Factors Influencing the Money Market

Maria Piotrowska*

Abstract

The paper presents the results of testing the expectations hypothesis and the market segmentation hypothesis in respect to the T-bill market in Poland. The impacts of interbank money rates and exchange rate on the T-bill yield curve is also examined. Methodology is based on a cointegration analysis.

1. Introduction

In Poland, the issuing of Treasury securities was taken up again in 1989, after a fifty-year break. The dynamic increase in their sales was due to the substantial growth of the domestic public debt whose volume in the issued T-securities outstanding increased from 740 mln zloty in 1991 to 59708 mln zloty at the end of 1995. The dominant position in the structure of the public debt was held by two items. Treasury bills (39.6 per cent in 1995) and the so called passive bonds[1] (33.8 per cent). On the other hand, active bonds (t. e. bonds sold at auction sales) were and still are of markedly smaller importance 2.9 per cent at the end of 1992 and 18.6 per cent at the end of 1995. This clear disproportion between T-bills and active bonds made the Ministry of Finance extend its offer of medium-term bonds. The action resulted in the increase of the share of bonds in financing of the budget deficit, but T-bills still hold the dominant position.

One of the main purposes of managing the public debt is to minimize the interest costs. In Poland, it is a very important problem, because the costs constitute a substantial and constantly rising share in budget expenditures:

1992 -- 5.5 per cent of budget expenditures,

1994 -- 10 per cent of budget expenditures,

1995 -- 15.7 per cent of budget expenditures.

In 1995, T-bills had the largest share in the interest cost of the domestic public debt, which amounted to 63.2 per cent. With such high costs, it is necessary to try to lower interest rates on T-bills. The Ministry of Finance declares active policy of T-bills issuing which would realise that aim. The effect of such actions is dependent on factors influencing term structure of interest rates.

* Department of Economics, Wroclaw University of Economics, Wroclaw, Poland

1.The term passive bond denotes a bond which is a form of setting of the already existing liabilities of the state budget or a bond which is issued for other purposes not connectedwith the financing of the deficit.

2. Hypotheses on the Yield Curve

There are three basic hypotheses concerning the factors influencing the yield curve: the expectations hypothesis, the liquidity premium view and the market segmentation argument. The detailed descriptions of each of them can be found in literature[2]. Here, I would like to present them very shortly.

The first hypothesis states that the investor's expectations regarding future changes in short term interest rates determine the shape of the curve, and that the long-term interest rate may be represented as a geometric average of a series of rates on current and future short-term securities whose combined maturities equal that of the long-term security. This would suggest that changes in long-term interest rates occur with delay in comparison to the changes in short-term interest rates; so, the actions of the government should be limited to influencing the short-term rates. Manipulating with relative supplies of long and short-term T-bill is useless. It cannot change the shape of the yield curve because investors regard all securities-whatever their maturity -- as perfect substitutes. Therefore, relative supplies simply do not matter to them.

The liquidity premium view shows the risk of changing interest rates as the factor influencing the shape of the yield curve. The risk increases together with the lengthening of maturity time of the yield curve. The risk increases together with the lengthening of maturity time of a T-bill. Therefore, the investors will be willing to buy a long-term security if they obtain extra profit in the form of liquidity premium, compensating the interest-rate risk.

The market segmentation hypothesis argues that demand and supply curves are the dominant factors shaping the level of interest rates within each maturity range. This suggests that the government economic policy could alter the shape of the yield curve by shifting the supplies of different-maturity securities relatively to the demand for those securities. This policy conclusion directly contradicts the expectations hypothesis.

The presented hypotheses concern influencing the shape of the yield curve in a fully-developed T-bills market in which there are both medium and long-term bonds, and a long-term interest rate usually means the rate of interest of a 10 to 15 or 20-year bond. In this work, the analysis of term structure of interest rates has been limited to T-bills only, so obtained results should be treated as introduction to further study.

1 The term passive bond denotes a bond which is a form of setting of the already existing liabilities of the state budget or a bond which is issued for other purposes not connected with the financing of the deficit.

2. Key research studies in the development and testing of expectations hypothesis include works by: Buse [1], Fisher [5], Kessel [13], Malkiel [15], Meiselman [16] and Walsh [18]. Important research studies contributing to the development and investigation of the market segmentation argument include the following: Culbertson [2], Dobson, Sutch and Vanderford [3], Eliott and Echols [4], Kessel 13], Malkiel [15], Modigliani and Sutch [17].

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3. Data and Methodology

DATA

The following variables were included in the research:

a) T-bills market (Treasury bills market):
- interest rates of 8-, 13-, 26-, 39-, 52-week T-bills: i8, i13, i26, i39, i52;
- supplies of 8-, 13-, 26-, 39-, 52-week T-bills: sup8, sup13, sup26, sup39, sup52 (mln zl);
- relative supplies, i.e shares of supply of n-week T-bill in the total supply (n = 8, 13, 26, 39, 52): $_s$8, $_s$13, $_s$26, $_s$39, $_s$52;
- relative demands, i.e shares of demand of n-week T-bill in the total demand (n = 8, 13, 26, 39, 52): p8, p13, p26, p39, p52;
- values of offers (for n-week T-bill) accepted by the Ministry of Finance: of8, of13, of26, of39, of52; (mln zl);
- ratios of offers (for n-week T-bill) accepted by the Ministry of Finance to demand for n-week T-bill: ofp8, ofp13, ofp26, ofp39, ofp52;

b) Interbank money market rates, called WIBORs (Warsaw Interbank Offered Rates):
- interest rates of 1-day loans: O/N, T/N, S/N;
- interest rates of 1 and 2-week loans: W1, W2;
- interest rates of 1-, 2-, 3-month loans: M1, M2, M3;

c) Central bank intervention was described by:
- open market operations balance: O, min zl;

d) Exchange rate:
- PLN /USD: k.

METHODOLOGY

The first step of the analysis was to investigate existence of the long-term relations between the variables. I have applied the cointegration method suggested by Johansen [8], [9], [10] and Johanse and Juselius [11], [12]. - maximum likelihood in an error correction model (MLECM). The method of MLECM estimates b by

maximum likelihood in the ECM:

$\Delta X_t = \Pi X_{t-m} + \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{m-1} \Delta X_{t=m-1} + a + \xi_t$; t = 1...T, ξ_t " i.i.d. $N_\xi (O,\Sigma)$

were the following hypothesis is assumed: $H_1 (r) : \Pi = \alpha\beta'$

The hypothesis $H_1 (r)$ implies that under certain conditions (see Johansen [9]) the process ΔX_t is stationary, X_t is nonstationary, but also that βX_t is stationary. Thus the stationary relations among nonstationary variables, i.e., as cointegrating relations (see Johansen and Juselius [12, p.216].

Two objections have been raised against Johansen's method:

- The number of lags (m) in the ECM is unknown;
- $\{\xi_t\}$ may be non - Gaussian.

Johansen and Juselius [12] suggest to start the empirical analysis from the misspecification tests (normality test and LM test), which should help making decision whether the lag lengm is enough. The Johansen's procedure is analyse whether there exist stationary linear relations between the levels of the variables, and if this is the case, whether the unrestricted result is consistent with the hypothetical long-run relations. The expectations hypothesis, for example, requires that the cointegrating vector was 1. Johansen and Juselius [11], [12] suggested some tests for linear structural hypotheses on the cointegrating vectors. The hypotheses are formulated in terms of the cointegrating relations b, since these describe the long-run relations in which most economic structural hypotheses are formulated. These hypotheses are structural in the sense that they do not depend on any normalisation of the parameter β [12, p.225]. One of these hypotheses, H_5, is formulated by asking whether the cointegrating relation is stationary by itself, i.e., without involving the other variables of the system.

I was encouraged to apply the Johansen's procedure by investigation results given in Gonzalo's paper. Gonzalo examined the asymptotic distribution of the estimators resulting from five methods, and showed that Johansen's procedure had clearly better properties than the other were non - Gaussian or when the dynamics were unknown and we overparametrized by including additional lags in the ECM. At the end of the paper I have investigated short-term dynamics of the T-bill interest rates using simultaneous equations model.

4. The Empirical Results of the Coitegration Analysis.

The point of start was to establish the integration order of the variables. The results of ADF test (augmented Dickey - Fuller test) showed that only three variables were I (0), (i.e., ratios of offers to demand for 13-, 26-, 39-week bills) and the others were integrated of order one, I (1), - Table 1.

It was impossible to present the complete results of cointegration analysis for

all the variables, so only example of then, was included in the paper (Table 2) summary of the results was showed in tables 3-7. In general, the results of normality test were not satisfying in many cases, so I was forced to choose a number of lags basing only on the LM test.

LONG-TERM RELATIONS

The expectations hypothesis requires the following conditions:

1. Interest rates must be cointegrated.
2. The cointegrating vector must be 1, it means the cointegrating relation must be stationary by itself.

The test results gave mixed evidence (Table 3). They did not confirm univocally existence of one cointegrating relation between all the T-bill interest rates. LM test did not reject the hypothesis on autocorrelation of residuals rof all the equations. Therefore the hypothesis on existence of one cointegrating vector can not be fully accepted.

The expectations hypothesis was confirmed only for pairs of the shorter interest rates (i26 - i13; i26 - i8; i13 - 18). The test results pointed out existence of the stationary, long-term relations between these interest rates. On the other hand no stationary by themselves long-term relations between the longer rates (i52, i39) and the shorter ones were found (if the cointegrating vector existed it was not of the form [1; -1]). Confirmation of the expectations hypothesis for the shorter T-bill interest rates, given by the cointegration analysis, should be treated as a start point for further study.

The market segmentation hypothesis works when there are stationary long-term relations between interest rates and supplies as well as demands for securities, in each segment of the market. Existence of such relations creats the conditions for successful policy of the Finance Ministry.

Unfortunately the research results did not give optimistic. news for the Ministry (Tables 4, 5). There were no stationary by themselves, long-term relations between the T-bill interest rates and relative supplies and relative demands. The test results look more encouragingly when relationship between shorter rates and relative supplies of T-bills were investigated. There was one cointegrating vector for each such a pair. The test of the coefficients of these vectors gave interesting results:

- relation between the shortest interest rate (i8) and relative supply (p8) was not stationary by itself (the cointegrating vector was not of the form [1; -1]);
- sings of the coefficients of cointegrating vector for 13-week bill were opposite to the signs required by the market segmentation hypothesis, e.i., estimated vector was [1; 1] and expected vector should be [1; -1]. It would suggest that for 13-week T-bill, there existed stationary long-term influence of relative supply on interest rate;
- only relation between interest rate and relative supply for 26-week bill was coincident with the market segmentation hypothesis. In long run the level of the interest rate was adjusting to the relative supply (as well as to the value of

offers accepted by the Ministry of Finance). I have not found, however, any cointegrating relations between the longer rates (i52, i39) end relative supplies (as well as values of offers accepted by the Ministry of Finance).

There fore in long-term the Finance Ministry policy of active influencing T-bill interest rates was limited to two shorter rates (i8, i26) and only with reference to one of then (i26) impact of the Ministry intervention was both long-term and stationary by itself. It seem the Ministry decisions on size of 13-week bill supply were more passive then active, e.i., the supply was adjusted to the interest rate.

In accordance with the market segmentation hypothesis in long run the interest rates should be influenced by demand for securities. The test results pointed out that:

- interest rates of the shortest end the longest bills (i8, i52) were not cointegrated with demands for these bills;
- however for the others there were long-term relations between them and demands;
- cointegrating relations were stationary by themselves only for two kinds of bills (for 13- and 26-week bills);
- signs of the cointegrating vector coefficients were not comsitent with expected ones e.i. estimated vector were [1; -1] and expected ones should be [1; 1]. It would suggest that in long run demands for bills were adjusting to the interest rates, not conversely.

The results confirmed fully none of the yield curve hypotheses. It induced me to look for another factors which could influence the T-bills market.

At first I have checked whether the money market interest rates (WIBORs) had long-term impact on T-bill interest rates (Table 6). It turned out that two WIBORs - 1 and 2-week interest rates - influenced almost all the T-bill rates (except i26) and two of these relations (with i13 and i52) were stationary by themselves. I have found no cointegration between the T-bill interest rates and open market operation balance. The next factor, which I have included, was the exchange rate (PLN / USD).

The T-bills market lived through some waves of speculative demand, connected with expectations on the Polish currency appreciation. I have tried to find the answer to a question whether the influence of exchange rate on the T-bills market had only short-term character. The cointegration test pointed out existence of some long-term relationships which few of them were stationary by themselves.
There were the cointegrating relations between all the T-bill interest rate and exchange rate, but no cointegrating vector was 1. It would be interesting to ask whether in long run the interest rates were adjusting to exchange rate or maybe conversely. In the former case the signs of the cointegrating vector coefficients should be [+; -], in the latter case [+; +] for all the cointegrating vectors the signs of the estimated coefficients were [+; +]. It would pointed out that in long run the exchange rate was adjusting to the T-bill interested rates, not conversely.

On the other hand the results of cointegration analysis showed that in long run demand for each kind of bill was adjusting to exchange rate the adjustment process was stationary by itself for the shorted bills)8-, 13-, 26-weeks).

Extended list of variables gave, therefore, interesting information on their long-term influence on the T-bills market.

SHORT-TERM DYNAMICS

Short term impact of all the considered factors on dynamics of the T-bill interest rates was describing by simultaneous equations model . Results of estimation were presented in Table 8. They suggested the following conclusions:

- There were the short-term relationships between the longer rates (i52, i39, i26), while dynamics of the shorter rates was almost not influenced by changes in the other rates;
- In short run the Ministry of Finance affected all the T-bill interest rates. They responded to changes in the bill supply (both changes in the level of supply and in the structure of supply) as well as to changes in values of offers accepted by the Ministry (except i13, i52). Dynamics of 26-week bill rate included term of error-correction for the long-term relations between this rate and supply (The cointegrating vector was 1 - Table 4)
- Short-term changes in demand for bills had impact only on three of the T-bill interest rates (i8, i13, i39). It should be noticed that demand did not influenced the other rates (i26, i52) either in short run or in long run.
- Estimation of the model confirmed importance of the long-term influence of 1- and 2-week WIBORs on the bill interest rates. The interbank money market affected the rate of the longest bill most widely. Its dynamics was adjusting not only to fluctuations from long-term trend on 2-weeks WIBOR and also was including lagged changes in 1-month WIBOR and open market operation balance.
- In short run changes in exchange rate influenced only dynamics of the shortest rate (i8)
- Dynamics of i52 was explained best of all by the selected variables, e.i., R2 was highest (R2 = 93.5 %), RSS was lowest (RSS = 57.7) and the result of normality test pointed out that the selected variable set was probably sufficient to account for the variation in i52. Estimation of equations for i8 and i39 was also acceptable (although RSS was two high), while the selected variable sets were not sufficient for explain i13 and i26. It induces to continue research on factors influencing the T-bill market.

CONCLUDING REMARKS

The empirical results did not confirm fully the traditional hypotheses on the yield curve. There were the stationary, long-term relations only between shorter rates. Policy of the Finance Ministry had impuct on the T-bill interest rates mainly in short run. The result gave interesting information on demand for bills. In long run demand was adjusting to the interest rates of bills, and to the exchange rate. It would suggest that investors were able to apply available information for making decision.

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Table 1 TEST FOR INTEGRATION

Symbol of variable	Regression $\Delta y_t = a_0 + a_1 T + \gamma y_{t-1} + \sum_{i=1}^{p} a_i \Delta y_{t-i} + u_t$			Order of integration
	Number of lags p	$H_0 : \gamma = 0$ Statistic ADF		
		without trend	with trend	
i 8	4	- 2,535 (- 2,8907)	- 3,369 (- 3,4645)	I (1)
i 13	6	- 1,412 (- 2,8976)	- 3,434 (- 3,4659)	I (1)
i 26	3	- 1,094 (- 2,8963)	- 3,063 (- 3,4639)	I (1)
i 39	3	- 1,574 (- 2,8963)	- 3,442 (- 3,4639)	I (1)
i 59	3	- 1,774 (- 2,8963)	- 3,409 (- 3,4649)	I (1)
sup 8	6	- 2,792 (- 2,8976)	- 2,929 (- 3,4659)	I (1)
sup 13	8	- 2,669 (- 2,8986)	- 2,788 (- 3,4673)	I (1)
sup 26	5	- 2,516 (- 2,8972)	- 3,107 (- 3,4639)	I (1)
sup 39	3	- 2,744 (- 2,8963)	- 2,929 (- 3,4652)	I (1)
sup 52	4	- 1,997 (- 2,8967)	- 3,371 (- 3,4645)	I (1)
s 8	6	- 2,774 (- 2,8976)	- 2,994 (- 3,4659)	I (1)
s 13	5	- 2,581 (- 2,8972)	- 2,863 (- 3,4652)	I (1)
s 26	6	- 1,094 (- 2,8976)	- 3,355 (- 3,4659)	I (1)
s 39	4	- 1,919 (- 2,8967)	- 2,694 (- 3,4655)	I (1)
s 52	4	- 0,891 (- 2,8977)	- 3,233 (- 3,4655)	I (1)
p 8	7	- 2,141 (- 2,8981)	- 1,884 (- 3,4666)	I (1)
p 13	3	- 2,386 (- 2,8963)	- 2,722 (- 3,4639)	I (1)
p 26	2	- 2,264 (- 2,8959)	- 2,988 (- 3,4632)	I (1)
p 39	4	- 2,331 (- 2,8967)	- 3,031 (- 3,4645)	I (1)
p 52	6	- 1,047 (- 2,8976)	- 3,203 (- 3,4659)	I (1)
of 8	8	- 2,577 (- 2,8986)	- 3,179 (- 3,4673)	I (1)
of 13	4	- 2,379 (- 2,8967)	- 2,917 (- 3,4645)	I (1)
of 26	7	- 1,184 (- 2,8981)	- 3,441 (- 3,4666)	I (1)
of 39	4	- 2,406 (- 2,8967)	- 3,053 (- 3,4645)	I (1)
of 52	3	- 0,800 (- 2,8963)	- 3,326 (- 3,4639)	I (1)
ofp 8	6	- 2,195 (- 2,8976)	- 2,512 (- 3,4659)	I (1)
ofp 13	6	- 3,820 (- 2,8976)	- 3,798 (- 3,4659)	I (0)
ofp 26	6	- 5,764 (- 2,8981)	- 5,727 (- 3,4666)	I (0)
ofp 39	12	- 3,539 (- 2,9012)	- 3,501 (- 3,4713)	I (0)
ofp 52	8	- 2,866 (- 2,8991)	- 2,852 (- 3,4681)	I (1)
K	1	- 0,302 (- 2,8955)	- 1,729 (- 3,4626)	I (1)
O / N	2	- 1,937 (- 2,8959)	- 3,028 (- 3,4632)	I (1)
T / N	1	- 0,418 (- 2,8955)	- 2,274 (- 3,4626)	I (1)
S / N	1	- 0,659 (- 2,8955)	- 2,303 (- 3,4626)	I (1)
W1	1	- 0,369 (- 2,8955)	- 2,123 (- 3,4626)	I (1)
W2	2	- 0,998 (- 2,8959)	- 3,079 (- 3,4632)	I (1)
M1	1	- 0,093 (- 2,8955)	- 1,948 (- 3,4626)	I (1)
M2	1	- 0,015 (- 2,8955)	- 2,127 (- 3,4626)	I (1)
M3	1	- 0,254 (- 2,8955)	- 2,496 (- 3,4626)	I (1)
	5	- 2,481 (- 2,8972)	- 2,692 (- 3,4652)	I (1)

Notes: The general LM test for autocorrelation was used to check whether the value of p was large enough to ensure that ut white noise. Critical values are in parentheses.
In brackets there are 95 % critical values given in Mackinnon [14]·····→

Table 2. Example of cointegration analysis by Johansen's method.

A. Choice of lag number

Variables	Numbers of lags for which test results point out cointegration between variables m = 1, 2, 3, 4, 5, 6, 7, 8	Misspecificiation tests: normality test - Jarque - Bera statistic $\chi^2(2)$ autocorrelation test - LM $\chi^2(12)$						Choosen number of lag VAR = m
		Equations	VAR = m_1		VAR = m_2		VAR = m_3	
			$\chi^2(2)$	$\chi^2(12)$	$\chi^2(2)$	$\chi^2(12)$	$\chi^2(2)$	$\chi^2(12)$
			VAR = 3		VAR = 4		VAR = 5	
i 13, **i** 8	3, 4, 5	Δ **i** 13 Δ **i** 13	466,5	2,28	463,7	2,54	452,7	3,71	VAR = 3
		Δ **i** 13 Δ **i** 13	25,9	8,08	32,9	4,91	32,9	4,11	

B. Cointegration tests for choosen number of lag

Variables	VAR = m	H_0	H_1	λ_{max}		trace		Number of cointegrating rectors r	Test on the coefficients of the cointegrating vector H_5 : [1; -1]
i 13, **i** 8	VAR = 3	r = 0 r ≤ 1	r = 1 r = 2	24,98 2,67	14,07 3,76	27,65 2, 67	15,41 3,76	r = 1	$\chi^2(1) = 2{,}69$ cointegrating relation is stationary by itself

Variables	VAR = m r	β	α	π	
				i 13	**i** 8
i 13	VAR = 3 r = 1	0,0206	- 17,8193	- 0,3663	0,2137
i 8		- 0,0119	40,3787	0,8301	- 0,4843

Notes: β - cointegrating vector, α - weights; $\pi = \alpha\,\beta'$

Table 3 Long - term relationships between interest rates of T - bills.

Variables	Results of misspecificiation tests for choosen number of lags			Number of cointegration vectors r	H_5 : Cointegrating vector is of the form [1; - 1]	Variables are cointegrated
	Choosen number of lags VAR = m	Yes / No	Lack of autocorrelation Yes / No		Yes / No	Yes / No
i 52, i 39, i 26, i 13, i 8	VAR = 7	No	2/5 Yes	r = 1	[1; -1; -1; -1; -1] No	Yes (?)
i 52, i 39	VAR = 4	No	No	r = 1 (?)	No	No
	VAR = 5, 7, 8	No	No			
i 52, i 26	VAR = 4	No	Yes	r = 1	No	Yes
i 52, i 13	VAR = 4	No	1/2 Yes	r = 1	No	Yes (?)
i 52, i 8	VAR = 3	No	Yes	r = 1	No	Yes
i 39, i26	VAR = 4	No	Yes	r = 1	No	Yes
i 39, i 13	VAR = 8	No	1/2 Yes	r = 1	No	Yes (?)
i 39, i 8	VAR = 8	No	Yes	r = 0	-	No
i 26, i 13	VAR = 3	No	Yes	r = 1	Yes	Yes
i 26, i 8	VAR = 3	No	Yes	r = 1	Yes	Yes
i 13, i 8	VAR = 3	No	Yes	r = 1	Yes	Yes
i 26, i 13, i 8	VAR = 3	No	Yes	r = 2	[1; -1; -1] No	Yes

Table 4 Long - term relationships between T - bill interest rates (i...) and relative supplies of T - bills (s...) and relative demands for T - bills (p...).

Variables	Results of misspecification tests for choosen number of lags			Number of cointegration vectors r	H_5 : Cointegrating vector is of the form [1; - 1]	Variables are cointegrated	Comment
	Choosen number of lags VAR = m	Yes / No	Lack of autocorrelation Yes / No		Yes / No	Yes / No	
i 8 - **s** 8, **p** 8	VAR = 4	2/3 Yes	Yes	r = 0	-	No	
i 13 - **s** 13, **p** 13	VAR = 7	2/3 Yes	Yes	r = 2	[1; -1; 0] Yes [1; -1; 1] No	Yes	
i 26 - **s** 26, **p** 26	VAR = 4	1/3 Yes	Yes	r = 1	[1; -1; 1] No [1; -1; 0] Yes	Yes	
i 39 - **s** 39, **p** 39	VAR = 8	No	Yes	r = 0	-	No	
i 52 - **s** 52, **p** 52	VAR = 7	No	Yes	r = 0	-	No	
i 8 - **s** 8	VAR = 6	1/2 Yes	Yes	r = 1	[1; -1] No	Yes	
i 13 - **s** 13	VAR = 7	1/2 Yes	Yes	r = 1	[1; 1] Yes!	Yes	s 13 = f (i 13)
i 26 - **s** 26	VAR = 8	No	Yes	r = 1	[1; -1] Yes	Yes	
i 39 - **s** 39	VAR = 8	No	Yes	r = 0	-	No	
i 52 - **s** 52	VAR = 7	No	No	r = 0	-	No	
	VAR = 4, 6, 8	No	No				
i 8 - **p** 8	VAR = 8	1/2 Yes	Yes	r = 0	-	No	
i 13 - **p** 13	VAR = 8	1/2 Yes	Yes	r = 1	[1; -1] Yes!	Yes	p 13 = f (i 13)
i 26 - **p** 26	VAR = 8	1/2 Yes	Yes	r = 1	[1; -1] Yes!	Yes	p 26 = f (i 26)
i 39 - **p** 39	VAR = 4	No	Yes	r = 1	[1; -1] No	Yes	p 39 = f (i 39)
i 52 - **p** 52	VAR = 8	No	Yes	r = 0	-	No	

Table 5 Long - term relationships between T - bill interest rates (i...) and offers accepted by the Ministry of Finance (of...) and ratios of accepted offers to demands for T - bill (ofp...).

Variables	Results of misspecificiation tests for choosen number of lags			Number of cointegration vectors	H_5 : Cointegrating vector is of the form [1; - 1]	Variables are cointegrated	Comment
	Choosen number of lags VAR = m	Yes / No	Lack of autocorrelation Yes / No	r	Yes / No	Yes / No	
i 8 - **of** 8	VAR = 8	No	Yes	r = 1	[1; -1] No	Yes	
i 13 - **of** 13	VAR = 8	1/2 Yes	Yes	r = 0	-	No	
i 26 - **of** 26	VAR = 4	1/2 Yes	Yes	r = 1	[1; -1] Yes	Yes	
i 39 - **of** 39	VAR = 8	No	Yes	r = 0	-	No	
i 52 - **of** 52	VAR = 8	No	Yes	r = 0	-	No	
i 8 - **ofp** 8	VAR = 8	No	Yes	r = 0	-	No	
i 52 - **of** 52	VAR = 6	1/2 Yes	Yes	r = 1	[1; 1] Yes	Yes	ofp 52 = f (i 52)

Table 6 Long - term relationships between T - bill interest rates (**i**...) and money market interest rates (**O/N, T/N, S/N, W1, W2, M1, M2, M3**) and open market operations balance (**O**)

Variables	Results of misspecificiation tests for choosen number of lags			Number of cointegration vectors r	H_5 : Cointegrating vector is of the form [1; - 1]	Variables are cointegrated	Comment
	Choosen number of lags VAR = m	Yes / No	Lack of autocorrelation Yes / No		Yes / No	Yes / No	
i 8 - all WIBORs	VAR = 5	-	-	λ_{max} r = 4 trace r = 6	No	Yes	
i 8 - **O/N, T/N, S/N**	VAR = 8	No	Yes	r = 1	No	Yes	
i 8 - **W1, W2**	VAR = 4	No	Yes	r = 1	No	Yes	
i 8 - **M1, M2, M3**	VAR = 6	No	1/2 Yes	r = 1	-	Yes (?)	
i 13 - all WIBORs	VAR = 5	-	-	r = 5	No	Yes	
i 13 - **O/N, T/N, S/N**	VAR = 8	No	Yes	r = 2	No	Yes	
i 13 - **W1, W2**	VAR = 3	No	Yes	r = 2	[1; -1; -1] Yes	Yes	
i 13 - **M1, M2, M3**	VAR = 6	No	1/2 Yes	r = 1	No	Yes (?)	
i 26 - all WIBORs	VAR = 4	-	-	λ_{max} r = 4 trace r = 5	No	Yes	
i 26 - **O/N, T/N, S/N**	VAR = 8	No	Yes	r = 1	No	Yes	
i 26 - **W1, W2**	VAR = 8	No	Yes	r = 0	-	No	
i 26 - **M1, M2, M3**	VAR = 6	No	1/2 Yes	r = 1	No	Yes (?)	
i 39 - all WIBORs	VAR = 8	-	-	λ_{max} r = 4 trace r = 6	No	Yes	
i 39 - **O/N, T/N, S/N**	VAR = 7	No	Yes	r = 3	No	Yes	
i 39 - **W1, W2**	VAR = 4	No	Yes	r = 2	No	Yes	
i 39 - **M1, M2, M3**	VAR = 6	No	1/2 Yes	r = 1	No	Yes (?)	
i 52 - all WIBORs	VAR = 5	-	-	λ_{max} r = 5 trace r = 6	No	Yes	
i 52 - **O/N, T/N, S/N**	VAR = 8	No	Yes	r = 1	No	Yes	
i 52 - **W1, W2**	VAR = 4	No	Yes	r = 2	[1; 0; -1] Yes	Yes	
i 52 - **W1**	VAR = 4	No	Yes	r = 1	No	Yes	
i 52 - **W2**	VAR = 4	No	Yes	r = 1	[1; -1] Yes	Yes	
i 52 - **M1, M2, M3**	VAR = 6	No	1/2 Yes	r = 1	No	Yes (?)	
each i... - **O**	each m	-	-	r = 0	-	No	

Table 7 Long - term relationships between money market variables an exchange rate, PLN / USD (k).

Variables	Results of misspecificiation tests for choosen number of lags			Number of cointegration vectors r	H_5 : Cointegrating vector is of the form [1; - 1]	Variables are cointegrated	Comment
	Choosen number of lags VAR = m	Yes / No	Lack of autocorrelation Yes / No		Yes / No	Yes / No	
i 8 - k	VAR = 3	No	Yes	r = 1	[1; 1] No	Yes	signs of β
i 13 - k	VAR = 3	No	Yes	r = 1	[1; 1] No	Yes	• estimated
i 26 - k	VAR = 3	No	Yes	r = 1	[1; 1] No	Yes	i + ; k +
i 39 - k	VAR = 8	1/2 Yes	Yes	r = 1	[1; 1] No	Yes	• expected
i 52 - k	VAR = 3	No	Yes	r = 1	[1; 1] No	Yes	i + ; k -
p 8 - k	VAR = 3	Yes / No	Yes	r = 1	[1; 1] Yes	Yes	
p 13 - k	VAR = 7	Yes / No	Yes	r = 1	[1; 1] Yes	Yes	
p 26 - k	VAR = 6	Yes / No	Yes	r = 1	[1; 1] Yes	Yes	
p 39 - k	VAR = 8	No	Yes	r = 1	[1; 1] No	Yes	
p 52 - k	VAR = 5	No	Yes	r = 1	[1; 1] No	Yes	
O / N - k	VAR = 5	No	Yes	r = 1	[1; 1] No	Yes	
T / N - k	VAR = 6	No	Yes	r = 1	[1; 1] No	Yes	
S / N - k	VAR = 8	No	Yes	r = 1	[1; 1] No	Yes	
W1 - k	each m	No	1 / 2 Yes	r = 0	-	No	
W2 - k	each m	No	1 / 2 Yes	r = 0	-	No	
M1 - k	each m	No	1 / 2 Yes	r = 0	-	No	
M2 - k	each m	No	1 / 2 Yes	r = 0	-	No	
M3 - k	each m	No	1 / 2 Yes	r = 0	-	No	
O - k	VAR = 3	No	Yes	r = 1	[1; -1] Yes	Yes	

Table 8 Estimation of simultaneous equations model of the T - bill interest rates (2 S L S method).

y / x	Δ i 8	Δ i 13	Δ i 26	Δ i 39	Δ i 52
Δ i 8 (-4)			- 0,077 (-1,823)		
Δ i 26 (0)				- 0,139 (-1,909)	0,115 (4,076)
Δ i 26 (-1)			- 0,602 (-6,113)	- 0,202 (-2,389)	0,150 (4,996)
Δ i 26 (-2)			- 0,718 (-6,879)		0,075 (2,551)
Δ i 26 (-3)			- 0,573 (-5,664)		
Δ i 26 (-4)			- 0,533 (-5,071)		0,165 (5,134)
Δ i 39 (0)	- 0,086 (-2,073)				
Δ i 39 (-5)			0,282 (4,873)		- 0,093 (-5,339)
Δ i 52 (0)			0,705 (4,372)	1,627 (5,486)	
Δ i 52 (-1)				0,594 (2,894)	- 0,163 (-3,085)
Δ i 52 (-2)					
Δ i 52 (-3)					- 0,227 (-2,849)
Δ i 52 (-4)		0,543 (2,888)			- 0,283 (-3,473)
Δ **sup** 8 (0)	0,023 (3,969)				
Δ **sup** 13 (0)		0,022 (4,199)			
Δ **sup** 39 (-1)				0,014 (3,674)	
Δ **sup** 52 (0)					0,0041 (3,611)
Δ **s** 26 (0)			0,391 (5,047)		
Δ **s** 26 (-5)			- 0,196 (-2,774)		
Δ **s** 39 (0)				0,449 (6,181)	- 0,0515 (-2,871)
Δ **s** 39 (-3)			0,109 (4,079)		
Δ **s** 52 (0)					0,0317 (1,835)
Δ **s** 52 (-3)					0,035 (2,623)
Δ **p** 8 (0)	0,731 (10,888)				
Δ **p** 8 (-2)	- 0,0122 (-2,764)				
Δ **p** 13 (0)		0,267 (3,779)			
Δ **p** 13 (-6)		- 0,258 (-3,295)			
Δ **p** 39 (0)				0,637 (9,198)	
Δ **of** 8 (0)	- 0,468 (-6,862)				
Δ **of** 26 (-2)			- 0,082 (-1,823)		
Δ **of** 39 (0)				- 0,541 (-6,061)	
Δ **ofp** 8 (0)	0,156 (12,342)				
ofp 13 (-4)				- 0,045 (-2,345)	
ofp 39 (0)				0,110 (5,777)	0,017 (3,607)
Δ **k** (-3)	- 47,547 (-3,743)				
Δ **k** (-4)	53,813 (4,685)				
Δ **S / N** (-6)	- 1,769 (-2,122)				
Δ **M1** (-1)					0,576 (0,1798)
Δ **O** (-3)					0,00048 (4,013)
ei8 W1 W2 II (-1)	- 0,056 (1,786)				
ei13 W1 W2 II (-1)		- 0,589 (-5,600)			
ei 39 **W1 W2** II (-1)				- 0,197 (-2,947)	
ei 52 **W2** (-1)					- 0,182 (-2,690)
ei 13 **p** 13 (-1)		- 0,182 (-3,538)			
ei 26 **s** 26 (-1)			- 0,322 (-3,112)		
constant	- 2,199 (1,835)	- 13,419 (-5,625)	2,059 (2,196)	- 12,834 (-2,926)	- 0,988 (-2,863)
R^2	0,918	0,714	0,831	0,852	0,935
RSS	582,3	1002,7	582,3	794,9	57,7
Sargan's test	χ^2 (31) = 42,45	χ^2 (31) = 26,13	χ^2 (29) = 30,96	χ^2 (30) = 40,745	χ^2 (22) = 24,59
Normality test χ^2(2)	0,188	81,412	24,831	2,195	0,013

Notes: t - ratios are in parentheses.