

Analysis of determinants of cyclical declines in the level of selected index proposals and the volume of their Eligible Transactions Pool at the end of the month

The aim of the analysis:

Identification of factors and the scale of their impact on cyclical end-of-month declines in the level of WIRF and POLSTR index proposals as well as the volume of their Eligible Transactions Pool.

- A.** Econometric analysis of determinants of the WIRF level and the volume of the WIRF Eligible Transactions Pool in the context of their cyclical declines at the end of the month
- B.** Econometric analysis of determinants of the POLSTR level and the volume of the POLSTR Eligible Transactions Pool in the context of their cyclical declines at the end of the month

A. Econometric analysis of determinants of the WIRF level and the volume of the WIRF Eligible Transactions Pool in the context of their cyclical declines at the end of the month

Analysis period: Jan'2021 – Jun'2024

Data frequency: daily (index dates, i.e. business days)

Explained variables:

1) change in the modified¹ level of the WIRF index compared to the previous index date - in pp. ($\Delta WIRF_ADJ$),

2) change in the volume of the WIRF Eligible Transactions Pool compared to the previous index date – in PLN bn ($\Delta WIRF_WOL$).

Set of potential explanatory variables:

- change in the value of a binary variable indicating whether a given index date is the last business day of the month compared to the previous index date, that is - in effect - a variable assuming 3 values: 1- a given index date is the last business day of the month, -1 – a given index date is the first business day of the month, 0 – a given index date is neither the last nor the first business day of the month (ΔKC_MCA)²,

- change in the number of non- business days following a given index date compared to the previous index date³ (ΔDNI_NIEROB),

- change in banks' current account balance in the NBP compared to the previous index date (comparison of balances at the end of the day) – in PLN bn ($\Delta RACH_BIEŻ$),

- change in banks' funds in the ON deposit in the NBP compared to the previous index date (comparison of balances at the end of the day) – in PLN bn ($\Delta DEPO_NBP$),

- change in banks' funds invested in 7-day NBP bills (i.e. the NBP main operations) compared to the previous index date (comparison of balances at the end of the day) – in PLN bn (ΔOP_PODST),

- change in banks' funds invested in NBP bills with maturity of less than 7 days (i.e. the NBP fine-tuning operations) compared to the previous index date (comparison of balances at the end of the day) – in PLN bn (ΔOP_DOSTR),

- change in the sum of banks' funds invested in NBP bills of any maturity (i.e. both main and fine-tuning operations) compared to the previous index date (comparison of balances at the end of the day) – in PLN bn (ΔOP_PODST_DOSTR),

- change in the sum of banks' funds invested in NBP bills of any maturity (i.e. both main and fine-tuning operations) and funds in the ON deposit in the NBP compared to the previous index date (comparison of balances at the end of the day) – in PLN bn ($\Delta OP_PODST_DOSTR_DEPO$),

¹ The modification of the index level consists of subtracting the NBP reference rate (adapted to the ACT/365 convention) from its level. This operation is aimed at eliminating the impact of changes in NBP interest rates on the index.

² In this analysis this variable will be considered as the impact of the monthly process of determining the bank tax basis as the state of selected categories of bank assets at the month end.

³ For example, on Friday $\Delta DNI_NIEROB = 2$, because on the preceding Thursday $DNI_NIEROB = 0$, and on Friday $DNI_NIEROB = 2$ (due to the two days of the upcoming weekend assuming no additional non- business days).

- change in the sum of banks' funds invested in NBP bills of any maturity (i.e. both main and fine-tuning operations), funds in the ON deposit in the NBP and current account balance in the NBP compared to the previous index date (comparison of balances at the end of the day) – in PLN bn ($\Delta\acute{S}RODKI_W_NBP$).

Method of explanatory variables selection:

In selecting the final specification of the econometric model, i.e. selecting the set of explanatory variables, a „from general to specific” method was used. It consists of estimating a model with a specific starting set of potential explanatory variables („general” model) and then, from among the statistically non-significant explanatory variables the one with the highest p-value under the t-Student's test of explanatory variable significance is removed, after which the reduced model is re-estimated and again the least significant of the statistically nonsignificant explanatory variables is removed from the model - this procedure is repeated sequentially until a model with only significant explanatory variables is obtained („specific” model).

In the above manner, each starting set of potential explanatory variables is assigned a final model with only statistically significant explanatory variables. From the resulting group of final models, the one with the highest value of the adjusted⁴ coefficient of determination R^2 is selected.

Starting specification of the model („general” model):

$$Y_t = \alpha_0 + \alpha_1 X_{1,t} + \dots + \alpha_k X_{k,t} + \varepsilon_t ,$$

where:

Y_t – explained variable,

$X_{1,t}, \dots, X_{k,t}$ – starting set of potential explanatory variables,

t – index date,

ε_t – random component of the model,

$\alpha_0, \dots, \alpha_k$ – structural parameters of the model.

The structural parameters of the model are expressed in the units in which the explanatory variable of the model is expressed in (i.e. $\Delta WIRF_ADJ$ in pp., while $\Delta WIRF_WOL$ in PLN bn).

List of alternative starting sets of potential explanatory variables:

1) $\Delta KC_MCA, \Delta DNI_NIEROB, \Delta RACH_BIE\acute{Z}, \Delta DEPO_NBP, \Delta OP_PODST, \Delta OP_DOSTR$;

2) $\Delta KC_MCA, \Delta DNI_NIEROB, \Delta RACH_BIE\acute{Z}$;

3) $\Delta KC_MCA, \Delta DNI_NIEROB, \Delta\acute{S}RODKI_W_NBP$;

4) $\Delta KC_MCA, \Delta DNI_NIEROB, \Delta DEPO_NBP, \Delta OP_PODST, \Delta OP_DOSTR$;

5) $\Delta KC_MCA, \Delta DNI_NIEROB, \Delta OP_PODST_DOSTR$;

6) $\Delta KC_MCA, \Delta DNI_NIEROB, \Delta DEPO_NBP, \Delta OP_PODST_DOSTR$;

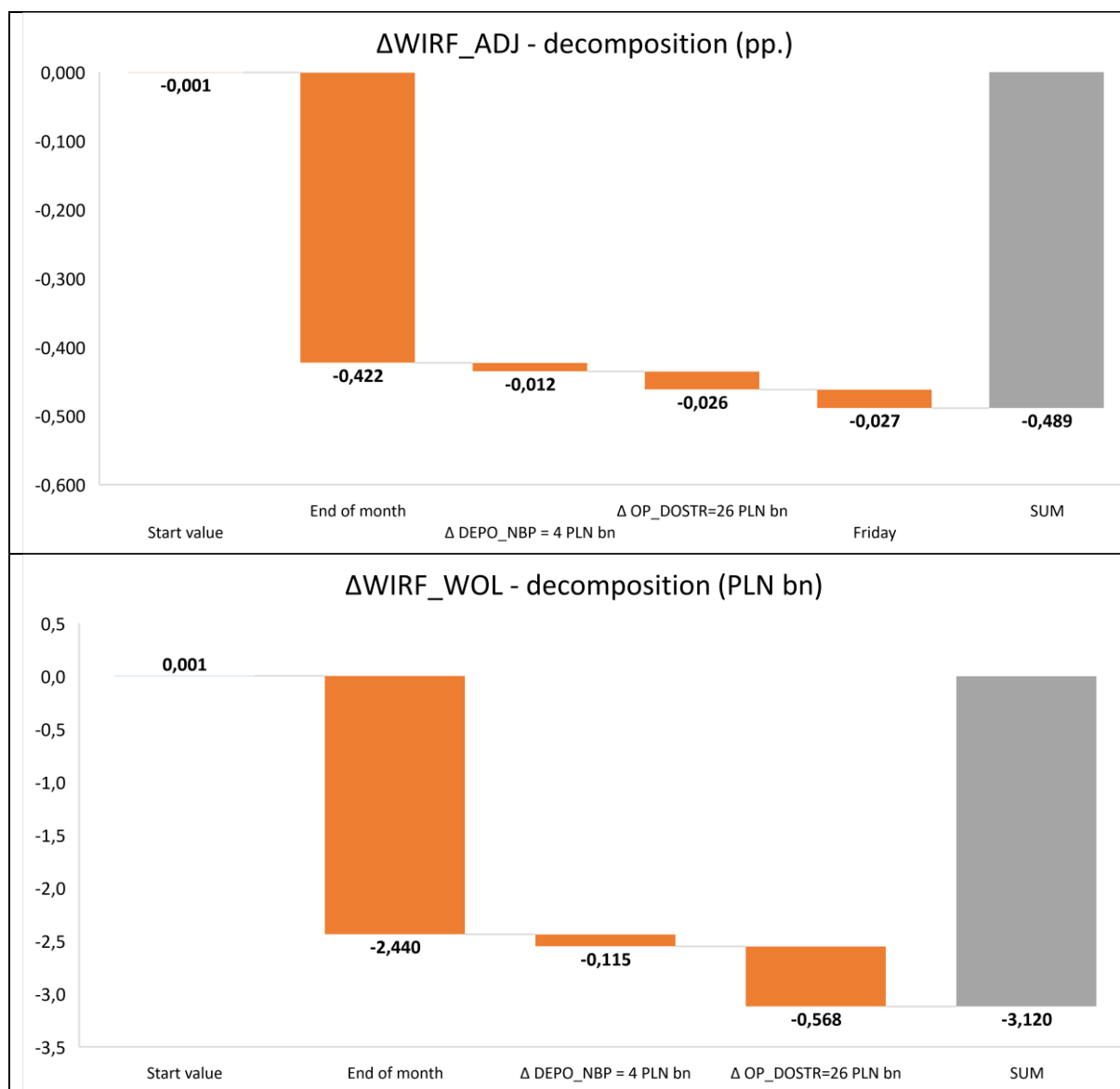
⁴ The adjusted R^2 includes in its formula an adjustment related to the number of explanatory variables, so this measure of model fit to empirical data allows for comparisons of models that differ in the number of explanatory variables.

7) ΔKC_MCA , ΔDNI_NIEROB , $\Delta OP_PODST_DOSTR_DEPO$.

Summary of structural parameter estimates of selected final models (i.e. „specific” models):

Explained variable (Y_t)	Estimates of structural parameters				
	Intercept	ΔKC_MCA	$\Delta DEPO_NBP$	ΔOP_DOSTR	ΔDNI_NIEROB
$\Delta WIRF_ADJ$ (pp.)	-0.001	-0.422	-0.003	-0.001	-0.013
$\Delta WIRF_WOL$ (PLN bn)	0.001	-2.440	-0.029	-0.022	-

Charts 1 Decomposition of the change in WIRF level and the change in the volume of its Eligible Transactions Pool at the end of the month (a hypothetical case is presented: the last business day of the month being a Friday⁵, in which both the banks' deposit balance in the NBP and the value of NBP bills issued under fine-tuning operations increase on an average recorded scale of non-zero change⁶):



⁵ It is assumed here that on Friday $\Delta DNI_NIEROB = 2$ due to the 2 days of the upcoming weekend, assuming no additional non-business days due to holidays immediately following that weekend (e.g. on Friday, March 29 2024 $\Delta DNI_NIEROB = 3$ due to Easter Monday on April 1 2024).

⁶ I.e. on a scale equal to the average of the absolute values of non-zero daily changes rounded to PLN bn. The scales of change defined in such a way are PLN 4 bn for $\Delta DEPO_NBP$ and PLN 26 bn for ΔOP_DOSTR .

Key conclusions from analysis A:

1) Among the analyzed potential determinants of WIRF volatility, both its level and the volume of its Eligible Transactions Pool, the key role – incomparably greater than the other factors considered – is played by **the cyclical end-of-month effect** associated with the highest probability with the monthly process of determining the bank tax basis as the state of selected categories of bank assets at the month end. This phenomenon translates into **a strong temporary decline in the index level (on average by 42.2 bp) and the volume of its Eligible Transactions Pool (on average by PLN 2.44 bn) on the last business day of the month** (a symmetrical upward rebound occurs on the first business day of the following month), which is related to banks' reluctance to take deposits on that day as they increase the bank tax basis.

2) The number of non-business days following a given index date has a statistically significant, although quite limited, impact on the WIRF index level - **each additional non-working day following the index date lowers the index level by approximately 1.35 bp on average**⁷. At the same time this factor does not demonstrate a statistically significant impact on the volume of the WIRF Eligible Transactions Pool (hence the lack of information on the chart). These estimates imply that the more non-business days following a given index date, the lower the demand from banks for cash at ON maturity and - at the same time - the greater their supply on that index date, which results in a decrease in the interest rate of transactions included in the WIRF Eligible Transactions Pool with an unchanged total volume of those transactions.

3) **The increase in the banks' funds in the ON deposit in the NBP** on the average scale of non-zero change⁸ (i.e. **by PLN 4 bn**) translates into **a decrease in the index level by an average of 1.2 bp and the volume of its Eligible Transactions Pool by an average of PLN 0.115 bn**. These estimates imply that the more funds are transferred by banks to the NBP in the form of ON deposits, the lower the banks' demand for cash at ON maturity, which results in a decrease in the interest rate of transactions included in the WIRF Eligible Transactions Pool as well as a drop in the total volume of those transactions.

4) **The increase in the banks' funds invested in NBP bills issued within the NBP fine-tuning operations** on the average scale of non-zero change⁹ (i.e. **by PLN 26 bn**) translates into **a decrease in the index level by an average of 2.6 bp and the volume of its Eligible Transactions Pool by an average of PLN 0.568 bn**. These estimates imply that the more funds are invested by banks in NBP bills within the NBP fine-tuning operations, the lower the banks' demand for cash at ON maturity, which results in a decrease in the interest rate of transactions included in the WIRF Eligible Transactions Pool as well as a drop in the total volume of those transactions.

⁷ For example, from Thursday to Friday the number of non-business days following the given index date increases by 2 (i.e. from 0 to 2 days), which translates into a decrease in the index level by an average of 2.7 bp.

⁸ I.e. on a scale equal to the average of the absolute values of non-zero daily changes rounded to PLN bn.

⁹ See: previous footnote.

B. Econometric analysis of determinants of the POLSTR¹⁰ level and the volume of the POLSTR Eligible Transactions Pool in the context of their cyclical declines at the end of the month

Analysis period: Jan'2021 – Jun'2024

Data frequency: daily (index dates, i.e. business days)

Explained variables:

1) change in the modified¹¹ level of the POLSTR index compared to the previous index date - in pp. ($\Delta POLSTR_ADJ$),

2) change in the volume of the POLSTR Eligible Transactions Pool compared to the previous index date – in PLN bn ($\Delta POLSTR_WOL$).

Set of potential explanatory variables:

- change in the value of a binary variable indicating whether a given index date is the last business day of the month compared to the previous index date, that is - in effect - a variable assuming 3 values: 1- a given index date is the last business day of the month, -1 – a given index date is the first business day of the month, 0 – a given index date is neither the last nor the first business day of the month (ΔKC_MCA)¹²,

- change in the number of non- business days following a given index date compared to the previous index date¹³ (ΔDNI_NIEROB),

- change in banks' current account balance in the NBP compared to the previous index date (comparison of balances at the end of the day) – in PLN bn ($\Delta RACH_BIEŻ$),

- change in banks' funds in the ON deposit in the NBP compared to the previous index date (comparison of balances at the end of the day) – in PLN bn ($\Delta DEPO_NBP$),

- change in banks' funds invested in 7-day NBP bills (i.e. the NBP main operations) compared to the previous index date (comparison of balances at the end of the day) – in PLN bn (ΔOP_PODST),

- change in banks' funds invested in NBP bills with maturity of less than 7 days (i.e. the NBP fine-tuning operations) compared to the previous index date (comparison of balances at the end of the day) – in PLN bn (ΔOP_DOSTR),

- change in the sum of banks' funds invested in NBP bills of any maturity (i.e. both main and fine-tuning operations) compared to the previous index date (comparison of balances at the end of the day) – in PLN bn (ΔOP_PODST_DOSTR),

¹⁰ The analysis took into account the POLSTR index with a Minimum Volume Threshold of PLN 50 mn and a cut-off level in the Main Adjustment of 25% (parameterization obtained as a result of calibration aimed at minimizing index volatility).

¹¹ The modification of the index level consists of subtracting the NBP reference rate (adapted to the ACT/365 convention) from its level. This operation is aimed at eliminating the impact of changes in NBP interest rates on the index.

¹² In this analysis this variable will be considered as the impact of the monthly process of determining the bank tax basis as the state of selected categories of bank assets at the month end.

¹³ For example, on Friday $\Delta DNI_NIEROB = 2$, because on the preceding Thursday $DNI_NIEROB = 0$, and on Friday $DNI_NIEROB = 2$ (due to the two days of the upcoming weekend assuming no additional non- business days).

- change in the sum of banks' funds invested in NBP bills of any maturity (i.e. both main and fine-tuning operations) and funds in the ON deposit in the NBP compared to the previous index date (comparison of balances at the end of the day) – in PLN bn ($\Delta OP_PODST_DOSTR_DEPO$),

- change in the sum of banks' funds invested in NBP bills of any maturity (i.e. both main and fine-tuning operations), funds in the ON deposit in the NBP and current account balance in the NBP compared to the previous index date (comparison of balances at the end of the day) – in PLN bn ($\Delta \acute{S}RODKI_W_NBP$).

Method of explanatory variables selection:

In selecting the final specification of the econometric model, i.e. selecting the set of explanatory variables, a „from general to specific” method was used. It consists of estimating a model with a specific starting set of potential explanatory variables („general” model) and then, from among the statistically non-significant explanatory variables the one with the highest p-value under the t-Student's test of explanatory variable significance is removed, after which the reduced model is re-estimated and again the least significant of the statistically nonsignificant explanatory variables is removed from the model - this procedure is repeated sequentially until a model with only significant explanatory variables is obtained („specific” model).

In the above manner, each starting set of potential explanatory variables is assigned a final model with only statistically significant explanatory variables. From the resulting group of final models, the one with the highest value of the adjusted¹⁴ coefficient of determination R^2 is selected.

Starting specification of the model („general” model):

$$Y_t = \alpha_0 + \alpha_1 X_{1,t} + \dots + \alpha_k X_{k,t} + \varepsilon_t,$$

where:

Y_t – explained variable,

$X_{1,t}, \dots, X_{k,t}$ – starting set of potential explanatory variables,

t – index date,

ε_t – random component of the model,

$\alpha_0, \dots, \alpha_k$ – structural parameters of the model.

The structural parameters of the model are expressed in the units in which the explanatory variable of the model is expressed in (i.e. $\Delta POLSTR_ADJ$ in pp., while $\Delta POLSTR_WOL$ in PLN bn).

List of alternative starting sets of potential explanatory variables:

1) $\Delta KC_MCA, \Delta DNI_NIEROB, \Delta RACH_BIE\acute{Z}, \Delta DEPO_NBP, \Delta OP_PODST, \Delta OP_DOSTR$;

2) $\Delta KC_MCA, \Delta DNI_NIEROB, \Delta RACH_BIE\acute{Z}$;

3) $\Delta KC_MCA, \Delta DNI_NIEROB, \Delta \acute{S}RODKI_W_NBP$;

4) $\Delta KC_MCA, \Delta DNI_NIEROB, \Delta DEPO_NBP, \Delta OP_PODST, \Delta OP_DOSTR$;

¹⁴ The adjusted R^2 includes in its formula an adjustment related to the number of explanatory variables, so this measure of model fit to empirical data allows for comparisons of models that differ in the number of explanatory variables.

5) ΔKC_MCA , ΔDNI_NIEROB , ΔOP_PODST_DOSTR ;

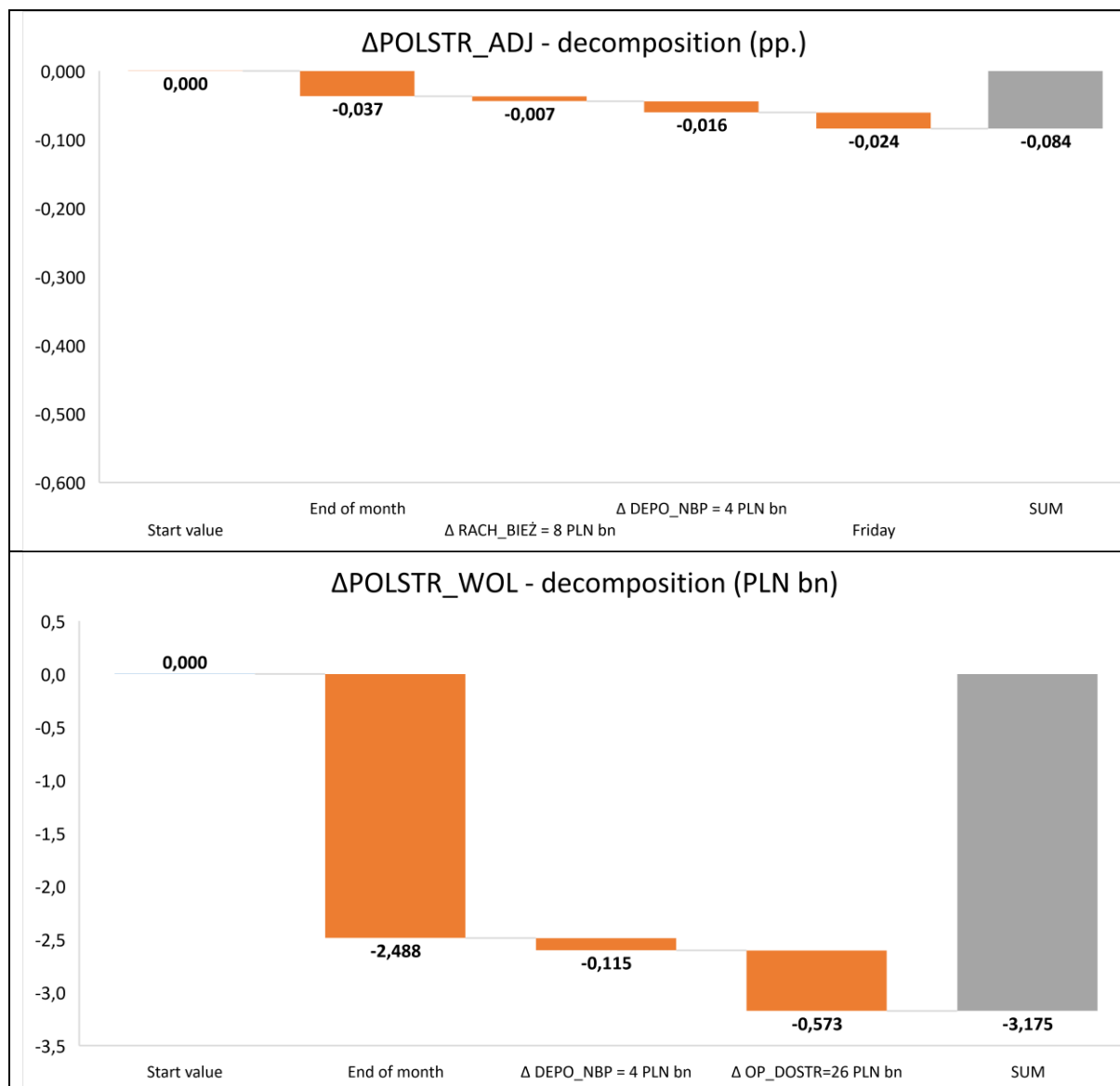
6) ΔKC_MCA , ΔDNI_NIEROB , $\Delta DEPO_NBP$, ΔOP_PODST_DOSTR ;

7) ΔKC_MCA , ΔDNI_NIEROB , $\Delta OP_PODST_DOSTR_DEPO$.

Summary of structural parameter estimates of selected final models (i.e. „specific” models):

Explained variable (Y_t)	Estimates of structural parameters					
	Intercept	ΔKC_MCA	$\Delta RACH_BIE\dot{Z}$	$\Delta DEPO_NBP$	ΔOP_DOSTR	ΔDNI_NIEROB
$\Delta POLSTR_ADJ$ (pp.)	0.000	-0.037	-0.001	-0.004	-	-0.012
$\Delta POLSTR_WOL$ (PLN bn)	0.000	-2.488	-	-0.029	-0.022	-

Charts 2 Decomposition of the change in the POLSTR level and the change in the volume of its Eligible Transactions Pool at the end of the month (a hypothetical case is presented: the last business day of the month being a Friday¹⁵, in which the banks' deposit balance in the NBP as well as the value of NBP bills issued under fine-tuning operations and the banks' current account balance in the NBP increase on an average recorded scale of non-zero change¹⁶):



¹⁵ It is assumed here that on Friday $\Delta DNI_NIEROB = 2$ due to the 2 days of the upcoming weekend, assuming no additional non-business days due to holidays immediately following that weekend (e.g. on Friday, March 29 2024 $\Delta DNI_NIEROB = 3$ due to Easter Monday on April 1 2024).

¹⁶ I.e. on a scale equal to the average of the absolute values of non-zero daily changes rounded to PLN bn. The scales of change defined in such a way are PLN 4 bn for $\Delta DEPO_NBP$ and PLN 26 bn for ΔOP_DOSTR .

Key conclusions from analysis B:

1) Already a preliminary assessment of Charts 2 allows for stating that the impact of the explanatory variable concerning the "end-of-month effect" (ΔKC_MCA) is significantly smaller in the case of POLSTR compared to WIRF in the case of the explained variable in the form of the level of a given index proposal. As for the inference regarding all individual influence factors, it is indicated that among the analyzed potential determinants of POLSTR volatility, both of its level and the volume of its Eligible Transactions Pool, the most important role - but in the case of the level of the index proposal only slightly greater than for the other factors considered - is played by **the cyclical end-of-month effect** associated with the highest probability with the monthly process of determining the bank tax basis as the state of selected categories of banks' assets at the end of the month. The key role of this factor is maintained in the case of the impact on the level of the volume of the POLSTR Eligible Transactions Pool. This phenomenon translates into **a moderate temporary decline in the index level (on average by 3.7 bp) and a strong decline in the volume of the POLSTR Eligible Transactions Pool (on average by PLN 2.49 bn) on the last business day of the month** (a symmetrical upward rebound occurs on the first business day of the following month), which is related to banks' reluctance to take deposits on that day as they increase the bank tax basis.

2) The number of non-business days following a given index date has a statistically significant, although quite limited, impact on the POLSTR index level - **each additional non-working day following the index date lowers the index level by approximately 1.2 bp on average**¹⁷. At the same time this factor does not demonstrate a statistically significant impact on the volume of the POLSTR Eligible Transactions Pool (hence the lack of information on the chart). These estimates imply that the more non-business days following a given index date, the lower the demand from banks for cash at ON maturity and - at the same time - the greater their supply on that index date, which results in a decrease in the interest rate of transactions included in the POLSTR Eligible Transactions Pool with an unchanged total volume of those transactions.

3) **The increase in the banks' funds in the ON deposit in the NBP** on the average scale of non-zero change¹⁸ (i.e. **by PLN 4 bn**) translates into **a decrease in the index level by an average of 1.6 bp and the volume of its Eligible Transactions Pool by an average of PLN 0.115 bn**. These estimates imply that the more funds are transferred by banks to the NBP in the form of ON deposits, the lower the banks' demand for cash at ON maturity, which results in a decrease in the interest rate of transactions included in the POLSTR Eligible Transactions Pool as well as a drop in the total volume of those transactions.

4) **The increase in the banks' funds invested in NBP bills issued within the NBP fine-tuning operations** on the average scale of non-zero change¹⁹ (i.e. **by PLN 26 bn**) translates into **a decrease in the volume of POLSTR Eligible Transactions Pool by an average of PLN 0.573 bn**. At the same time this factor does not demonstrate a statistically significant impact on the POLSTR level (hence the lack of information on the chart). These estimates imply that the more funds are invested by banks in NBP bills within the NBP fine-tuning operations, the lower the banks' demand for cash at ON maturity, which results in a decrease in the total volume of transactions included in the POLSTR Eligible Transactions Pool amid stable interest rates of those transactions.

¹⁷ See: footnote 7.

¹⁸ See: footnote 8.

¹⁹ See: footnote 8.