | 2 | TAR / M-TAR | 1 | 2 |
| I CRED FIRMS < 4MLN AVG | TAR / M-TAR | 1 | 1 | TAR / M-TAR | 1 | 0 |
| I CRED FIRMS > 4MLN AVG | M-TAR | 1 | 0 | - | 2 | 1 |
| I CRED FIRMS AVG FLOW | - | 2 | 1 | M-TAR | 2 | 1 |

## 5.4 Asymmetries in the short term



This section addresses the results assigned to short term asymmetries. Tables 5-9 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 (3-month WIBOR), the level of the output gap, the level of liquidity and the deviations of CPI from the central bank's inflation target.

Concerning the direction of the change of the 3-month 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 3-month WIBOR.

The adjustment of deposits of firms (to 1 month and average flows) in both periods and deposits of households from 3 to 6 months in the shorter 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 ambiguous. It seems that the reaction of some of the interest rates is stronger when the output gap is high (see Table 6). There is evidence that the interest rates for deposits of households and firms tend to react stronger when the output gap is high. The same is true for credits for house purchases and credits to firms to 4 million Polish zloty in the longer sample. 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 longer term deposits (from 6 to 12 months), credits for sole proprietors, credits to firms average and above 4 million Polish zloty as well as in the shorter sample deposits of households from 3 to 6 months. Thus, it is difficult to judge about the character (and the direction) of these asymmetries.



Also concerning the level of liquidity the results indicate asymmetric adjustment of the interest rates when different levels of liquidity are observed (see Table 7). Most of the asymmetries concern 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 in both samples as well. 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). In contrary longer term deposits for firms (from 6 to 12 months) in the shorter period and credits for house purchases average flow as well as credits for firms to 4 million Polish zloty in the longer sample 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.

Next, we investigate the deviations of the CPI from the central bank's inflation target, which can be viewed as a measure of expectations for the future level of the central bank's rate (see Table 8). It appears that when the level of inflation relative to the target is low, and the market participants may expect the central bank's rate to decrease, the deposit rates, i.e. deposits of firms (to 1 month and average flows in both periods, from 3 to 6 months in shorter period) and longer term deposits of households (from 6 to 12 months in the longer period) adjust faster, possibly because it is more

profitable for banks to accelerate their decreases.[22] Whereas, when the level of inflation relative to the target is low and the market participants expect the central bank's rate to decrease, credits for firms (average flow and above 4 million Polish zloty) seem to display slower adjustment, but all the lending rates for households seem to adjust quicker. Some of these credits might be very desirable for banks and their behavior might stem from high level of competition. Therefore, they prefer not to wait with decreasing these rates to attract customers or to avoid adverse selection problem.

In addition, we consider asymmetries concerning the absolute value of the CPI deviations from the central bank's target (see Table 9), which can be treated as a simple measure of central bank's credibility. Interestingly, we find out that deposit rates seem to react faster when these deviations are relatively small[23] whereas lending rates for firms in both periods and lending rates for households in the longer period seem to react faster when the deviations are larger. Therefore, it seems that when the central bank's policy is somehow more successful, then deposit rates adjust faster, while, on the contrary, when there are larger deviations form the target, then credit rates adjust faster, perhaps due to the fact that the larger deviations are associated with a higher uncertainty and increases of the interest rates when banks are less interested in attracting creditors.



[22] The only exception here are longer term deposits for firms, characterized by high level of variability.
[23] As before the only exception are longer term deposits rate for firms.

Table 5: Asymmetries concerning increase vs. decrease of WIBOR 3M

| | January 2004 - August 2008 | | | | January 2004 - November 2011 | | | |
|---|---|---|---|---|---|---|---|---|
| | $\beta_m^- + \sum_{i=1}^n \beta_m^-$ | $\beta_m^+ + \sum_{i=1}^n \beta_m^+$ | $H_0: \beta_m^- + \sum_{i=1}^n \beta_m^- = \beta_m^+ + \sum_{i=1}^n \beta_m^+$ | $H_0: \beta_m^- = \beta_m^+ \; \beta_{m,i}^- = \beta_{m,i}^+$ | $\beta_m^- + \sum_{i=1}^n \beta_m^-$ | $\beta_m^+ + \sum_{i=1}^n \beta_m^+$ | $H_0: \beta_m^- + \sum_{i=1}^n \beta_m^- = \beta_m^+ + \sum_{i=1}^n \beta_m^+$ | $H_0: \beta_m^- = \beta_m^+ \; \beta_{m,i}^- = \beta_{m,i}^+$ |
| I DEP HSH 1M | 0,43 | 0,53 | 0,49 | | 0,34 | 0,40 | 0,53 | |
| I DEP HSH 6M | 0,65 | 0,15* | 0,06 | | 0,90 | 0,63 | 0,31 | 0,20 |
| I DEP HSH 12M | 0,62* | 0,51* | 0,84 | | 0,63 | 0,28* | 0,37 | |
| I DEP HSH AVG FLOW | 0,81 | 0,63 | 0,24 | 0,13 | 0,66 | 0,46 | 0,17 | 0,06 |
| I DEP FIRMS 1M | 0,78 | 0,41 | 0,07 | | 0,85 | 0,44 | 0,00 | |
| I DEP FIRMS 6M | 0,78 | 0,77 | 0,90 | | 0,90 | 0,66 | 0,20 | 0,02 |
| I DEP FIRMS 12M | 0,78 | 0,71 | 0,81 | 0,01 | 0,77 | 1,07 | 0,26 | |
| I DEP FIRMS AVG FLOW | 0,78 | 0,44 | 0,07 | | 0,79 | 0,50 | 0,02 | |
| I CRED HSH HP AVG FLOW | 1,02 | 0,89 | 0,61 | 0,87 | 0,77 | 0,88 | 0,47 | 0,59 |
| I CRED HSH PI AVG | 0,48 | 0,52 | 0,88 | | 1,04 | 0,94 | 0,72 | 0,57 |
| I CRED HSH CONS AVG | 0,79* | 0,64* | 0,88 | 0,78 | -0,22* | -0,76 | 0,23 | |
| I CRED FIRMS < 4MLN AVG | 0,66 | 0,78 | 0,39 | | 0,65 | 0,79 | 0,32 | |
| I CRED FIRMS > 4MLN AVG | 0,93 | 0,98 | 0,91 | | 1,29 | 2,08 | 0,03 | 0,08 |
| I CRED FIRMS AVG FLOW | 1,03 | 1,43 | 0,16 | 0,15 | 1,15 | 1,47 | 0,23 | 0,48 |

* statistically insignificant; in 4, 5, 8, 9 columns p-value for Wald statistic, red color for asymmetries;

Table 6: Asymmetries concerning the level of the output gap

| | January 2004 - August 2008 | | | | | January 2004 - November 2011 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\beta_m^- + \sum_{i=1}^n \beta_m^-$ | $\beta_m^+ + \sum_{i=1}^n \beta_m^+$ | $H_0: \beta_m^- + \sum_{i=1}^n \beta_m^- = \beta_m^+ + \sum_{i=1}^n \beta_m^+$ | $H_0: \beta_m^- = \beta_m^+ \; \beta_{m,i}^- = \beta_{m,i}^+$ | $\tau$ | $\beta_m^- + \sum_{i=1}^n \beta_m^-$ | $\beta_m^+ + \sum_{i=1}^n \beta_m^+$ | $H_0: \beta_m^- + \sum_{i=1}^n \beta_m^- = \beta_m^+ + \sum_{i=1}^n \beta_m^+$ | $H_0: \beta_m^- = \beta_m^+ \; \beta_{m,i}^- = \beta_{m,i}^+$ | $\tau$ |
| I DEP HSH 1M | 0,60 | 0,44 | 0,31 | | -0,003 | 0,14* | 0,45 | 0,01 | | -0,005 |
| I DEP HSH 6M | 0,65 | 0,20* | 0,09 | | 0,000 | 0,85 | 1,04 | 0,68 | 0,76 | 0,009 |
| I DEP HSH 12M | 0,23* | 1,26 | 0,04 | | 0,005 | 0,63 | -0,26* | 0,08 | | 0,006 |
| I DEP HSH AVG FLOW | 0,92 | 0,71 | 0,21 | 0,09 | -0,003 | 0,51 | 0,64 | 0,25 | 0,01 | -0,003 |
| I DEP FIRMS 1M | 0,36 | 0,99 | 0,00 | | 0,005 | 0,62 | 1,03 | 0,01 | | 0,005 |
| I DEP FIRMS 6M | 0,72 | 1,08 | 0,05 | | 0,007 | 0,82 | 1,02 | 0,33 | 0,02 | 0,003 |
| I DEP FIRMS 12M | 0,60 | 1,04 | 0,15 | 0,35 | 0,000 | 1,81 | 0,82 | 0,05 | | -0,008 |
| I DEP FIRMS AVG FLOW | 0,40 | 0,98 | 0,00 | | 0,005 | 0,59 | 1,04 | 0,00 | | 0,005 |
| I CRED HSH HP AVG FLOW | 0,87 | 1,12 | 0,26 | 0,02 | -0,003 | 0,49 | 0,91 | 0,00 | 0,00 | -0,004 |
| I CRED HSH PI AVG | 1,00 | 0,42 | 0,06 | | -0,003 | 1,40 | 0,74 | 0,01 | 0,01 | -0,003 |
| I CRED HSH CONS AVG | 0,83* | 0,37* | 0,66 | 0,29 | 0,001 | -0,16* | -0,87 | 0,12 | | 0,000 |
| I CRED FIRMS < 4MLN AVG | 0,52 | 0,74 | 0,18 | | 0,000 | 0,57 | 0,82 | 0,06 | | -0,001 |
| I CRED FIRMS > 4MLN AVG | 1,28 | 0,96 | 0,37 | | 0,001 | 2,97 | 1,45 | 0,03 | 0,08 | -0,008 |
| I CRED FIRMS AVG FLOW | 0,62* | 1,30 | 0,26 | 0,04 | -0,005 | 2,53 | 1,14 | 0,00 | 0,02 | -0,008 |

* statistically insignificant; in 4, 5, 9, 10 columns p-value for Wald statistic, red color for asymmetries;

Table 7: Asymmetries concerning the level of liquidity

| | January 2004 - August 2008 | | | | | January 2004 - November 2011 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\beta_m^- + \sum_{i=1}^n \beta_m^-$ | $\beta_m^+ + \sum_{i=1}^n \beta_m^+$ | $H_0: \beta_m^- + \sum_{i=1}^n \beta_m^- = \beta_m^+ + \sum_{i=1}^n \beta_m^+$ | $H_0: \beta_m^- = \beta_m^+ \; \beta_{m,i}^- = \beta_{m,i}^+$ | $\tau$ | $\beta_m^- + \sum_{i=1}^n \beta_m^-$ | $\beta_m^+ + \sum_{i=1}^n \beta_m^+$ | $H_0: \beta_m^- + \sum_{i=1}^n \beta_m^- = \beta_m^+ + \sum_{i=1}^n \beta_m^+$ | $H_0: \beta_m^- = \beta_m^+ \; \beta_{m,i}^- = \beta_{m,i}^+$ | $\tau$ |
| I DEP HSH 1M | 0,32 | 0,59 | 0,09 | | 0,014 | 0,33 | 0,57 | 0,22 | | 0,032 |
| I DEP HSH 6M | 0,10* | 0,66 | 0,03 | | 0,017 | 0,97 | 0,58 | 0,18 | 0,56 | 0,026 |
| I DEP HSH 12M | -0,55* | 0,85 | 0,02 | | 0,011 | -0,01* | 0,83 | 0,02 | | 0,015 |
| I DEP HSH AVG FLOW | 1,03 | 0,77 | 0,29 | 0,14 | 0,009 | 0,59 | 0,54 | 0,79 | 0,00 | 0,011 |
| I DEP FIRMS 1M | -0,09* | 0,76 | 0,00 | | 0,011 | 0,08* | 0,81 | 0,00 | | 0,010 |
| I DEP FIRMS 6M | 0,42 | 0,87 | 0,00 | | 0,010 | 0,81 | 0,87 | 0,80 | 0,01 | 0,011 |
| I DEP FIRMS 12M | 1,08 | 0,53 | 0,06 | 0,16 | 0,017 | 1,07 | 0,69 | 0,13 | | 0,015 |
| I DEP FIRMS AVG FLOW | -0,07* | 0,77 | 0,00 | | 0,009 | 0,04* | 0,80 | 0,00 | | 0,010 |
| I CRED HSH HP AVG FLOW | 1,05 | 0,67 | 0,17 | 0,05 | 0,028 | 0,93 | 0,64 | 0,05 | 0,03 | 0,014 |
| I CRED HSH PI AVG | 0,44 | 1,02 | 0,08 | | 0,027 | 0,53 | 1,27 | 0,00 | 0,00 | 0,013 |
| I CRED HSH CONS AVG | -2,03 | 1,39 | 0,00 | 0,02 | 0,014 | -0,67 | 0,80 | 0,01 | | 0,027 |
| I CRED FIRMS < 4MLN AVG | 0,71 | 0,57 | 0,37 | | 0,018 | 0,71 | 0,14* | 0,08 | | 0,060 |
| I CRED FIRMS > 4MLN AVG | 0,77 | 1,31 | 0,18 | | 0,014 | 1,44 | 2,22 | 0,38 | 0,09 | 0,066 |
| I CRED FIRMS AVG FLOW | 1,42 | 0,82* | 0,33 | 0,02 | 0,030 | 1,17 | 1,72 | 0,37 | 0,07 | 0,066 |

* statistically insignificant; in 4, 5, 9, 10 columns p-value for Wald statistic, red color for asymmetries;

Table 8: Asymmetries concerning the deviations of CPI from central bank's target

| | January 2004 - August 2008 | | | | | January 2004 - November 2011 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\beta_m^- + \sum_{i=1}^n \beta_m^-$ | $\beta_m^+ + \sum_{i=1}^n \beta_m^+$ | $H_0: \beta_m^- + \sum_{i=1}^n \beta_m^- = \beta_m^+ + \sum_{i=1}^n \beta_m^+$ | $H_0: \beta_m^- = \beta_m^+ \; \beta_{m,i}^- = \beta_{m,i}^+$ | $\tau$ | $\beta_m^- + \sum_{i=1}^n \beta_m^-$ | $\beta_m^+ + \sum_{i=1}^n \beta_m^+$ | $H_0: \beta_m^- + \sum_{i=1}^n \beta_m^- = \beta_m^+ + \sum_{i=1}^n \beta_m^+$ | $H_0: \beta_m^- = \beta_m^+ \; \beta_{m,i}^- = \beta_{m,i}^+$ | $\tau$ |
| I DEP HSH 1M | 0,41 | 0,61 | 0,19 | | 0,016 | 0,30 | 0,51 | 0,10 | | 0,016 |
| I DEP HSH 6M | 0,79 | 0,24* | 0,11 | | -0,011 | 0,67 | 0,94 | 0,38 | 0,51 | 0,000 |
| I DEP HSH 12M | 0,99 | 0,24* | 0,13 | | 0,009 | 0,97 | 0,19* | 0,03 | | 0,006 |
| I DEP HSH AVG FLOW | 0,79 | 0,78 | 0,90 | 0,07 | 0,009 | 0,54 | 0,69 | 0,32 | 0,15 | 0,015 |
| I DEP FIRMS 1M | 0,78 | 0,39 | 0,04 | | 0,009 | 0,82 | 0,44 | 0,00 | | 0,015 |
| I DEP FIRMS 6M | 0,95 | 0,67 | 0,04 | | 0,005 | 0,78 | 1,06 | 0,17 | 0,13 | 0,012 |
| I DEP FIRMS 12M | 0,60 | 1,17 | 0,05 | 0,14 | 0,011 | 0,67 | 1,23 | 0,03 | | 0,011 |
| I DEP FIRMS AVG FLOW | 0,79 | 0,42 | 0,04 | | 0,009 | 0,78 | 0,48 | 0,02 | | 0,015 |
| I CRED HSH HP AVG FLOW | 1,62 | 0,86 | 0,01 | 0,04 | -0,010 | 1,51 | 0,75 | 0,00 | 0,01 | -0,010 |
| I CRED HSH PI AVG | 1,18 | 0,40 | 0,01 | | -0,002 | 1,36 | 0,86 | 0,07 | 0,02 | 0,004 |
| I CRED HSH CONS AVG | 1,99 | -0,07* | 0,06 | 0,30 | -0,006 | 1,12 | -0,58 | 0,01 | | -0,003 |
| I CRED FIRMS < 4MLN AVG | 0,56 | 0,72 | 0,32 | | 0,005 | 0,67 | 0,77 | 0,56 | | 0,016 |
| I CRED FIRMS > 4MLN AVG | 0,99 | 1,35 | 0,31 | | 0,015 | 1,12 | 2,18 | 0,00 | 0,00 | 0,010 |
| I CRED FIRMS AVG FLOW | 0,96 | 1,70 | 0,01 | 0,02 | 0,015 | 1,05 | 1,60 | 0,02 | 0,06 | 0,010 |

* statistically insignificant; in 4, 5, 9, 10 columns p-value for Wald statistic, red color for asymmetries;



Table 9: Asymmetries concerning the absolute value of the deviations of CPI from central bank's target

| | January 2004 - August 2008 | | | | | January 2004 - November 2011 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\beta_m^- + \sum_{i=1}^n \beta_m^-$ | $\beta_m^+ + \sum_{i=1}^n \beta_m^+$ | $H_0: \beta_m^- + \sum_{i=1}^n \beta_m^- = \beta_m^+ + \sum_{i=1}^n \beta_m^+$ | $H_0: \beta_m^- = \beta_m^+ \; \beta_{m,i}^- = \beta_{m,i}^+$ | $\tau$ | $\beta_m^- + \sum_{i=1}^n \beta_m^-$ | $\beta_m^+ + \sum_{i=1}^n \beta_m^+$ | $H_0: \beta_m^- + \sum_{i=1}^n \beta_m^- = \beta_m^+ + \sum_{i=1}^n \beta_m^+$ | $H_0: \beta_m^- = \beta_m^+ \; \beta_{m,i}^- = \beta_{m,i}^+$ | $\tau$ |
| I DEP HSH 1M | 0,40 | 0,60 | 0,16 | | 0,015 | 0,32 | 0,40 | 0,44 | | 0,009 |
| I DEP HSH 6M | 0,48 | 0,10* | 0,17 | | 0,019 | 0,82 | 0,89 | 0,81 | 0,89 | 0,010 |
| I DEP HSH 12M | 1,50 | 0,32* | 0,05 | | 0,009 | 1,09 | 0,30* | 0,04 | | 0,008 |
| I DEP HSH AVG FLOW | 0,93 | 0,74 | 0,27 | 0,12 | 0,009 | 0,85 | 0,52 | 0,02 | 0,03 | 0,009 |
| I DEP FIRMS 1M | 0,86 | 0,46 | 0,07 | | 0,008 | 0,84 | 0,48 | 0,00 | | 0,009 |
| I DEP FIRMS 6M | 1,12 | 0,73 | 0,06 | | 0,012 | 0,78 | 1,05 | 0,17 | 0,15 | 0,012 |
| I DEP FIRMS 12M | 0,49 | 1,04 | 0,06 | 0,17 | 0,011 | 0,61 | 1,18 | 0,02 | | 0,011 |
| I DEP FIRMS AVG FLOW | 0,91 | 0,48 | 0,04 | | 0,006 | 0,78 | 0,50 | 0,03 | | 0,015 |
| I CRED HSH HP AVG FLOW | 0,02* | 1,08 | 0,00 | 0,01 | 0,005 | 0,12* | 0,89 | 0,00 | 0,00 | 0,003 |
| I CRED HSH PI AVG | 0,12* | 0,59 | 0,17 | | 0,007 | 0,60 | 1,22 | 0,02 | 0,02 | 0,009 |
| I CRED HSH CONS AVG | 0,24* | 0,60* | 0,73 | 0,40 | 0,011 | -1,12 | -0,16* | 0,05 | | 0,005 |
| I CRED FIRMS < 4MLN AVG | 0,53 | 0,69 | 0,48 | | 0,005 | 0,68 | 0,75 | 0,64 | | 0,016 |
| I CRED FIRMS > 4MLN AVG | 0,94 | 1,38 | 0,20 | | 0,015 | 1,39 | 2,50 | 0,01 | 0,01 | 0,018 |
| I CRED FIRMS AVG FLOW | 0,89 | 1,59 | 0,01 | 0,04 | 0,015 | 1,18 | 1,74 | 0,06 | 0,05 | 0,018 |

* statistically insignificant; in 4, 5, 9, 10 columns p-value for Wald statistic, red color for asymmetries;

# 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 average flow (I CRED HSH HP AVG FLOW),
- credits to firms average flow (I CRED FIRMS AVG FLOW),

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



We compare the results of forecasting from the error correction model (ECM) with asymmetries [24] and ECM without asymmetries. We chose the models with all statistically significant coefficients.

As far as the short term asymmetries are concerned we consider different threshold variables for each of the examined interest rates. These are the variables for which the strongest short term asymmetries were revealed:

- for deposits of households to 1 month flow - the level of liquidity in the shorter sample and the level of output gap in the longer sample
- for deposits of firms to 1 month flow - increase and decrease of the money market rate,
- for credits to households for house purchases average flow - absolute value of CPI deviations from the central bank's rate,
- for credits to firms average flow - CPI deviations from the central bank's rate.

M-TAR model is used to account for long term asymmetries.

[24] presented in the previous section

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 May 2011.

The root mean squared errors for both symmetric and asymmetric models are presented in Table 10. The forecasts are made for one and six steps ahead for the longer sample and for one, six and forty five 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 symmetric models seem to perform better. Whereas for the period 01:2004 - 05:2011 the asymmetric model is better for deposits of households and symmetric model is better for deposits of firms. Nonetheless, it appears that there is no reason to use asymmetric models as far as forecasting the short term deposit rates in Poland is concerned.

On the other hand, the forecasting performance of asymmetric models is better for the credit rates. The long term forecast (45 steps ahead) is significantly better for both credit rates for house purchases and credit rates to firms. As it is presented in the bottom-left graphs in Figure 10 the long term forecast for these credit rates are far more accurate for the asymmetric models than the symmetric ones. The shorter term forecasts are better for the asymmetric model in case of: credits for house purchases in the period 01:2004 - 02:2008, and in the period 01:2004 - 05:2011 but only one step ahead, as well as for the credit rates to firms in the period 01:2004 - 05:2011 for six steps ahead.

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.

Table 10: Root Mean Squared Errors - multiplied by $10^6$

| sample | 01:2004 - 02:2008 | | 01:2004 - 05:2011 | |
|---|---|---|---|---|
| | symmetric model | asymmetric model | symmetric model | asymmetric model |
| | | | | |
| I DEP HSH 1M | | | | |
| one step ahead | 0,91 | 1,98 | 5,85 | 5,11 |
| six steps ahead | 0,75 | 1,27 | 5,62 | 3,98 |
| 45 steps ahead | 29,88 | 31,30 | - | - |
| | | | | |
| I DEP FIRMS 1M | | | | |
| one step ahead | 18,59 | 25,58 | 3,56 | 10,74 |
| six steps ahead | 11,44 | 14,95 | 1,30 | 7,01 |
| 45 steps ahead | 7,59 | 7,65 | - | - |
| | | | | |
| I CRED HSH HP AVG FLOW | | | | |
| one step ahead | 0,18 | 0,05 | 0,11 | 0,09 |
| six steps ahead | 4,15 | 2,22 | 0,15 | 0,61 |
| 45 steps ahead | 88,23 | 26,77 | - | - |
| | | | | |
| I CRED FIRMS AVG FLOW | | | | |
| one step ahead | 0,89 | 3,22 | 0,16 | 0,80 |
| six steps ahead | 2,38 | 3,42 | 7,60 | 7,21 |
| 45 steps ahead | 54,26 | 10,66 | - | - |

asymmetric model - ECM with asymmetries in the both long and short term

Figure 10. Forecasts for the interest rates for 01:2004 - 02:2008 and 01:2004 - 05:2011

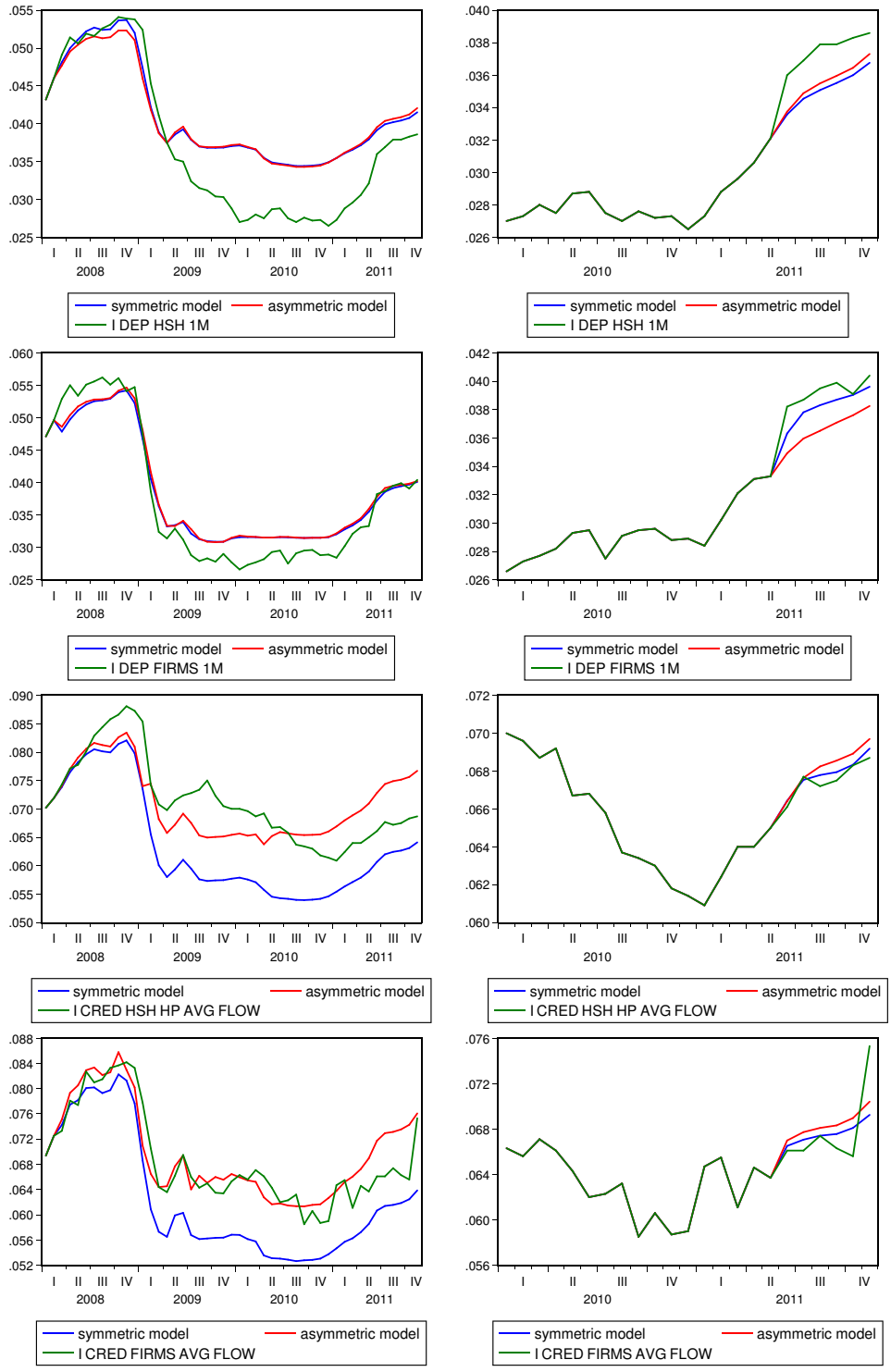


Figure 1. The relevant characteristics of the economy

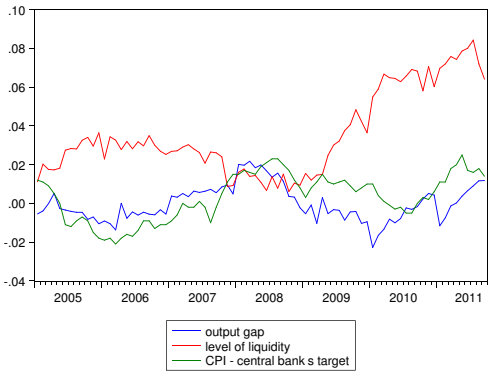



Figure 2. NBP reference rate and WIBOR

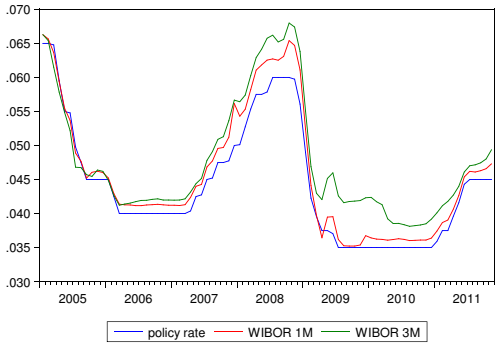



Figure 3. Deposits of households

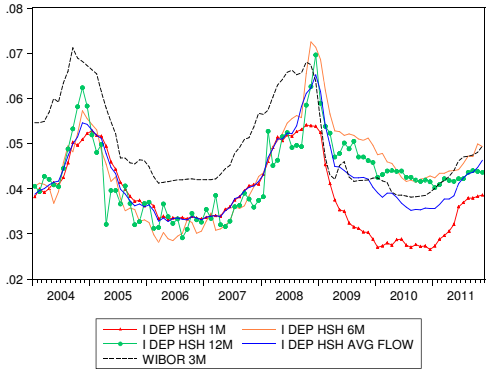



Figure 4. Deposits of firms

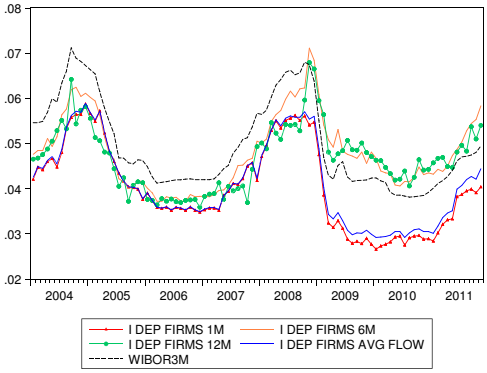



Figure 5. Credits to households

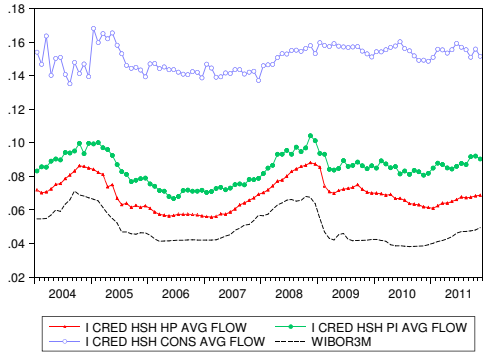
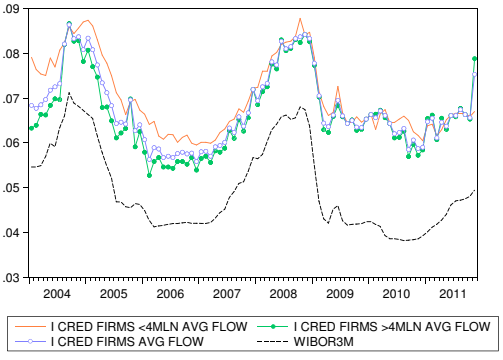



Figure 6. Credits to firms



# 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 2011.

Firstly, we consider the long term relations of the chosen lending and deposit rates with the respective money market rate. We find out that many of the interest rates are not cointegrated in the whole examined period. Moreover, some of them are not cointegrated even in the period prior to the financial crisis. 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 the examined interest rates seem to exhibit an asymmetric long-term adjustment.

Using the TAR model we find out that banks tend to adjust the interest rates for credits to firms to 4 million Polish zloty and credits for house purchases quicker when the error correction term is above their threshold values. It might be due to stronger competition for these credits as well as the adverse selection problem, as higher rates could attract riskier projects. On the other hand, banks seem to adjust the rates for credits to sole proprietors and consumer credits, which are perceived as relatively more risky, faster when the error correction term is below their threshold value. It might be more profitable for them to increase these rates more quickly, due to for instance less sophisticated customers, low competition or monopolistic competition. Moreover, applying the M-TAR model we detect that for most of the lending rates the discrepancies from the equilibrium seem to be smoothed out relatively quicker when the sizable changes of the error correction term occur. It might be interpreted as a quicker reaction to an increasing risk in a particular credit market segment.

Secondly, we analyze the short term relations. In the short term we consider five 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 is asymmetric. Only the short term deposits of firms react significantly stronger to decreases than to increases of the money market rate. The results for the level of economic activity and the level of liquidity are ambiguous, as the interest rates seem to react stronger when different levels of these characteristics are observed.

Furthermore as far as asymmetries assigned to the CPI deviations from the central bank's target are concerned, it seems that when the level of inflation (CPI) is relatively high deposit and lending rates for households adjust more slowly. Whereas, when the level of inflation (CPI) is relatively low, then credits to firms seem to perform slower

adjustment. One of the possible explanations is that it might be more profitable for banks to delay the increases of deposit rates and the decreases of some credit rates. Moreover, we find out that deposit rates seem to react faster when the absolute value of the CPI deviations from the central bank's target are relatively small, whereas lending rates seem to react faster when the deviations are large. Nevertheless, many different factors probably influence the interest rate transmission process and it is difficult to separate just one of them. Perhaps it is due to the fact that the larger deviations are associated with a higher uncertainty and then banks might prefer to attract depositors and not creditors.

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 the case of longer term forecasts for the credit rates. 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.

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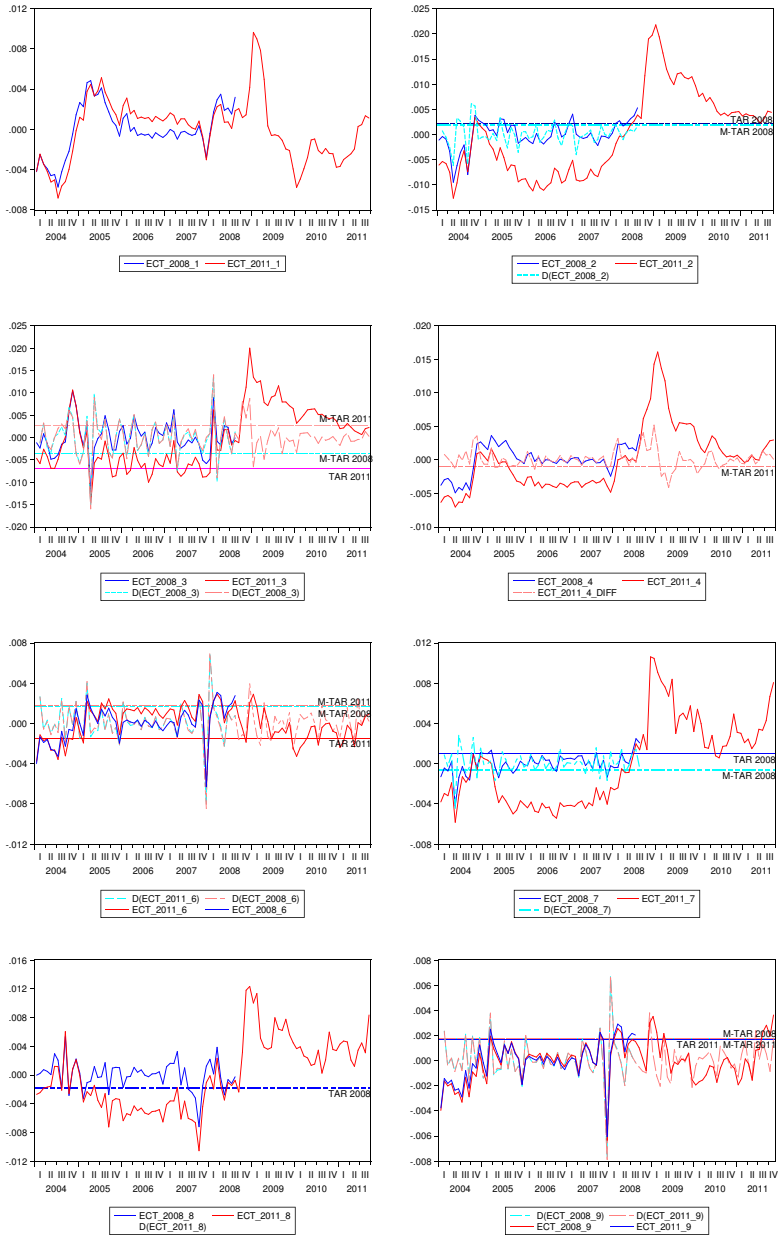
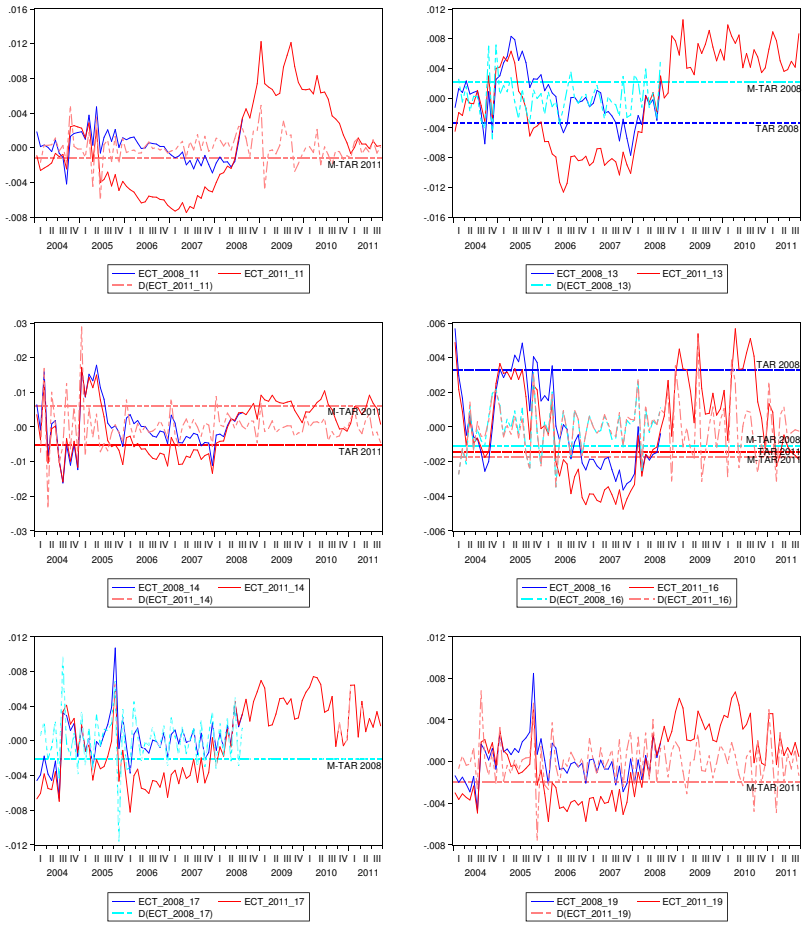
# A Appendix

Figure 8. Error correction term for the deposit rates




Deposit rates: 1 - I DEP HSH 1M, 2 - I DEP HSH 6M, 3 - I DEP HSH 12M, 4 - I DEP HSH AVG FLOW, 6 - I DEP FIRMS 1M, 7 - I DEP FIRMS 6M, 8 - I DEP FIRMS 12M, 9 - I DEP FIRMS AVG FLOW.

Figure 9. Error correction term for the lending rates




Lending rates: 11 - I CRED HSH HP AVG FLOW 13 - I CRED HSH PI AVG, 14 - I CRED HSH CONS AVG, 16 - I CRED FIRMS <4M AVG, 17 - I CRED FIRMS >4M AVG, 19 - I CRED FIRMS AVG FLOW.

Table 11: Johansen Cointegration Test 01.2004 - 08.2008 with WIBOR 3M

| | number of lags = 1 | | | | number of lags = 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Trace Statistic | | Max-Eigenvalue Statistic | | Trace Statistic | | Max-Eigenvalue Statistic | |
| No. of cointegrating relationships | None | At most 1 | None | At most 1 | None | At most 1 | None | At most 1 |
| I DEP HSH 1M | 16,7 | 5,2 | 11,5 | 5,2 | 15,7 | 6,7 | 9,0 | 6,7 |
| I DEP HSH 6M | 17,0 | 2,9 | 14,1 | 2,9 | 11,6 | 5,6 | 6,0 | 5,6 |
| I DEP HSH 12M | 21,4* | 1,4 | 20,0 | 1,4 | 18,9 | 3,2 | 15,7 | 3,2 |
| I DEP HSH AVG FLOW | 16,9 | 4,5 | 12,4 | 4,5 | 14,4 | 5,8 | 8,6 | 5,8 |
| I DEP FIRMS 1M | 22,4* | 2,9 | 19,5 | 2,9 | 22,3* | 6,8 | 15,5 | 6,8 |
| I DEP FIRMS 6M | 14,5 | 2,2 | 12,2 | 2,2 | 13,3 | 4,0 | 9,3 | 4,0 |
| I DEP FIRMS 12M | 17,8 | 1,5 | 16,3 | 1,5 | 16,8 | 3,2 | 13,5 | 3,2 |
| I DEP FIRMS AVG FLOW | 22,1* | 2,8 | 19,3 | 2,8 | 22,1* | 6,8 | 15,3 | 6,8 |
| I CRED HSH HP AVG FLOW | 30,2* | 4,6 | 25,7* | 4,6 | 19,6 | 4,4 | 15,2 | 4,4 |
| I CRED HSH PI AVG | 23,7* | 3,8 | 19,9 | 3,8 | 24,6* | 5,6 | 19,0 | 5,6 |
| I CRED HSH CONS AVG | *n/a* | *n/a* | *n/a* | *n/a* | *n/a* | *n/a* | *n/a* | *n/a* |
| I CRED FIRMS < 4M AVG | 34,1* | 3,5 | 30,7* | 3,5 | 23,1* | 4,1 | 19,0 | 4,1 |
| I CRED FIRMS > 4M AVG | 16,0 | 1,7 | 14,3 | 1,7 | 14,4 | 3,9 | 10,5 | 3,9 |
| I CRED FIRMS AVG FLOW | 20,8* | 3,2 | 17,5 | 3,2 | 18,1 | 6,2 | 11,8 | 6,2 |

* denotes rejection of the hypothesis at the 5% level

Table 12: Johansen Cointegration Test 01.2005 - 08.2008 with WIBOR 3M

| | number of lags = 1 | | | | number of lags = 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Trace Statistic | | Max-Eigenvalue Statistic | | Trace Statistic | | Max-Eigenvalue Statistic | |
| No. of cointegrating relationships | None | At most 1 | None | At most 1 | None | At most 1 | None | At most 1 |
| I DEP HSH 1M | 27,6* | 3,1 | 24,5* | 3,1 | 21,3* | 5,0 | 16,4 | 5,0 |
| I DEP HSH 6M | 14,9 | 2,2 | 12,7 | 2,2 | 10,1 | 2,0 | 8,1 | 2,0 |
| I DEP HSH 12M | 23,2* | 2,8 | 20,4* | 2,8 | 20,6* | 2,1 | 18,5 | 2,1 |
| I DEP HSH AVG FLOW | 25,1* | 2,5 | 22,6* | 2,5 | 17,6 | 4,3 | 13,3 | 4,3 |
| I DEP FIRMS 1M | 32,5* | 2,9 | 29,5* | 2,9 | 24,2* | 4,5 | 19,7 | 4,5 |
| I DEP FIRMS 6M | 12,6 | 2,9 | 9,7 | 2,9 | 10,6 | 2,1 | 8,5 | 2,1 |
| I DEP FIRMS 12M | 15,8 | 3,5 | 12,3 | 3,5 | 18,6 | 1,8 | 16,7 | 1,8 |
| I DEP FIRMS AVG FLOW | 32,0* | 3,1 | 28,9* | 3,1 | 23,4* | 4,7 | 18,7 | 4,7 |
| I CRED HSH HP AVG FLOW | 34,8* | 10,6* | 24,2* | 10,6* | 20,6* | 4,5 | 16,2 | 4,5 |
| I CRED HSH PI AVG | 28,6* | 6,3 | 22,3* | 6,3 | 16,8 | 3,9 | 12,9 | 3,9 |
| I CRED HSH CONS AVG | *n/a* | *n/a* | *n/a* | *n/a* | *n/a* | *n/a* | *n/a* | *n/a* |
| I CRED FIRMS < 4M AVG | 26,7* | 6,7 | 20,1 | 6,7 | 14,5 | 5,9 | 8,6 | 5,9 |
| I CRED FIRMS > 4M AVG | 12,8 | 3,0 | 9,8 | 3,0 | 10,6 | 2,2 | 8,5 | 2,2 |
| I CRED FIRMS AVG FLOW | 14,7 | 4,2 | 10,5 | 4,2 | 12,2 | 4,0 | 8,2 | 4,0 |

* denotes rejection of the hypothesis at the 5% level

Table 13: Johansen Cointegration Test 01.2004 - 11.2011 with WIBOR 3M

| | number of lags = 1 | | | | number of lags = 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Trace Statistic | | Max-Eigenvalue Statistic | | Trace Statistic | | Max-Eigenvalue Statistic | |
| No. of cointegrating relationships | None | At most 1 | None | At most 1 | None | At most 1 | None | At most 1 |
| I DEP HSH 1M | 21,0* | 4,5 | 16,5 | 4,5 | 17,2 | 5,6 | 11,6 | 5,6 |
| I DEP HSH 6M | 15,4 | 3,8 | 11,6 | 3,8 | 14,1 | 2,8 | 11,3 | 2,8 |
| I DEP HSH 12M | 15,1 | 6,1 | 9,0 | 6,1 | 10,8 | 3,9 | 6,9 | 3,9 |
| I DEP HSH AVG FLOW | 16,6 | 7,0 | 9,6 | 7,0 | 15,5 | 4,4 | 11,1 | 4,4 |
| I DEP FIRMS 1M | 12,8 | 4,4 | 8,3 | 4,4 | 9,6 | 3,4 | 6,2 | 3,4 |
| I DEP FIRMS 6M | 14,3 | 1,7 | 12,6 | 1,7 | 11,0 | 1,5 | 9,5 | 1,5 |
| I DEP FIRMS 12M | 11,8 | 3,8 | 8,0 | 3,8 | 6,9 | 2,0 | 4,9 | 2,0 |
| I DEP FIRMS AVG FLOW | 13,4 | 4,8 | 8,6 | 4,8 | 9,7 | 3,7 | 6,1 | 3,7 |
| I CRED HSH HP AVG FLOW | 16,2 | 3,0 | 13,2 | 3,0 | 11,7 | 2,4 | 9,3 | 2,4 |
| I CRED HSH PI AVG | 12,6 | 2,7 | 9,9 | 2,7 | 10,8 | 1,9 | 8,9 | 1,9 |
| I CRED HSH CONS AVG | 16,6 | 7,1 | 9,5 | 7,1 | 15,1 | 6,2 | 8,8 | 6,2 |
| I CRED FIRMS < 4MLN AVG | 20,4* | 7,2 | 13,2 | 7,2 | 19,3 | 8,7 | 10,7 | 8,7 |
| I CRED FIRMS > 4MLN AVG | 14,4 | 4,3 | 10,1 | 4,3 | 10,3 | 3,3 | 7,0 | 3,3 |
| I CRED FIRMS AVG FLOW | 16,3 | 4,8 | 11,4 | 4,8 | 12,3 | 3,7 | 8,6 | 3,7 |

* denotes rejection of the hypothesis at the 5% level

Table 14: Johansen Cointegration Test 01.2005 - 11.2011 with WIBOR 3M

| | number of lags = 1 | | | | number of lags = 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Trace Statistic | | Max-Eigenvalue Statistic | | Trace Statistic | | Max-Eigenvalue Statistic | |
| No. of cointegrating relationships | None | At most 1 | None | At most 1 | None | At most 1 | None | At most 1 |
| I DEP HSH 1M | 28,9* | 4,3 | 24,7* | 4,3 | 17,9 | 5,4 | 12,5 | 5,4 |
| I DEP HSH 6M | 15,6 | 1,8 | 13,8 | 1,8 | 17,1 | 2,4 | 14,7 | 2,4 |
| I DEP HSH 12M | 16,3 | 4,8 | 11,5 | 4,8 | 9,3 | 3,3 | 6,0 | 3,3 |
| I DEP HSH AVG FLOW | 16,2 | 4,0 | 12,2 | 4,0 | 14,7 | 4,0 | 10,7 | 4,0 |
| I DEP FIRMS 1M | 17,0 | 4,1 | 12,9 | 4,1 | 10,4 | 3,6 | 6,9 | 3,6 |
| I DEP FIRMS 6M | 16,6 | 1,0 | 15,6 | 1,0 | 10,3 | 0,9 | 9,4 | 0,9 |
| I DEP FIRMS 12M | 17,2 | 3,5 | 13,7 | 3,5 | 7,9 | 1,6 | 6,3 | 1,6 |
| I DEP FIRMS AVG FLOW | 18,3 | 4,2 | 14,1 | 4,2 | 9,8 | 3,4 | 6,4 | 3,4 |
| I CRED HSH HP AVG FLOW | 19,8 | 2,0 | 17,8 | 2,0 | 12,3 | 2,1 | 10,2 | 2,1 |
| I CRED HSH PI AVG | 14,8 | 1,6 | 13,2 | 1,6 | 9,7 | 1,0 | 8,7 | 1,0 |
| I CRED HSH CONS AVG | 16,5 | 5,2 | 11,3 | 5,2 | 13,2 | 4,6 | 8,6 | 4,6 |
| I CRED FIRMS < 4MLN AVG | 20,7* | 7,9 | 12,8 | 7,9 | 20,3* | 7,0 | 13,3 | 7,0 |
| I CRED FIRMS > 4MLN AVG | 13,7 | 3,2 | 10,5 | 3,2 | 8,0 | 2,2 | 5,9 | 2,2 |
| I CRED FIRMS AVG FLOW | 15,2 | 3,4 | 11,8 | 3,4 | 10,1 | 2,3 | 7,8 | 2,3 |

* denotes rejection of the hypothesis at the 5% level

Table 15: Engle-Granger Cointegration Test (t-statistics) starting from 01.2005

| | 01.2005 - 08.2008 | | 01.2005 - 11.2011 | |
|---|---|---|---|---|
| | WIBOR 3M | WIBOR 1M | WIBOR 3M | WIBOR 1M |
| I DEP HSH 1M | -2,63 | -4,03* | -3,93* | -2,60 |
| I DEP HSH 6M | -3,47* | -2,50 | -1,30 | -1,27 |
| I DEP HSH 12M | -6,26* | -5,60* | -2,70 | -2,52 |
| I DEP HSH AVG FLOW | -3,04* | -3,20* | -2,19 | -1,57 |
| I DEP FIRMS 1M | -4,57* | -6,58* | -2,95* | -6,52* |
| I DEP FIRMS 6M | -4,18* | -1,72 | -0,40 | -0,75 |
| I DEP FIRMS 12M | -5,05* | -4,45* | -2,06 | -1,86 |
| I DEP FIRMS AVG FLOW | -4,54* | -6,52* | -3,21* | -6,57* |
| I CRED HSH HP AVG FLOW | -3,37* | -4,50* | -1,37 | -1,24 |
| I CRED HSH PI AVG | -1,96 | -2,72 | -1,20 | -1,48 |
| I CRED HSH CONS AVG | *n/a* | *n/a* | -2,67 | -1,86 |
| I CRED FIRMS < 4MLN AVG | -1,96 | -1,14 | -1,52 | -1,02 |
| I CRED FIRMS > 4MLN AVG | -5,84* | -4,30* | -1,66 | -1,43 |
| I CRED FIRMS AVG FLOW | -2,46 | -4,60* | -1,73 | -1,45 |

critical values for cointegration: -3,73 1% significance level, -3,17 5% significance level, -2,91 10% significance level, see Enders (1995); * denotes cointegration;