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Mariusz Kapuściński – Narodowy Bank Polski; mariusz.kapuscinski@nbp.pl

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Abstract

In this study I analyse the effects of a bank levy, as introduced in Poland, on areas which appear to be relevant from the perspective of a central bank. I apply the difference-in-differences method, using bank level panel data. I find that the introduction of the bank levy has affected the use of some monetary policy instruments, money market rates and volumes, and deposit and loan rates. However, I find little evidence of its impact on loan volumes, bank profitability, capital and risk-taking. This means that the bank levy has had important implications for monetary policy implementation, interest rate benchmark reform and monetary conditions, but (as yet) less so for financial stability. As an extension of the study, I document its effects on assets and Treasury bond holdings (including their changes at the end of the month), and estimate the impact of bank balance sheet adjustments on government revenues.

JEL codes: C23, E43, E51, E52, G18, H26, H39

Keywords: bank levy, difference-in-differences, panel data, monetary policy instruments, money market, financial stability

1 Introduction

After the Global Financial Crisis several countries introduced a bank levy. For example, Hungary put it into effect in 2010, Cyprus, Germany and the UK in 2011, Netherlands in 2012, and Finland a year later until 2015 (European Commission, 2021). They differ in terms of their aim, tax base, rate and whether they accumulate in a fund or are paid into general revenue. For a review of applied solutions see, for example, Devereux et al. (2019) and Kogler (2019).

In February 2016 a bank levy ('a tax on certain financial institutions') was introduced in Poland. In the case of banks, its base is the excess of assets above PLN 4 bn, lowered (mainly) by their capital and Treasury securities held by them. The tax base is set as of the last day of the month, and its rate amounts to 0.0366%. Besides banks with insufficiently high assets (net of capital and Treasury securities), the bank levy is not paid by state-owned banks (as defined by the Banking Act; at the time of writing the article there was only one bank under this group) and banks under recovery proceedings.

On the one hand, the introduction of the bank levy in the given form could make its payers consider holding lower levels of assets other than Treasury securities and lower levels of liabilities other than capital, by adjusting the composition or the level of their balance sheets (quantity effects). On the other hand, respective balance sheet components are not perfect substitutes. Furthermore, not only the lowering of the level of a balance sheet reduces costs, but also revenues, which might affect the potential to generate profits. These factors should put a limit on the scale of the adjustment of banks to the bank levy in the ways mentioned above.

An alternative way for banks to compensate for the impact of the bank levy on their financial results would be to demand a higher rate on assets (other than Treasury securities) and a lower rate on liabilities (other than capital; price effects). The scale of the required change in rates depends on the term of the transaction and the stage of the month at which it was made. One extreme is the lending of funds overnight (ON) on the last day of the month on the interbank money market. In this case the payer of the bank levy bears the alternative cost of not buying Treasury securities instead. This cost would be compensated by a premium of about 13 percentage points (0.0366%*(360/1)). Compensating the cost of a transaction in the opposite direction would require an analogous discount (i.e. about 13 percentage points). On the other extreme are instruments with a term of one month or longer (including loans for/deposits from households and non-financial corporations). In that case the required premium/discount decreases to 0.44 percentage points (0.0366%*(360/30)).

At this point two caveats appear to be worth making. First, in the case of some instruments, rates are fixed. In particular, rates on monetary policy instruments are set by the Monetary Policy Council and are not differentiated among counterparties.

Therefore, they cannot respond to the bank levy. Second, except when there are no other viable possibilities, it appears more likely to resign from a transaction than to agree to a very high premium/discount. In this sense, not only the demanding of a premium/discount could be reflected in the observed rates, but also in volumes. For theoretical studies on the effects of the bank levy see, for example, Cannas et al. (2014) and Diemer (2017) (but also Capelle-Blancard and Havrylchyk, 2017; Kogler, 2019).

Taking these considerations into account, the introduction of the bank levy could affect areas which appear to be relevant from the perspective of a central bank. It could lower the use of monetary policy instruments by the payers of the levy. Among other things, this means that they would limit the purchases of Narodowy Bank Polski (NBP) bills on open market operations, lower the use of the deposit facility and hold lower levels of current accounts at NBP. This should be observed the last day of the month.

The NBP bills make a more complex case. On the one hand, only one main open market operation in a given month has a maturity covering its last day (they are conducted weekly, with a one-week maturity). On the other hand, a cyclical change in the structure of assets between NBP bills and Treasury securities would be associated with bearing transactional costs. Therefore, in response to the introduction of the bank levy, its payers could lower their holdings of NBP bills permanently.

Another potential consequence of the introduction of the bank levy is a decrease in the propensity of its payers to lend or borrow funds on the interbank market. As mentioned above, the adjustment could also take place through prices (i.e. be reflected in elevated rates on funds lent and lowered rates on funds borrowed by the payers). Similarly as in case of monetary policy instruments, this should concern transactions with a maturity covering the last day of the month.

The effects of the bank levy could also be experienced by households and non-financial corporations. Deposit rates could decrease, while loan rates could increase. Banks could also limit loan volumes.

Banks themselves could experience a decrease in profitability and – as a result – a decrease in capital ratios. However, this depends on the effectiveness of the above-mentioned actions towards compensating the impact of the bank levy on their financial results (i.e. a change in the structure or in the level of the balance sheet, higher rates on some assets and lower rates on some liabilities). These actions could also include an increase in risk-taking.

The aim of this study is to identify the consequences of a bank levy, as introduced in Poland. (It is not to establish the net effect of the levy, however.) I analyse the effects on areas which appear to be relevant from the perspective of a central bank: monetary policy operations, the money market, deposit rates, loan rates and volumes, bank profitability, capital and risk-taking. The study is the first to analyse the impact of a bank levy on the use of monetary policy instruments. Furthermore,

the study appears to be the first to research into its effects on money market rates and volumes using the difference-in-differences (DID) method (applying it to previously unutilised transactional data from the payment system). The DID method is also used in the rest of the study and is applied to bank level panel data from various publicly unavailable sources. The impact of the bank levy in Poland on bank profitability has been previously studied only using the DID method with another country as a control group. The effect on capital ratios appears not to have been studied for Poland. The impact on bank risk-taking in Poland has been studied only using the composition of loans as a measure of risk.

I find that the introduction of the bank levy has affected demand for NBP bills on main open market operations, money market rates and volumes, and deposit and loan rates, for deposits from non-financial corporations and loans for house purchases. However, I find little evidence of its impact on loan volumes (except perhaps for loans for house purchases), bank profitability, capital and risk-taking (when measured by a mean risk weight, adjusted for Treasury securities). This means that the bank levy has had important implications for monetary policy implementation, interest rate benchmark reform and monetary conditions, but (as yet) less so for financial stability. As an extension of the study I document effects on assets and Treasury bond holdings (including their changes at the end of the month), and estimate the impact of bank balance sheet adjustments on government revenues.

The rest of the article is structured as follows. In the second section I review related empirical literature. The third section describes research design. In the next three sections there are results, diagnostic tests and additional sensitivity analysis and extensions. The last section concludes.

2 Review of empirical literature

The study is related mainly to three groups of articles. The first one attempts to identify the effects of bank levies, either in a single country or in a panel of economies. Starting with studies focusing on Poland, Hryckiewicz et al. (2018) found that after the introduction of the bank levy the volume (and the number) of interbank market transactions with a maturity covering the end of the month has decreased. Furthermore, the dispersion of rate quotes (between banks in respective days) has increased for maturities between ON and 2 weeks when covering the month-end, and decreased for maturities of 1 month and longer. A general decrease in the volatility of 1-month and longer rate quotes has also been observed. Puławska (2020b) found a decrease in 1-month and an increase in 3-month interbank market lending (relative to assets) and lower interest income on interbank loans, controlling for an interbank market rate. She also identified a general increase in the dispersion of rate quotes for shorter maturities (i.e. ON and tomorrow/next) and a decrease for longer ones (i.e. 1-month and 3-month). Additionally, an increase in the volume of Treasury securities (relative to assets) was found.

Compared to those two studies, this one uses both the difference between periods before and after the introduction of the bank levy, and between the payers of the bank levy and remaining banks to identify the causal effect (as opposed to using only the former difference). Also, different data sets are used. As far as models for volumes are concerned, Hryckiewicz et al. (2018) employed the Money Market Monitoring System data and Puławska (2020b) – data from ORBIS Bank Focus. For rates, both studies used WIBOR (Warsaw interbank offered rate) quotes. In contrast, this study employs previously unutilised transactional data from the payment system, both on volumes and rates.

Borsuk et al. (2020) focused on the impact of the bank levy on loan rates and volumes. They found a positive impact on loan rates and a negative impact on loan volumes, both driven by loans for house purchases. They also identified a relative increase in the share of more risky loans for consumption (passively – by lower growth in loans for house purchases) and interpret it as a sign of increased risk-taking.

The main difference between that study and this one is that I explicitly control for systematic differences between banks fulfilling the conditions of being the payers of the bank levy and remaining banks, avoiding the use of 'bad controls' at the same time. This matters because before the introduction of the bank levy the treatment status of respective banks (i.e. counterfactual payer vs non-payer) has been changing, so the differences are not fully reflected in bank fixed effects (as they would be in a standard case). Some control variables could serve as a proxy for the pre-bank levy status (for example, assets or a measure of profitability, used by Borsuk et al., 2020), but – being potentially affected by the bank levy themselves – they make 'bad controls'

(see Angrist and Pischke, 2009). The simple way this issue is handled in this study – by the 'treated' dummy, as described in the next section – also allows to test for common trends.[1] Other differences include the use of period fixed effects in this study, but not in Borsuk et al. (2020). It is to absorb any variability resulting from factors affecting both the payers of the bank levy and remaining banks which are not directly controlled, especially occurring around the introduction of the levy (as increased contributions for the Bank Guarantee Fund).[2]

The impact on loan rates was also studied by Ceponis et al. (2021), and on loan volumes (as well as on ROA, the value of assets and the number of employees) by Jarno and Kołodziejczyk (2018). The first study found a statistically significant, positive effect, the second one found no statistically significant effects. Both studies applied the DID method, using Czechia as a control group. An impact on loan rates was also found in Chmielewski et al. (2018) in the case of loans for non-financial corporations. Furthermore, they identified an impact on deposit rates. They used aggregate data.

Witkowski (2017) found no negative effect of the introduction of the bank levy on bank stock prices. Borowski et al. (2016) simulated the potential impact of the bank levy on loan volumes *ex ante*, assuming a 70-percent pass-through from increased costs to financial results and capital. A narrative analysis of the effects of the bank levy in Poland can be found in Graca (2020), Łupińska (2018), Martysz and Bartlewski (2018) and Muszyński (2017).

Moving on to international experiences (bearing in mind the differences in design), Capelle-Blancard and Havrylchyk (2017) conducted research into the effects of the bank levy in Hungary. They found a positive impact on net interest and fee margins, as well as on rates on outstanding (but not new) loans for house purchases. According to the results of Buch et al. (2016), the introduction of the bank levy in Germany has affected loan volumes (negatively) and deposit rates (positively), but only in the case of banks affected by the levy the most. Also for Germany, Haskamp (2018) identified an increase in loan rates – not only in case of the payers of the bank levy, but also for their competitors not covered by the levy. They also found a negative impact on loan volumes, partially compensated by higher loans of the competitors. Puławska (2020a, 2021) identified a negative effect of bank levies in Hungary and Germany on bank profitability, but only in Germany on loan volumes. In Hungary banks were found to engage in tax avoidance. Also in Hungary, an increase in bank risk-taking could be observed as a response to the bank levy. In Germany – a decrease.

[1] A changing status *after* the introduction of the bank levy (and potentially as a response to the bank levy) is another issue. In this study it is handled, by using instrumental variables estimation (with the status from the month before the introduction of the levy as an instrument for the actual treatment status post-levy).

[2] Also, Borsuk et al. (2020) remove from the sample banks with assets below EUR 2 bn (an equivalent of more than PLN 8 bn), implying that their control group contains only the state-owned bank and banks under recovery proceedings, but not banks too small to pay the bank levy. I do not make such an adjustment.

For Australia, Chronopoulos et al. (2019) found a decrease in bank stock prices after the announcement of the introduction of the bank levy in 2017 (in contrast to the results of Witkowski, 2017, for Poland).

Kogler (2019) and Devereux et al. (2019) carried out an analysis on panel data for banks in Europe. The first study found an increase in lending and deposit rates, as well as in net interest margins in response to the introduction of the bank levy. In the second study, on the one hand, a decrease in bank leverage was found. On the other hand, bank risk-taking has increased.

The second, underresearched strand of related literature is composed of studies modelling the use of standard monetary policy instruments by banks. They include: Bindseil (2005), Bindseil et al. (2005) and Ewerhart et al. (2009).

The last group of articles to which this study contributes are studies on bank window dressing and its effects on the money market, including: Allen and Saunders (1992), Furfine (1999), Yang and Shaffer (2010), Vasileiou (2015), Hoag (2016), Behn et al. (2019) and Klee et al. (2019).

3 Research design

Method

This study attempts to identify the consequences of the bank levy in Poland by using the difference-in-differences method. A similar approach for this purpose has been used (explicitly or implicitly), for example, by Borsuk et al. (2020), Capelle-Blancard and Havrylchyk (2017), Buch et al. (2016), Haskamp (2018), Devereux et al. (2019), and Kogler (2019).

The use of propensity-score methods besides the DID – a potentially useful approach in the case of non-random assignment to the treatment or the control group – would entail at least two major problems. First, the relationship between the treatment status and some bank characteristics (i.e. the volume of assets net of capital and Treasury securities, ownership status, recovery proceedings status) is such that when trying to estimate the parameters of a binary choice model there would be a quasi-complete separation. This implies that the parameters could not be estimated. Therefore, the construction of meaningful propensity scores would be non-trivial. Second, some relevant bank characteristics could themselves be affected by the bank levy. Being used as control variables (indirectly or directly) they would be 'bad controls', whose use could make the identified causal effect biased (Angrist and Pischke, 2009).

The main challenge with the application of the DID method to this case appears to be with the fact that the treatment status of some banks has been changing – both before (in a counterfactual sense) and after the introduction of the bank levy (see Figure 1). I adjust for this in two ways. First, I identify the counterfactual treatment status of respective banks in each period before the introduction of the bank levy (besides doing so for remaining periods). I use it to construct a 'treated' dummy and employ it as one of the dependent variables in all models, even as bank fixed effects – which would be sufficient in the case of a constant treatment status – are used as well. This should absorb systematic differences between treated and control groups (arising, for example, from the different average size of banks within them). Second, as a part of a sensitivity analysis, I use the instrumental variable (IV) estimation, employing the treatment status from the month before the introduction of the bank levy as an instrument for the actual treatment status post-levy. The results of this part of the sensitivity analysis (i.e. the IV estimation) are presented in the section 'Additional sensitivity analysis and extensions'. Also, I carefully test for the presence of common trends and make adjustments in case of doubts about its presence (see section 'Diagnostic tests').

The equation of which parameters are estimated differs between groups of dependent (outcome) variables. For deposit and loan rates, loan volumes, return on assets[3],

[3]Return on assets was chosen as the measure of profitability instead of return on equity, as around

total capital ratio and mean risk weight it is the following:

$$y_{it} = \alpha_i + \mu_t + \gamma treated_{it} + \delta treatment_{it} treated_{it} + x'_{it}\beta + \varepsilon_{it},$$

where y is one of the dependent variables, *treated* is a dummy variable taking one in periods in which the given bank fulfils the conditions of being the payer of the bank levy (both before and after its introduction), *treatment* is a dummy variable taking one in periods after the introduction of the bank levy x is a set of control variables, α, μ, γ, δ and β are parameters, ε is an error term, and i and t are bank and period identifiers, respectively.

The focus will be on the estimate of δ, interpreted as the average treatment effect on the treated (ATET).

For demand for NBP bills, current accounts at NBP relative to required reserves, the use of the deposit facility and lending/borrowing in overnight interbank market transactions the equation had to be augmented and is the following:

$$\begin{aligned} y_{it} = {} & \alpha_i + \mu_t + \gamma treated_{it} + \zeta month\text{-}end_{it} treated_{it} + \delta treatment_{it} treated_{it} \\ & + \eta month\text{-}end_{it} treatment_{it} treated_{it} + x'_{it}\beta + \varepsilon_{it}, \end{aligned}$$

where *month-end* is a dummy variable taking one if the maturity of an operation/a transaction covers the last day of the month, and ζ and η are parameters. The meaning of the remaining variables, parameters and subscripts is as above.

The augmentation was due to a combination of two factors. The first one is the weekly (in the case of demand for NBP bills on main open market operations) or daily (in the case of most remaining variables) frequency of the data, as opposed to a monthly frequency in case of variables modelled using the previous equation. The second factor is the fact that the effects of the bank levy should concentrate at the end of the month (except perhaps for demand for NBP bills, as noted in the Introduction). Data on demand for NBP bills on fine-tuning operations are of an irregular frequency, with quasi-regular operations at maintenance period-ends and irregular operations at various stages of reserve maintenance periods (both temporarily discontinued in mid-2020).

Here, in the case of demand for NBP bills the parameters of interest are both δ and η, while for the remaining variables – η only.

As far as models for rates on overnight interbank market transactions are concerned, both sides of a transaction had to be taken into account, so the equation had to be

the introduction of the bank levy capital regulation was tightened (more for the treated than for the control group), potentially causing a level shift in the denominator of the latter measure. This could make the identified average treatment effect on the treated biased (overestimated) when using return on equity. Furthermore, data on equity are unavailable for branches of credit institutions, making the number of observations smaller.

expanded further:

$$
\begin{aligned}
y_{ijt} = {} & \alpha_{1,i} + \alpha_{2,j} + \mu_t + \gamma_1 \textit{treated-lender}_{ijt} + \zeta_1 \textit{month-end}_{ijt} \textit{treated-lender}_{ijt} \\
& + \delta_1 \textit{treatment}_{ijt} \textit{treated-lender}_{ijt} + \eta_1 \textit{month-end}_{ijt} \textit{treatment}_{ijt} \textit{treated-lender}_{ijt} \\
& + \gamma_2 \textit{treated-borrower}_{ijt} + \zeta_2 \textit{month-end}_{ijt} \textit{treated-borrower}_{ijt} \\
& + \delta_2 \textit{treatment}_{ijt} \textit{treated-borrower}_{ijt} + \eta_2 \textit{month-end}_{ijt} \textit{treatment}_{ijt} \textit{treated-borrower}_{ijt} \\
& + x'_{ijt}\beta + \varepsilon_{ijt},
\end{aligned}
$$

where i and j are lender and borrower identifiers, respectively. The meaning of remaining variables, parameters and subscripts remains as above.

The relevant ATET estimate on the lender side is η_1, while on the borrower side – η_2.

In one of the alternative specifications the separate lender and borrower fixed effects are replaced with joint lender-borrower fixed effects. Also, in some other alternative specifications (including for some other outcome variables) I restrict the data set to the last day of the month, which – to avoid strict collinearity – requires removing some terms. The latter is to test whether the results are not distorted by the use of period fixed effects in the environment of a very large number of periods.

Due to a relatively small number of observations (2324 transactions (552 covering the last day of the month), compared to 59001 transactions for the overnight money market), models for term interbank market prices and quantities were simplified. In the case of a model for term rates, compared to models for overnight rates, period fixed effects (i.e. the μ parameter) are not used. Instead, the set of controls was supplemented with some aggregate independent variables (see below). As far as models for quantities are concerned, volumes were replaced with the number of transactions. Furthermore, observations were summed over banks fulfilling the conditions of being the payers of the bank levy and the remaining banks (resulting in only two cross-sections) and over months. Transactions with a maturity not covering the end of the month were not counted. As a result, the equation could be made as simple as possible within the framework of the DID method:

$$
y_{it} = \alpha_i + \theta \textit{treatment}_{it} + \gamma \textit{treated}_{it} + \delta \textit{treatment}_{it} \textit{treated}_{it} + \varepsilon_{it},
$$

where θ is a parameter and the meaning of the remaining symbols is as before. The ATET estimate is δ.

Not only the core of equations, but also the set of controls differs between groups of dependent variables. In general, controls were chosen so that they are potentially significant for a given dependent variable and exogenous with respect to the introduction of the bank levy, at least in the short run. If they are potentially significant, but likely to be affected by the treatment (i.e. being 'bad controls'), they were not used in

baseline specifications – only in alternative ones, as a form of a sensitivity analysis.

In models for demand for NBP bills, current accounts at NBP relative to required reserves, the use of the deposit facility and lending/borrowing in overnight interbank market transactions the set of controls is composed of the net flow of funds due to:

- the sale/purchase of cash at NBP,
- retail payments (i.e. Elixir/Express Elixir orders) and
- wholesale payments (i.e. customer orders).

In the baseline model for overnight interbank rates no control variables are used. Controls applied in some alternative specifications are the following: the liquidity position of the lender and the borrower (measured as the sum of current accounts at NBP and the use of the deposit facility net of the use of the lombard facility and the volume of the transaction, relative to required reserves – potentially a 'bad control'), and the probability of lending and borrowing for respective sides of the transaction. The latter are used to mitigate the sample selection bias. Lending and borrowing probabilities are based on binary logit models, with the set of independent variables similar as in models for overnight interbank market volumes, but without period fixed effects and with some aggregate independent variables instead (see Online Appendix[4]). Such a set of regressors (in binary logit models) makes the estimates of lending and borrowing probabilities potential 'bad controls' as well.

In the baseline model for rates on deposits I also use no control variables. I apply another measure of liquidity (i.e. a ratio of liquid assets – Treasury securities and NBP bills – to liabilities, both unweighted) in some alternative specifications only, as a variable potentially affected by the bank levy.

As far as models for loan rates and volumes are concerned, the baseline set of control variables consists of:

- the share of impaired loans (for a given type of loans) and
- the minimum total capital ratio.[5]

In some alternative specifications I replace the minimum total capital ratio with a capital buffer (defined as the total capital ratio minus the minimum total capital ratio) and add the return on assets or the liquidity ratio – all potentially relevant for loan rates and volumes, but also potentially affected by the bank levy. In models for the return on assets, the total capital ratio and the mean risk weight, the control variables are similar, except for the fact that the return on assets could not be used as a control

[4]Available at: https://doi.org/10.6084/m9.figshare.17069876.

[5]I use the regulatory minimum total capital ratio. However, the use of the minimum total capital ratio allowing for a full dividend payout (set by the Financial Supervision Authority) does not change results.

in the model for itself and the capital buffer is not used in any specification for the total capital ratio.

In the model for term interbank rates, the main control variable is a 'WIMID' (Warsaw interbank mid) rate – the average of the WIBOR and the WIBID (Warsaw interbank bid) rate for a given maturity.[6] But the set of controls includes some other variables as well: month-end, quarter-end, year-end and maintenance period-end dummies, a treatment dummy and a month end-treatment interaction. (Note, period fixed effects are not used in this case.)

In some cases the set of control variables was supplemented with a lagged dependent variable, implicitly controlling for time-varying, explicitly uncontrolled factors. The models with and without the lagged dependent variable put a lower and an upper bound on the estimate of the ATET, respectively (Angrist and Pischke, 2009). Establishing which one is correct is non-trivial, as the autoregressive (AR) term tends to absorb some variability actually driven by factors explicitly controlled in the model, particularly when the persistence of the dependent variable is high. Therefore, the lagged dependent variable was used as a control only when the persistence of the dependent variable was moderate, or when the effect was expected to occur at the end of the month only (except for models for interbank rates, featured by discontinuities). That is, the lagged dependent variable was used in models for: current accounts at NBP relative to required reserves, the use of the deposit facility, lending/borrowing in overnight interbank market transactions, loan volumes and the return on assets. In the last two cases results from specifications without the AR term are presented as well.

As far as lags are concerned, in models for demand for NBP bills on main open market operations I use current values and the first lag of control variables, based on a search over up to 52 lags and the Schwarz criterion. In the remaining models of a frequency higher than monthly I use no lags for controls and the AR term of order 1 (if used at all). In monthly models control variables are used in lags from 1 to 12. No current values are used to avoid endogeneity. The AR term is of order 12 as well (again, if used at all). An exception is the minimum total capital ratio in models for the total capital ratio, of which only current values are used, as there appears to be a long-run relationship between the two.

I estimate the parameters of the models using the fixed effects estimator. Having a 'fixed N, large T' structure of the data, dynamic panel data estimators (including the

[6] Term WIBOR and WIBID rates could be affected by the introduction of the bank levy. However, the effect on their average is uncertain, with the levy theoretically affecting them symmetrically in opposite directions. In any case, an IV estimation with the reference rate (i.e. the main NBP rate) as an instrument for the WIMID rate does not change the results (see Online Appendix). (Neither does the replacement of the WIMID rate with the reference rate in an OLS (ordinary least squares)-based estimation.) The WIMID rate appears preferable, as it captures term-specific spreads, covering reference rate expectations and the term premium.

It should also be noted that only transactions with the following terms were included: tomorrow/next, 1-week, 2-weeks, 1-month, 3-months, 6-months and 1-year, so that their day of maturity could be estimated and a corresponding WIMID rate could be used.

Arellano-Bond estimator) appeared not to be the optimal solution. In models with a lagged dependent variable as one of the regressors the use of the fixed effects estimator results in a bias. However, taking into account a large number of observations in the time dimension and the use of the AR term only when its estimate is moderate (i.e. far from one), any bias should be limited. As mentioned, the IV estimation is also used for robustness.

The use of robust standard errors also did not appear as an obvious choice, as the estimated coefficient covariance matrix tended to be of a reduced rank. Therefore, uncorrected standard errors are reported. However, robust standard errors were tried in baseline models, with no qualitative effect on the results (see Online Appendix).

Data

I use data for Poland, mainly from several publicly unavailable sources. Data on the use of monetary policy instruments, the money market and control variables for these areas are from a base collecting the stocks of accounts of commercial banks at NBP (including their part imposed by the reserve requirement) and flows between them due to various types of orders, identified by their codes (i.e. the SORBNET2 database). These data appear not to have been used for a microeconometric analysis before. Remaining bank level panel data are from bank monetary and prudential reporting to NBP. Data on WIBOR and WIBID rates are from Refinitiv.

The SORBNET2 database covers commercial banks and those cooperative banks that maintain their reserves at NBP directly, not through an affiliating bank (among other types of entities, irrelevant from the point of view of the aim of the study). For each variable from the database, observations for bank-periods for which there were data on the reserve requirement were used, even if the latter was zero.

As far as data from monetary and prudential reporting are concerned, observations were used for bank-periods with non-zero loans. In the case of cooperative banks, only these reporting under monetary statistics directly were included in the sample. Observations for periods in which a given bank was under bankruptcy, liquidation or suspended were removed (as well for the first 12 months of activity of a given bank).

Data on deposit and loan rates are collected only for a panel of banks. Furthermore, data on the total capital ratio and its minimum levels are not reported by the branches of credit institutions. As the mean risk weight was estimated using data on the total capital ratio (as well as on capital, assets and off-balance sheet liabilities), it could not be calculated for the branches of credit institutions either. Hence, they (i.e. the branches of credit institutions) were not included in samples for models for the total capital ratio and the mean risk weight. Neither were they included in specifications with the minimum total capital ratio or the capital buffer as one of the control variables. However, alternative specifications without these controls were also used in each such

case and the results from them are presented. For periods in which data on capital were available only quarterly, they were interpolated using the same value for each month (in a given quarter).

Data from the SORBNET2 base are available from 10 June 2013. As far as monetary and prudential reporting is concerned, some variables could be constructed even starting in December 1996. The bottleneck is interest rate statistics (i.e. data on deposit and loan rates), starting in their current form in January 2004. Therefore, for consistency, January 2004 was taken as the starting point for all monthly data. At the beginning of the research process, data until September 2020 were available, making the end of the sample. In the case of the SORBNET2 data, the exact cut-off is 29 September – the last day of the reserve maintenance period.

Moving on to data transformations, loan volumes were log-differenced. In the first differences the following variables were used: the share of impaired loans, the minimum total capital ratio (except for models for the total capital ratio, where it was not transformed) and the liquidity ratio. The remaining variables were used in levels. For loan volume log-differences and the return on assets, 12-month moving averages were also tried in some specifications, of which results are reported.

Loan volumes were adjusted for exchange rate fluctuations, using bank-, period- and loan type-specific weights. Also, loan volumes, the return on assets and the share of impaired loans were seasonally adjusted using the STL decomposition (seasonal-trend decomposition using LOESS, locally estimated scatterplot smoothing), which allows for discontinuities. For this reason, to ensure seasonal adjustment of an adequate quality, banks with less than 36 observations were removed from the part of the study based on monthly data.

As the parameters of models were estimated using OLS-based methods, which are sensitive to outliers, it was attempted to limit their effects (i.e. the effects of outliers) by the use of winsorising. In the case of the log-differences of loan volumes, and the first differences of the share of impaired loans and the liquidity ratio the cut-off was set at the 2.5th and the 97.5th percentile. In the case of the total capital ratio, the mean risk weight and current accounts at NBP relative to required reserves winsorising was asymmetric, with observations above the 97.5th percentile replaced with the 97.5th percentile. In the case of the (daily) measure of a liquidity position, winsorising was focused on the upper tail in the case of the lender and on the lower tail in the case of the borrower. Other parameters of winsorising (in cases in which it was applied to a dependent variable) were tested as well – from replacing only 1% to as much as 10% of observations (see several alternative specifications in next section).

Mergers and acquisitions were treated differently in the part of the study based on monthly data and in its remaining parts, due to the different number of observations and the possibilities it leaves. In the first case, (as a baseline) a merger/acquisition adjustment was made only in the case of loan volumes. It was based on SARMA (seasonal

autoregressive moving average) models for their log-differences with merger/acquisition dummies, allowing for a level shift (but not for a shift in growth rates). The estimated effects of mergers/acquisitions, captured by the dummies, were removed. In the second case, banks after a merger or an acquisition were treated as different banks than pre-merger/acquisition. The second approach was also used in one alternative model for each variable with the monthly frequency, however. Under both approaches an additional adjustment was made. Namely, several pairs of banks which changed their form of activity from a domestic commercial bank to a branch of a credit institution under a different identifier were merged.

Finally, the process of the identification of the treatment status appears to be worth a more detailed description. Balance sheets components to estimate the tax base were taken from monetary/prudential reporting. Data for two minor components not mentioned in the Introduction – the value of assets bought from NBP and subsequently used as a collateral for the refinancing credit from the central bank, and the value of funds held in affiliating banks by cooperative banks associated with them – were not available. They were proxied by the minimum of NBP securities and the refinancing credit, and the deposits of monetary financial institutions (for affiliating banks only), respectively. The ownership status was from monetary/prudential reporting as well. As far as the recovery proceedings status is concerned, it is also disclosed under monetary/prudential reporting, but some discrepancies with publicly available information were found. Therefore, the data were cross-checked with an internal NBP database on the recovery proceedings status (based on information from the Financial Supervision Authority, available from 2008Q4) and public financial reports, and corrected if necessary.

It should be noted, however, that there could still be some discrepancies between balance sheet components reported to NBP and for the purpose of tax collection, occasionally resulting in an incorrect classification. Data on costs due to the bank levy have been collected under prudential reporting only since 2018, and only in a quarterly form, cumulatively from the beginning of the year. A comparison of the identified treatment status and the status implied from the tax costs data for 2018-2020 show an imperfect, but a very high accuracy of the former.

4 Results

Table 1 presents the results of models for demand for NBP bills on main (model 1) and fine-tuning (model 2) open market operations. The introduction of the bank levy has caused a decrease in demand for NBP bills of its payers on main open market operations. The decrease has not been limited to operations with a maturity covering the end of the month. On the contrary, it has been permanent (it has not been deeper at month-ends though).

The interpretation of this result is non-trivial, as it appears that the change in the behaviour of the payers of the bank levy has been associated with an at least partial change in the behaviour of the remaining banks in the opposite direction. This makes the average treatment effect on the treated overestimated. However, it can be corrected by estimating the parameters of a model with the 'treatment' variable and adding a parameter on it to the parameter on the 'treatment*treated' interaction. This yields an ATET estimate of PLN -1.55 bn instead of PLN -4.42 bn (see Online Appendix).

At first glance, a negative effect of the bank levy on demand for NBP bills can also be found in the case of fine-tuning open market operations. However, this result is driven by one entity – the bank with the largest purchases of NBP bills on fine-tuning operations on average. After its removal from the sample any effect disappears (see Online Appendix).

In table 2 the results of models for current accounts at NBP relative to required reserves are presented. Besides the baseline specification (model 1), there are four alternative ones (models 2-5). The first alternative specification uses only observations from the last day of the month. The remaining alternative specifications are to establish whether the results are not driven by the parameters of winsorising. The results unambiguously show that the introduction of the bank levy has caused a change in the reserve maintenance of its payers. At the end of the month their current accounts at NBP have been reduced by 25% of the required reserves after the introduction of the levy, according to the point estimate from the baseline specification. The results of model 3, in which only 1% of observations are winsorised, indicate an effect as large as 40%. However, with such a weak winsorising, an effect in the opposite direction for banks other than the payers of the bank levy arises. After correcting for this (as in the case of demand for NBP bills on main operations), the estimate decreases to 22%.

Table 3 presents the results of models for the use of the deposit facility. Similarly as in case of reserve maintenance, not only is there the baseline specification, but also an alternative one, using only observations from the last day of the month. Although the baseline model indicates a negative, statistically significant effect of the bank levy on the use of the deposit facility by its payers, a reduction in sample size to the most relevant periods – month-ends – leads to a decrease in statistical significance. Furthermore, in this case also (as in case of demand for NBP bills on fine-tuning

operations) any identified effect is driven by the largest entity (as far as the use of the deposit facility is concerned). After its removal the effect disappears (see Online Appendix).

Table 4 presents the results of models for rates on overnight interbank market transactions. As in previous models for daily data, one of the alternative specifications (i.e. used in model 2) focuses at month-ends. The next two look at the effects of the inclusion of additional control variables (potentially being 'bad controls', therefore omitted from the baseline model). The last alternative specification is to check whether baseline results are not affected by the way the bank fixed effects are introduced (by using joint lender-borrower fixed effects instead of separate fixed effects for the lender and the borrower). The results show that the introduction of the bank levy has caused an increase in rates on overnight interbank market transactions on the last day of the month in which the payer of the bank levy has been lending. However, the estimated effect is significantly smaller than the more than 13 percentage points needed to compensate the costs of the levy. The point estimate is between 0.06 and 0.09 percentage points, even controlling for lending/borrowing probabilities (this might be due to their 'bad control' property, however). A negative effect on rates on overnight interbank market transactions at month-ends in which the payer of the bank levy has been borrowing was found only in a single specification (i.e. used in model 2).

Moving on to quantities, table 5 presents the results of models for lending (models 1-2) and borrowing (models 3-4) in overnight interbank market transactions. Baseline specifications are used in models 1 and 3, while models 2 and 4 are for robustness, focusing on the last day of the month. The results can be summarised as implying a negative effect of the introduction of the bank levy on overnight interbank market volumes at month-ends. It has been driven by a lower propensity to accept deposits from other banks by the payers of the bank levy.

Tables 6-7 present the results of models for rates on term interbank market transactions and their number, respectively. As mentioned in the previous section, due to the small number of observations they were simplified compared to models for the overnight market. Also, given the constraints, no meaningful robustness checks appeared feasible. Therefore, these results need to be treated with caution. Interestingly, the results appear to be analogous to those for overnight transactions. That is, the bank levy has caused an increase in rates on term interbank market transactions with a maturity covering the last day of the month in which the payer of the bank levy has been lending. No statistically significant effect on the other side of transactions was found (a negative point estimate appears to be worth mentioning, however). The introduction of the bank levy has also contributed to a decline in the number of term transactions covering month-ends, mainly due to the lower propensity to accept deposits from other banks by the payers of the levy.

Tables 8-9 present the results of models for rates on deposits from households and non-financial corporations, respectively. Again, baseline models are supplemented with a sensitivity analysis. The latter is focused on whether the results are not distorted by small entities (defined as banks with the volume of loans below 1% of aggregate; model 2) or the omission of a measure of liquidity (model 3), and whether the treatment of mergers and acquisitions affects the impact of the levy identified by the models (model 4). In the case of rates on deposits from non-financial corporations, a negative, statistically significant and robust effect of the introduction of the bank levy was found. As far as rates on deposits from households are concerned, the results are less clear-cut. Each model gives a negative point estimate. However, they differ in terms of the degree of statistical significance. Also, it appears to be worth stressing already at this point that even the sign of the coefficient of interest ceases to be negative when using the instrumental variables estimation (see next section). Therefore, either there has been no effect of the bank levy on household deposit rates or there is an insufficient number of observations to identify it (as mentioned, interest rate statistics are reported only by a panel of banks).

In tables 10-13 the results of models for rates on loans are presented, respectively for loans: for consumption, for house purchases, to sole proprietors and to non-financial corporations. In this case, baseline models already contain control variables (i.e. impaired loans and minimum total capital ratio), and the sensitivity analysis is slightly extended. Besides the measure of liquidity (model 5), the return on assets and the capital buffer are tried as controls as well (model 4). Also, in one set of specifications (model 3) there is neither the minimum total capital ratio nor the capital buffer, so that observations for the branches of credit institutions (which, as mentioned, do not report capital) can be used. Only in the case of rates on loans for house purchases was a positive, statistically significant and relatively robust effect of the introduction of the bank levy found. The results of a single model (i.e. model 6) – treating banks after mergers/acquisitions as new entities – imply no effect of the levy. However, this might be a consequence of the relatively small number of observations related to this form of the treatment of mergers/acquisitions (divided units have a smaller number of observations in the time dimension each and banks with less than 36 observations were removed). At first glance, results for rates on loans to sole proprietors appear to be similar. However, this is the only case where (initially being intuitive) they change using a shortened sample to recover parallel trends before the treatment (see next section).

Tables 14-18 present the results of models for loan volumes (in log-differences): total, for consumption, for house purchases, to sole proprietors and to non-financial corporations, respectively. In this case the sensitivity analysis is further extended. Specifications used in models 6-7 test the role of the parameters of winsorising. In model 8 there is no autoregressive term. In model 9, besides no AR term, the dependent

variable is in a 12-month moving average of log-differences (being similar to the annual growth rate, but with attenuated outliers in monthly growth rates). As far as models for total loan volumes are concerned, an effect was detected only in one of them (i.e. model 9) and only at the 10% significance level. On the one hand, this could mean that in the data for the remaining models there is too much volatility to identify the causal effect. On the other hand, an increased persistence (due to the filtering, generating an annual 'base effect') could lead to spurious inference.

In the case of models for the components of total loans, a negative, statistically significant effect was found in two specifications (i.e. used in models 8-9) for loans for consumption and house purchases. The exclusion of the AR term appears to be the key. As mentioned in the previous section, models without the AR term make the upper bound of the estimates of the average treatment effect on the treated. But when the AR term is actually necessary to control for time-varying omitted variables, the lower bound (i.e. a model with the AR term) holds. In sum, the results do not rule out a negative effect of the introduction the bank levy on loans (particularly those for house purchases, as will be shown in next section), but – if any – they are by no means enough to be easily identified.

Table 19 presents the results of models for the return on assets. The sensitivity analysis is similar as in the case of models for loan volumes (except that, for obvious reasons, the return of assets could not be used as a control variable). Although there are models with a negative point estimate of the impact of the introduction of the bank levy on the return on assets, there are not many of them (i.e. 4 out of 10) and in no case is the parameter of interest statistically significant. This would be consistent with the finding that the payers of the bank levy have avoided some part of it (i.e. the levy) by shifting from NBP bills and window dressing their balance sheets at the end of the month (for more evidence see the section 'Additional sensitivity analysis and extensions'), and avoided the consequences of some other part by passing it onto their customers (as reflected in lower deposit rates and higher loan rates).

The last two groups of models, of which results are presented in tables 20-21, are for the total capital ratio and the mean risk weight, respectively. In this case the number of specifications under the sensitivity analysis is smaller, as there is no need for the AR term in baseline models and the variables are quite persistent, implying no need for moving averages. For the total capital ratio, both the statistical significance and the sign depend on the specification. Or, in other words, the results are not robust. As far as the mean risk weight is concerned, all models indicate a negative, statistically significant effect of the introduction of the bank levy. However, when Treasury securities are excluded from the formula for the mean risk weight no effect of the bank levy can be identified (see Online Appendix). So, the effect identified in models of which results are presented in table 20 appears to be due to the increased

holdings of Treasury securities. Except for this, there appears to be no effect of the levy on bank risk, as measured by the mean risk weight. However, an increased exposure to interest rate risk should be mentioned (see, for example, Narodowy Bank Polski, 2021).

5 Diagnostic tests

In order to establish whether the parallel trends assumption of the difference-in-differences method is fulfilled, three types of diagnostics were used.[7] First, the means (or medians, in the case of variables featured by outliers) of respective outcome variables over time for treatment and control groups were plotted, and visually checked. Second, a parallel-trends test was carried out. It is based on augmented models for respective outcome variables:

$$y_{it} = DID_{it} + \iota_{1,it} treated_{it}(pre\text{-}treatment_{it})t + \iota_{2,it} treated_{it} treatment_{it} t,$$

where DID is the right-hand side of equations described in the section 'Research design', *pre-treatment* is a dummy variable taking 1 before the introduction of the bank levy and ι is a parameter. The meaning of the remaining symbols is as before. The null hypothesis of the test is that the trends were parallel before the treatment – that is, ι_1 is zero. This could be verified using the t statistic. In the case of variables with frequencies below one month, the equation was adjusted to focus at month-ends (or both month-ends and the remaining periods in the case of models for demand for NBP bills).

The third type of diagnostics used was a Granger-type causality test. It is also based on adjusted models for respective outcome variables. Under the test the 'treatment' variable was replaced with a set of 'treatment*' dummy variables, taking one also for the year before the introduction of the bank levy and disaggregated into months (the same for interaction terms), so that:

$$treatment^*_{it} = \sum_{k=\tau-12}^{T} treatment^*_{k,it},$$

where (as mentioned) $treatment^*$ is a dummy variable taking one after the introduction of the bank levy and the year before, τ is the month of the introduction of the bank levy, T is the last month of the sample and k is a month identifier (with the meaning of the remaining symbols as before). The rest of the models remained unchanged. Under the test any 'effects' a year before the treatment were checked. If identified, they would most likely indicate a divergence in trends already shortly before the treatment. This is a form of the 'placebo test' (see, for example, Eggers et al., 2021). The null hypothesis of no anticipatory effects was verified using the Wald test of joint significance (and the F statistic), as in case of the parallel-trend test focusing at month-ends (or both month-ends and remaining periods) in the case of variables with higher frequencies.

[7] No diagnostics are provided for models for rates and volumes on the term interbank market, for similar reasons as those for which no sensitivity analysis was carried out (i.e. a small number of observations).

Figures 2-3 present means/medians of respective outcome variables for treatment and control groups. For some variables, at least for some periods they could not be published, as that could violate the public statistics law (due to an insufficient number of entities or excessive concentration). The data are presented only for variables for which at least 95% of observations could be published. The results of the parallel-trends test and the Granger-type causality test are presented in Table 22. Furthermore, in Figures 4-6 there are plots of the results of the Granger test (taking into account both the respective months the year before the introduction of the bank levy and (all) after the introduction of the bank levy).

The Granger test identified anticipatory effects only in the case of one variable and only at the 10% significance level (i.e. in the case of rates on overnight interbank market transactions, on the borrower side, where no causal effect was robustly identified). According to the results of the parallel-trends tests, the breach of this (i.e. the parallel-trends) assumption is most likely in the case of rates on: deposits from non-financial corporations and loans for consumption. However, the test statistic decreases to 1.22 (p-value: 0.22) and 0.15 (p-value: 0.88), respectively, when shortening the sample so that it starts in 2010/12 (i.e. after the withdrawal of the crisis-related 'confidence package' by NBP). At the same time, ATET estimates from baseline specifications (but shortened sample) keep their signs and statistical significance (-0.17, p-value: 0.00 and -2.84, p-value: 0.00, respectively).

A similar sensitivity analysis works for the volumes of loans for house purchases and rates on loans for non-financial corporations. Test statistics decrease to -0.21 (p-value: 0.83) and 1.02 (p-value: 0.31), the ATET estimates are -0.00 (p-value: 0.96) and -0.08 (p-value: 0.39), respectively (in the second case the same, counterintuitive sign, but a loss of statistical significance). In the model for the volume of loans for house purchases without the AR term on the shorter sample the ATET estimate goes down (compared to the full sample) to -0.25/100 (p-value: 0.08), which appears to be the best estimate of the upper bound for the causal effect in this case.

In the case of reserve maintenance, the no-parallel-trends result appears to be driven by observations for small-reserve (defined as <1% of aggregate) banks. After their removal, the test statistic decreases to 0.42 (p-value: 0.68) and the ATET estimate remains negative and statistically significant (-0.39, or -0.16 after the structure-change correction, p-value: 0.00).

A similar check does not work for demand for NBP bills on main operations. This might be due to omitted variables (for example, flows other than customer-driven, which are unlikely to be exogenous, though). However, visual inspection of the data (Figure 1) leaves little doubt about the presence of the causal effect.

Another case where parallel trends could be established using the shorter sample is the mean risk weight (the test statistic decreases to -1.29, with a p-value of 0.20, and the ATET estimate remains negative and statistically significant at any typical

level of significance). Furthermore, after excluding Treasury securities the test statistic decreases to 1.11 (p-value: 0.27), in a model using the full sample (but then the ATET estimate ceases to be significantly different from zero).

The only case where parallel trends could be recovered on the sample post-confidence package but the intuitive ATET estimate loses its significance is that of rates on loans to sole proprietors.

The final case that appears to require a comment is that of the volume of loans for consumption. Although the parallel-trends test does not detect the breach of this DID assumption (probably due to the inclusion of control variables and the autoregressive term in the baseline model), and neither does the Granger test indicate it, visual inspection of the data suggests a possible change in trends. So does the plot of the results of the Granger test – the point estimate of the treatment effect (or 'effect') is similar in the months for the year before and in the months after the introduction of the bank levy. The shortening of the sample keeps the ATET estimate for the baseline model insignificant (-0.00, p-value: 0.36), but leaves the problem with point estimates under the Granger test (its graphical representation) unchanged. For the model without the AR term on a shorter sample the estimate of the causal effect goes down in absolute terms (to -0.75/100), remains statistically significant (p-value: 0.00), but the doubts related to the anticipatory effects remain (see Online Appendix). Therefore, any effect on the introduction of the bank levy on the volume of loans for consumption should be deemphasised.

6 Additional sensitivity analysis and extensions

Instrumental variables estimation

Table 23 presents the results of models based on baseline specifications (limited to ATET estimates), but estimated using the IV method (instead of the OLS-based estimation). The treatment status from the month before the introduction of the bank levy was used as an instrument for the actual treatment status post-levy. The remaining variables were instrumented with themselves. The results differ qualitatively only in one case, in which evidence on any effect of the introduction of the bank levy has already been weak – that is, for rates on deposits from households. For the mean risk weight the ATET estimate keeps its sign, but loses statistical significance.

Impact on assets and the holdings of Treasury securities

The identification of the impact of the introduction of the bank levy on bank assets and their holdings of Treasury securities is not at the core of this study, but it could help to enrich the interpretation of some other results. On the first panel of Figure 7, the medians of the log-differences of assets over time for treated and control groups are plotted. On panel 2 there are also the means of the holdings of Treasury securities. The remaining two panels show a graphical representation of the results of a Granger-type test (as described in the previous section, but with no control variables).

The results show a one-off, statistically significant decrease in assets caused by the introduction of the bank levy, in the month of its introduction. Given the immediate nature of the response, it appears to be driven by instruments that could be liquidated in a very short term, as interbank market exposures. The ATET estimate for February 2016 is -0.03 (meaning a 3-percent decrease in assets).

For the holdings of Treasury securities an immediate effect of the levy is also apparent. The mean of ATET estimates for the period between February 2016 and September 2020 is PLN 7.2 bn. However, the trajectories were divergent already before the introduction of the bank levy (by PLN 2.9 bn on average), which makes this estimate unreliable. In any case, the increase in the holdings of Treasury securities of the payers of the bank levy after its introduction mirrors its effects on the holdings of NBP bills in the opposite direction. This implies that the payers have changed the form in which they hold their short-term liquidity.

Impact on window dressing (further)

The study showed a negative effect of the introduction of the bank levy on current accounts at NBP and interbank market deposits at month-ends (for the treated group). This means that the banks engage in window dressing in order to lower costs related to the bank levy. In the previous paragraph, the effect on the longer-term holdings of Treasury securities (mirroring an impact on the holdings of NBP bills) has been described. It appears to be interesting whether the payers of the bank levy have also been window dressing their Treasury security exposures at month-ends by carrying out either a series of outright transactions or buy-sell-back transactions, but documenting them in data reported for tax purposes as outrights (the purchase of Treasury securities before the month-end and sale after it). (Note, a buy-sell-back transaction documented in a standard way does not differ from a repo transaction and is not associated with a change of ownership of securities).

The Supreme Audit Office (2018) found little evidence of such behaviour. To further understand the adjustment mechanism of banks I check this using longer time series and the (simplified) difference-in-difference approach (in case the of the study of the Supreme Audit Office the method used has not been reported).

First, panel 1 of Figure 8 shows a net flow of funds due to KDPW (Krajowy Depozyt Papierów Wartościowych, the Central Securities Deposit of Poland) settlements between the payers of the bank levy and the remaining banks, 10 days around the last day of the month, before and after the introduction of the levy. Positive values indicate a net inflow towards the payers of the bank levy. These settlements (under SORBNET2 codes 641 and 643) are used for payments related to outright, repo and buy-sell-back transactions, among others things. After the introduction of the bank levy there was an increase in outflows of funds on the last day of the month and day before it, and an increase in inflows the day after it. This is consistent with the window dressing of Treasury securities exposures. However, this perspective does not say whether these were actually mainly transactions based on Treasuries, and – even if so – what kind of transactions (and therefore, whether they were actually lowering the cost of the levy).

To some extent this could be established using the KDPW data on the flows of securities due to outright, repo and buy-sell-back transactions, as presented on the remaining panels of Figure 8. Positive values indicate a net inflow of Treasury securities towards the payers of the bank levy. After the introduction of the bank levy, there was an increase in the inflows of Treasury securities starting two days before month-ends, and an increase in outflows until two days before the end of the month. There is a similar pattern for buy-sell backs, but limited to the last day of the month and the day after it. However, it is not clear how these transactions (i.e. buy-sell-backs) were reported for the purpose of tax collection. The pattern in repo transactions is not

the source of what can be observed in SORBNET2 data. Summing up, there is some evidence for window-dressing on Treasury securities, but its exact scale could not be established.

Impact of bank balance sheets adjustments on government revenues

Using the ATET estimates and the number of banks in the treatment group (characteristic for respective groups of variables), the effect of bank balance sheet adjustments on government revenues could be estimated. The shift of the payers of the bank levy from holding short-term liquidity in the form of NBP bills towards Treasury securities has resulted in revenues being lower by PLN 0.011 bn a month, or by PLN 0.627 bn for the period from the introduction of the bank levy to the end of the sample (i.e. from February 2016 to September 2020). The window dressing of balance sheets at month-ends has brought another PLN 0.005 bn a month and PLN 0.290 bn cumulatively.

7 Conclusion

The study showed that the introduction of the bank levy has caused a lasting decrease in demand for NBP bills of its payers on main open market operations. At the end of the month it has also contributed to a decrease in the current accounts at NBP of banks being the payers of the levy and their lower propensity to accept deposits on the money market. Also at month-ends, the bank levy has raised rates on the money market in transactions in which the payer of the levy has been lending. Furthermore, the introduction of the bank levy has caused a decrease in rates on deposits from non-financial corporations.

The study has also shown a possible positive effect of the bank levy on rates on loans for house purchases (meaning: an effect towards higher rates). However, no unambiguous evidence on the impact of the introduction of the levy on loan volumes (with some support for an effect on the volume of loans for house purchases), bank profitability, their capital position or risk-taking has been found. A one-off decrease in assets, an increase in the holdings of Treasury securities and the window dressing of Treasury securities exposures at month-ends was also documented.

The results have important implications. Starting with the area of monetary policy implementation, the bank levy has significantly changed the structure of demand for NBP bills on main open market operations. Aggregate effects were not the subject of the study. However, a decrease in the propensity of banks being the payers of the bank levy to hold short-term liquidity in the form of NBP bills makes adjustments to some payment shocks (i.e. an inflow of customer funds in their direction) difficult. This appears to have been reflected in recurring underbidding.

Furthermore, the desire to hold reduced current accounts at NBP by the payers of the bank levy on the last day of the month implies their steeper path within reserve maintenance periods. This is because lower current accounts at month-ends have to be compensated with their higher levels for the rest of the reserve maintenance periods (which, in turn, is a consequence of the fact that banks have to hold the required level of reserves on average, not necessarily each day). This could make an efficient implementation of monetary policy more challenging (with higher initial current accounts potentially resulting in lower rates, and lower current accounts afterwards – in increased vulnerability to payment shocks, in case of negative outcomes reflected in higher rates).

Another consequence of the bank levy from this angle is the difficulty in establishing whether the operating target of monetary policy (i.e. the POLONIA rate being close to the reference rate) is fulfilled on the last day of the month. The volume of overnight transactions on the money market is then subdued, and rates on transactions distorted.

The same (i.e. a subdued volume of transactions and distorted rates on them) concerns term transactions with maturities covering month-ends. A negative impact

of the introduction of the bank levy is not supportive for the reform of interest rate benchmarks related to the BMR regulation.

Moving on to the implications from the perspective of monetary conditions, on the one hand, the bank levy has loosened them, lowering deposit rates. On the other hand, the levy has contributed to the tightening of monetary conditions by raising rates on loans for house purchases.

It should be noted that although the consequences of the bank levy for bank profitability and other variables important from the perspective of financial stability have not showed up in the analysed sample, it does not mean that this will remain so in the longer period (especially in case of an adverse shock). With lower interest rates (as in much of 2020 and 2021), banks being the payers of the bank levy have smaller room to compensate for higher costs resulting from the tax with lower deposit rates. Therefore, the effects of the bank levy appear to require further monitoring.

From the perspective of the Treasury, according to back-of-the-envelope calculations, the decrease in NBP bills holdings (using Treasury securities to hold short-term liquidity instead) and the window dressing have lowered government revenues by an estimated PLN 0.917 bn in the analysed period. It appears that using the monthly average of balance sheets (instead of values at month-ends) as the tax base could limit window-dressing, but this would have a limited effect on revenues. At the same time, the effect on the money market is uncertain. Activity at month-ends could either go back or disappear altogether. From the perspective of monetary policy implementation and interest rate benchmark reform, exempting monetary policy instruments and interbank exposures would be a safer solution. On the other hand, banks could pass this onto deposit and loan rates.

In the future it could be useful to extend related research in three areas. First, any spillovers from the response of the payers of the bank levy to remaining banks could make the effects estimated using the difference-in-differences method biased. It appears worth trying to identify them and – if detected – correct for spillovers. Second, the estimated effects on rates on deposits and loans in this study are based on data from a panel of banks. Using data from profit and loss accounts and balance sheets, they could be estimated for the whole population, potentially improving the quality of estimates. Third, the effects in other areas – interest rates on transactions secured with Treasury securities, Treasury debt management (including the effects on rates on Treasury securities) and last but not least, fiscal policy (the redistribution of income between agents with likely different expenditure propensities) – could be interesting as well.

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Appendix

Table 1: Estimation output, models for demand for NBP bills on open market operations

Operations	(1) Main	(2) Fine-tuning
C	2.32	0.53
	(0.09)***	(0.06)***
Treated	2.99	0.33
	(0.18)***	(0.12)***
Month end*treated	-0.13	-0.18
	(0.25)	(0.14)
Treatment*treated	-4.42	-0.43
	(0.17)***	(0.11)***
Month end*treatment*treated	-0.14	0.12
	(0.31)	(0.18)
Sale/purchase of cash	0.09	0.13
	(0.29)	(0.22)
Retail payments	0.49	0.04
	(0.09)***	(0.05)
Wholesale payments	0.43	0.18
	(0.03)***	(0.01)***
Observations	13776	3332
R-squared	0.65	0.58

*** p<0.01, ** p<0.05, * p<0.1

Table 2: Estimation output, models for current accounts at NBP relative to required reserves

	(1)	(2)	(3)	(4)	(5)
C	0.48	1.22	0.25	0.58	0.48
	(0.00)***	(0.02)***	(0.01)***	(0.00)***	(0.00)***
Treated	0.03		0.03	0.01	0.03
	(0.01)***		(0.02)	(0.01)*	(0.01)***
Month end*treated	0.01	0.06	0.05	0.01	0.01
	(0.03)	(0.06)	(0.05)	(0.02)	(0.03)
Treatment*treated	-0.01		-0.03	0.00	-0.01
	(0.01)		(0.02)**	(0.01)	(0.01)
Month end*treatment*treated	-0.25	-0.29	-0.40	-0.23	-0.24
	(0.03)***	(0.05)***	(0.06)***	(0.02)***	(0.03)***
Sale/purchase of cash	0.24	-0.04	0.47	0.20	0.24
	(0.05)***	(0.37)	(0.09)***	(0.04)***	(0.05)***
Retail payments	0.19	0.25	0.24	0.17	0.19
	(0.01)***	(0.12)**	(0.02)***	(0.01)***	(0.01)***
Wholesale payments	0.13	0.10	0.20	0.10	0.13
	(0.00)***	(0.02)***	(0.01)***	(0.00)***	(0.00)***
AR(1)	0.57		0.81	0.46	0.57
	(0.00)***		(0.00)***	(0.00)***	(0.00)***
Observations	96912	4583	96912	96912	96912
R-squared	0.54	0.37	0.76	0.41	0.54
Periods	All	Month end	All	All	All
Winsorizing	Upper	Upper	Upper	Upper	0.05
	0.025	0.025	0.005	0.05	

*** p<0.01, ** p<0.05, * p<0.1

Table 3: Estimation output, models for use of deposit facility

	(1)	(2)
C	0.01	0.06
	(0.00)***	(0.02)***
Treated	-0.00	
	(0.00)	
Month end*treated	0.00	0.04
	(0.01)	(0.04)
Treatment*treated	0.00	
	(0.00)	
Month end*treatment*treated	-0.05	-0.06
	(0.02)***	(0.04)*
Sale/purchase of cash	0.04	-0.06
	(0.02)*	(0.23)
Retail payments	0.04	0.01
	(0.00)***	(0.07)
Wholesale payments	0.05	-0.03
	(0.00)***	(0.01)**
AR(1)	0.41	
	(0.00)***	
Observations	77391	3653
R-squared	0.25	0.13
Periods	All	Month end

*** p<0.01, ** p<0.05, * p<0.1

Table 4: Estimation output, models for rates on overnight interbank market transactions

	(1)	(2)	(3)	(4)	(5)
C	-0.06	-0.09	-0.07	-0.05	1.61
	(0.00)***	(0.02)***	(0.00)***	(0.00)***	(0.00)***
Treated lender	0.01		0.01	0.01	-0.01
	(0.00)***		(0.00)***	(0.00)***	(0.00)**
Month end*treated lender	-0.02	-0.03	-0.02	-0.02	-0.02
	(0.01)***	(0.02)	(0.01)**	(0.01)***	(0.01)***
Treatment*treated lender	-0.00		-0.00	-0.00	0.01
	(0.00)		(0.00)	(0.00)	(0.00)**
Month end*treatment*treated lender	0.07	0.09	0.06	0.07	0.06
	(0.01)***	(0.02)***	(0.01)***	(0.01)***	(0.01)***
Treated borrower	0.01		0.00	0.01	0.03
	(0.00)**		(0.00)*	(0.00)**	(0.00)***
Month end*treated borrower	-0.02	0.01	-0.02	-0.02	-0.02
	(0.01)***	(0.02)	(0.01)***	(0.01)***	(0.01)***
Treatment*treated borrower	-0.02		-0.02	-0.02	-0.02
	(0.00)***		(0.00)***	(0.00)***	(0.00)***
Month end*treatment*treated borrower	-0.01	-0.05	-0.00	-0.01	-0.01
	(0.01)	(0.02)***	(0.01)	(0.01)	(0.01)
(Current account+deposit-lombard+volume)/ required reserves lender			-0.00		
			(0.00)***		
(Current account+deposit-lombard-volume)/ required reserves borrower			-0.00		
			(0.00)		
Lending probability				-0.02	
				(0.00)***	
Borrowing probability				-0.01	
				(0.00)***	
Observations	59001	1768	54483	58929	56934
R-squared	0.28	0.33	0.26	0.29	0.97
Periods	All	Month end	All	All	All
Fixed effects	Three way	Three way	Three way	Three way	Two way

*** p<0.01, ** p<0.05, * p<0.1

Table 5: Estimation output, models for volumes of overnight interbank market transactions

	(1)	(2)	(3)	(4)
Dependent variable	ON lending	ON lending	ON borrowing	ON borrowing
C	0.05	0.06	0.05	0.04
	(0.00)***	(0.01)***	(0.00)***	(0.01)***
Treated	0.01		0.01	
	(0.00)**		(0.00)**	
Month end*treated	-0.03	0.00	-0.01	0.07
	(0.01)***	(0.01)	(0.01)	(0.01)***
Treatment*treated	-0.00		0.01	
	(0.00)		(0.00)**	
Month end*treatment*treated	-0.03	-0.02	-0.09	-0.10
	(0.01)**	(0.01)*	(0.01)***	(0.01)***
Sale/purchase of cash	0.07	-0.21	-0.07	-0.04
	(0.02)***	(0.07)***	(0.02)***	(0.07)
Retail payments	0.03	0.04	-0.05	-0.03
	(0.00)***	(0.02)**	(0.00)***	(0.02)
Wholesale payments	0.05	0.02	-0.03	-0.02
	(0.00)***	(0.00)***	(0.00)***	(0.00)***
AR(1)	0.41		0.43	
	(0.00)***		(0.00)***	
Observations	69779	3294	71062	3354
R-squared	0.43	0.41	0.54	0.35
Periods	All	Month end	All	Month end

*** p<0.01, ** p<0.05, * p<0.1

Table 6: Estimation output, models for rates on term interbank market transactions

	(1)
C	-0.01
	(0.02)
Month end	-0.03
	(0.02)
Treatment	0.01
	(0.02)
Month end*treatment	0.04
	(0.03)
Treated lender	-0.02
	(0.01)
Month end*treated lender	-0.00
	(0.01)
Treatment*treated lender	-0.01
	(0.02)
Month end*treatment*treated lender	0.06
	(0.02)**
Treated borrower	-0.01
	(0.02)
Month end*treated borrower	0.01
	(0.02)
Treatment*treated borrower	-0.01
	(0.02)
Month end*treatment*treated borrower	-0.05
	(0.03)
Maintenance period end	0.02
	(0.01)*
Quarter end	0.03
	(0.01)**
Year end	0.04
	(0.01)***
WIMID	1.00
	(0.01)***
Observations	2324
R-squared	0.97

*** p<0.01, ** p<0.05, * p<0.1

Table 7: Estimation output, models for number of term interbank market transactions

	(1)	(2)
Dependent variable	Term lending	Term borrowing
C	5.94	2.19
	(0.82)***	(0.91)**
Treatment	-4.87	-1.85
	(1.03)***	(1.15)
Treated	1.28	8.78
	(1.17)	(1.29)***
Treatment*treated	-1.08	-7.12
	(1.46)	(1.62)***
Observations	176	176
R-squared	0.25	0.35

*** p<0.01, ** p<0.05, * p<0.1

Table 8: Estimation output, models for rates on deposits from households

	(1)	(2)	(3)	(4)
C	2.97	2.93	2.95	3.12
	(0.03)***	(0.04)***	(0.03)***	(0.04)***
Treated	0.18	0.38	0.14	0.06
	(0.04)***	(0.05)***	(0.04)***	(0.06)
Treatment*treated	-0.11	-0.48	-0.11	-0.11
	(0.05)**	(0.09)***	(0.05)**	(0.05)*
Δ Liquidity			-0.05	
			(0.02)***	
Observations	3531	2832	3334	3286
R-squared	0.93	0.92	0.92	0.94
Size	All	Large	All	All
M&A adjustment	No	No	No	Yes

*** p<0.01, ** p<0.05, * p<0.1

Table 9: Estimation output, models for rates on deposits from non-financial corporations

	(1)	(2)	(3)	(4)
C	2.86	2.90	2.80	3.00
	(0.02)***	(0.04)***	(0.03)***	(0.03)***
Treated	0.15	0.28	0.14	-0.02
	(0.04)***	(0.05)***	(0.04)***	(0.04)
Treatment*treated	-0.46	-0.55	-0.46	-0.22
	(0.04)***	(0.08)***	(0.04)***	(0.05)***
Δ Liquidity			-0.04	
			(0.02)**	
Observations	3635	2793	3428	3390
R-squared	0.94	0.94	0.93	0.95
Size	All	Large	All	All
M&A adjustment	No	No	No	Yes

*** p<0.01, ** p<0.05, * p<0.1

Table 10: Estimation output, models for rates on loans for consumption

	(1)	(2)	(3)	(4)	(5)	(6)
C	16.88	17.65	16.85	16.57	16.85	18.71
	(0.22)***	(0.28)***	(0.21)***	(0.29)***	(0.22)***	(0.28)***
Treated	-0.67	-1.44	-0.67	-0.77	-0.67	-3.23
	(0.29)**	(0.35)***	(0.29)**	(0.29)***	(0.29)**	(0.40)***
Treatment*treated	-1.45	0.98	-1.46	-1.52	-1.38	-0.68
	(0.31)***	(0.57)*	(0.31)***	(0.31)***	(0.31)***	(0.38)*
Δ Impaired loans for consumption	0.58	0.75	0.58	1.06	0.52	-0.3
	(0.29)**	(0.33)**	(0.29)**	(0.3)***	(0.29)*	(0.3)
Δ Minimum total capital ratio	-0.78	-0.05			-0.9	3.21
	(1.59)	(1.72)			(1.59)	(1.54)**
Return on assets				10.05		
				(1.41)***		
Total capital ratio-				-0.1		
minimum total capital ratio				(0.04)***		
Δ Liquidity					0.26	
					(0.13)**	
Observations	3184	2603	3184	3184	3184	2778
R-squared	0.76	0.76	0.76	0.76	0.76	0.81
Size	All	Large	All	All	All	All
M&A adjustment	No	No	No	No	No	Yes

*** p<0.01, ** p<0.05, * p<0.1

Table 11: Estimation output, models for rates on loans for house purchases

	(1)	(2)	(3)	(4)	(5)	(6)
C	5.85	5.73	5.84	6.03	5.88	5.76
	(0.05)***	(0.06)***	(0.05)***	(0.07)***	(0.05)***	(0.06)***
Treated	0.36	0.39	0.36	0.38	0.35	0.71
	(0.07)***	(0.07)***	(0.07)***	(0.07)***	(0.07)***	(0.08)***
Treatment*treated	0.62	0.47	0.61	0.59	0.57	0.06
	(0.08)***	(0.12)***	(0.08)***	(0.08)***	(0.08)***	(0.10)
Δ Impaired loans for house purchases	0.48	0.33	0.49	0.49	0.48	0.36
	(0.11)***	(0.12)***	(0.11)***	(0.11)***	(0.11)***	(0.11)***
Δ Minimum total capital ratio	-0.39	-0.07			-0.39	-0.63
	(0.41)	(0.36)			(0.41)	(0.39)
Return on assets				-1.72		
				(0.42)***		
Total capital ratio-				-0.01		
minimum total capital ratio				(0.01)*		
Δ Liquidity					-0.21	
					(0.04)***	
Observations	3073	2471	3073	3073	3073	2679
R-squared	0.82	0.86	0.82	0.82	0.82	0.85
Size	All	Large	All	All	All	All
M&A adjustment	No	No	No	No	No	Yes

*** p<0.01, ** p<0.05, * p<0.1

Table 12: Estimation output, models for rates on loans to sole proprietors

	(1)	(2)	(3)	(4)	(5)	(6)
C	8.16	8.12	8.11	8.20	8.21	8.23
	(0.09)***	(0.11)***	(0.09)***	(0.10)***	(0.09)***	(0.12)***
Treated	-1.38	-1.31	-1.37	-1.37	-1.39	-1.30
	(0.12)***	(0.14)***	(0.12)***	(0.12)***	(0.12)***	(0.18)***
Treatment*treated	0.49	0.92	0.48	0.45	0.44	0.25
	(0.14)***	(0.26)***	(0.14)***	(0.14)***	(0.14)***	(0.16)
Δ Impaired loans to sole proprietors	0.4	0.37	0.4	0.39	0.45	0.4
	(0.08)***	(0.09)***	(0.08)***	(0.08)***	(0.08)***	(0.08)***
Δ Minimum total capital ratio	-1.54	-1.73			-1.51	-2.63
	(0.66)**	(0.71)**			(0.66)**	(0.67)***
Return on assets				1.9		
				(0.64)***		
Total capital ratio-				-0.05		
minimum total capital ratio				(0.01)***		
Δ Liquidity					-0.42	
					(0.06)***	
Observations	3065	2542	3065	3065	3065	2698
R-squared	0.71	0.69	0.71	0.71	0.71	0.75
Size	All	Large	All	All	All	All
M&A adjustment	No	No	No	No	No	Yes

*** p<0.01, ** p<0.05, * p<0.1

Table 13: Estimation output, models for rates on loans to non-financial corporations

	(1)	(2)	(3)	(4)	(5)	(6)
C	5.89	5.51	5.89	5.89	5.90	6.06
	(0.05)***	(0.07)***	(0.04)***	(0.06)***	(0.05)***	(0.06)***
Treated	-0.15	0.00	-0.14	-0.15	-0.14	-0.38
	(0.06)**	(0.09)	(0.06)**	(0.06)**	(0.06)**	(0.08)***
Treatment*treated	-0.38	-0.33	-0.38	-0.38	-0.39	-0.20
	(0.08)***	(0.15)**	(0.08)***	(0.08)***	(0.08)***	(0.10)**
Δ Impaired loans to non-financial	0.29	0.26	0.29	0.28	0.29	0.21
corporations	(0.05)***	(0.06)***	(0.05)***	(0.05)***	(0.05)***	(0.06)***
Δ Minimum total capital ratio	-0.11	-0.21			-0.09	-0.53
	(0.41)	(0.43)			(0.41)	(0.43)
Return on assets				0.17		
				(0.36)		
Total capital ratio-				-0		
minimum total capital ratio				(0.01)		
Δ Liquidity					-0.05	
					(0.03)	
Observations	3385	2660	3385	3385	3385	2987
R-squared	0.84	0.84	0.84	0.84	0.84	0.85
Size	All	Large	All	All	All	All
M&A adjustment	No	No	No	No	No	Yes

*** p<0.01, ** p<0.05, * p<0.1

Table 14: Estimation output, models for volumes of loans (log-differences)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
C	0.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.01	0.01	0.00
	(0.00)***	(0.00)	(0.00)**	(0.00)***	(0.00)***	(0.00)**	(0.00)***	(0.00)***	(0.00)***	(0.00)***
Treated	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)*	(0.00)*	(0.00)*	(0.00)***	(0.00)*	(0.00)**	(0.00)*	(0.00)***	(0.00)***	(0.00)**
Treatment*treated	-0.00	-0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)*	(0.00)	(0.00)
Δ Impaired loans	-0.01	-0	-0.01	-0	-0.01	-0.01	-0	-0.01	-0.01	-0.01
	(0)***	(0)***	(0)***	(0)*	(0)***	(0)***	(0)***	(0)***	(0)***	(0)***
Δ Minimum total capital ratio	-0.01	-0.01			-0.01	-0.01	-0.01	-0.05	-0.07	-0.02
	(0.01)	(0.01)			(0.01)	(0.01)	(0.01)	(0)***	(0.01)***	(0.01)**
Return on assets				0.01						
				(0)***						
Total capital ratio-				0						
minimum total capital ratio				(0)***						
Δ Liquidity					0					
					(0)					
AR	0.59	0.7	0.55	0.54	0.59	0.52	0.64			0.58
	(0.02)***	(0.02)***	(0.02)***	(0.02)***	(0.02)***	(0.02)***	(0.02)***			(0.02)***
Observations	8318	3694	10379	8319	8318	8318	8318	8326	8399	7828
R-squared	0.26	0.53	0.22	0.27	0.27	0.22	0.30	0.41	0.18	0.28
Size	All	Large	All	All	All	All	All	All	All	All
M&A adjustment	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	New unit
Winsorizing	0.05	0.05	0.05	0.05	0.05	0.01	0.1	0.05	0.05	0.05
Moving average	No	No	No	No	No	No	No	Yes	No	No

*** p<0.01, ** p<0.05, * p<0.1

Table 15: Estimation output, models for volumes of loans for consumption (log-differences)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
C	0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00
	(0.00)*	(0.00)	(0.00)	(0.00)	(0.00)*	(0.00)*	(0.00)**	(0.00)***	(0.00)***	(0.00)
Treated	0.00	0.00	-0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
	(0.00)	(0.00)***	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)***	(0.00)***	(0.00)
Treatment*treated	-0.00	-0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)***	(0.00)***	(0.00)
Δ Impaired loans for consumption	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.02	-0.02	-0.01
	(0)***	(0)***	(0)***	(0)***	(0)***	(0)***	(0)***	(0)***	(0)***	(0)***
Δ Minimum total capital ratio	-0	-0			-0	-0.02	-0	-0.04	-0.05	-0
	(0.01)	(0.01)			(0.01)	(0.01)	(0.01)	(0.01)***	(0.01)***	(0.01)
Return on assets				-0						
				(0)						
Total capital ratio-minimum total capital ratio				0						
				(0)*						
Δ Liquidity					0					
					(0)					
AR	0.75	0.7	0.73	0.75	0.76	0.61	0.78			0.68
	(0.02)***	(0.02)***	(0.02)***	(0.02)***	(0.02)***	(0.02)***	(0.01)***			(0.02)***
Observations	7268	3614	8331	7269	7268	7268	7268	7272	7309	6778
R-squared	0.43	0.50	0.40	0.43	0.43	0.24	0.50	0.37	0.23	0.42
Size	All	Large	All	All	All	All	All	All	All	All
M&A adjustment	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	New unit
Winsorizing	0.05	0.05	0.05	0.05	0.05	0.01	0.1	0.05	0.05	0.05
Moving average	No	No	No	No	No	No	No	Yes	No	No

*** p<0.01, ** p<0.05, * p<0.1

Table 16: Estimation output, models for volumes of loans for house purchases (log-differences)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00
	(0.00)***	(0.00)***	(0.00)***	(0.00)**	(0.00)***	(0.00)**	(0.00)***	(0.00)***	(0.00)***	(0.00)**
Treated	0.00	-0.00	0.00	0.00	0.00	0.00	-0.00	0.01	0.01	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)***	(0.00)***	(0.00)
Treatment*treated	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.01	-0.01	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)***	(0.00)***	(0.00)
Δ Impaired loans for house purchases	-0.01	0	-0.01	-0.01	-0.01	-0.01	-0.01	-0.1	-0.1	-0.01
	(0)***	(0)	(0)***	(0)***	(0)***	(0)**	(0)***	(0)***	(0)***	(0)***
Δ Minimum total capital ratio	-0.01	-0			-0.01	-0.02	-0.01	-0.06	-0.08	0
	(0.01)	(0)			(0.01)	(0.01)*	(0.01)	(0.01)***	(0.01)***	(0.01)
Return on assets				-0.01						
				(0)***						
Total capital ratio-minimum total capital ratio				0						
				(0)*						
Δ Liquidity					0					
					(0)					
AR	0.81	0.86	0.81	0.81	0.81	0.72	0.84			0.8
	(0.01)***	(0.01)***	(0.01)***	(0.01)***	(0.01)***	(0.02)***	(0.01)***			(0.01)***
Observations	6329	3669	6794	6330	6329	6329	6329	6333	6366	5824
R-squared	0.67	0.84	0.66	0.67	0.67	0.51	0.71	0.51	0.39	0.66
Size	All	Large	All	All	All	All	All	All	All	All
M&A adjustment	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	New unit
Winsorizing	0.05	0.05	0.05	0.05	0.05	0.01	0.1	0.05	0.05	0.05
Moving average	No	No	No	No	No	No	No	Yes	No	No

*** p<0.01, ** p<0.05, * p<0.1

Table 17: Estimation output, models for volumes of loans to sole proprietors (log-differences)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
C	0.00	0.00	-0.00	-0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)*	(0.00)	(0.00)	(0.00)	(0.00)***	(0.00)***	(0.00)
Treated	0.00	0.00	0.00	0.00	0.00	-0.00	0.00	0.01	0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)***	(0.00)**	(0.00)
Treatment*treated	-0.00	-0.00	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Δ Impaired loans to sole proprietors	-0	-0	-0	-0	-0	-0.01	-0	-0.02	-0.01	-0
	(0)*	(0)	(0)	(0)	(0)	(0)***	(0)*	(0)***	(0)***	(0)**
Δ Minimum total capital ratio	-0	-0.01			-0	-0	-0	-0.06	-0.05	-0.01
	(0.01)	(0.01)			(0.01)	(0.02)	(0.01)	(0.01)***	(0.01)***	(0.01)
Return on assets				0						
				(0.01)						
Total capital ratio-minimum total capital ratio				0						
				(0)***						
Δ Liquidity					-0					
					(0)					
AR	0.63	0.61	0.65	0.62	0.63	0.39	0.67			0.59
	(0.02)***	(0.03)***	(0.02)***	(0.02)***	(0.02)***	(0.03)***	(0.02)***			(0.02)***
Observations	7225	3469	7820	7226	7225	7225	7225	7228	7249	6741
R-squared	0.26	0.33	0.29	0.26	0.26	0.12	0.30	0.40	0.17	0.26
Size	All	Large	All	All	All	All	All	All	All	All
M&A adjustment	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	New unit
Winsorizing	0.05	0.05	0.05	0.05	0.05	0.01	0.1	0.05	0.05	0.05
Moving average	No	No	No	No	No	No	No	Yes	No	No

*** p<0.01, ** p<0.05, * p<0.1

Table 18: Estimation output, models for volumes of loans to non-financial corporations (log-differences)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
C	0.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.01	0.01	0.00
	(0.00)	(0.00)	(0.00)	(0.00)**	(0.00)*	(0.00)	(0.00)**	(0.00)***	(0.00)***	(0.00)*
Treated	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)*	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Treatment*treated	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)***	(0.00)**	(0.00)
Δ Impaired loans to non-financial corporations	-0.01	-0	-0.01	-0	-0.01	-0.01	-0	-0.01	-0.01	-0.01
	(0)***	(0)	(0)***	(0)***	(0)***	(0)***	(0)***	(0)***	(0)***	(0)***
Δ Minimum total capital ratio	-0	-0			-0	-0.01	-0	-0.03	-0.03	-0.01
	(0.01)	(0.01)			(0.01)	(0.02)	(0.01)	(0.01)***	(0.01)**	(0.01)
Return on assets				0.01						
				(0.01)						
Total capital ratio-minimum total capital ratio				0						
				(0)***						
Δ Liquidity					-0					
					(0)					
AR	0.43	0.38	0.37	0.36	0.43	0.35	0.46			0.43
	(0.03)***	(0.04)***	(0.03)***	(0.03)***	(0.03)***	(0.03)***	(0.03)***			(0.03)***
Observations	8078	3485	9798	8079	8078	8078	8078	8083	8127	7543
R-squared	0.15	0.17	0.13	0.16	0.15	0.13	0.16	0.37	0.12	0.16
Size	All	Large	All	All	All	All	All	All	All	All
M&A adjustment	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	New unit
Winsorizing	0.05	0.05	0.05	0.05	0.05	0.01	0.1	0.05	0.05	0.05
Moving average	No	No	No	No	No	No	No	Yes	No	No

*** p<0.01, ** p<0.05, * p<0.1

Table 19: Estimation output, models for return on assets

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
C	0.02	0.02	0.01	0.02	0.02	0.03	0.02	0.04	0.04	0.02
	(0.00)***	(0.01)***	(0.00)***	(0.00)***	(0.00)***	(0.00)***	(0.00)***	(0.00)***	(0.00)***	(0.00)***
Treated	-0.01	-0.00	-0.01	-0.01	-0.00	-0.00	-0.00	0.03	0.02	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)***	(0.01)***	(0.01)
Treatment*treated	-0.00	-0.00	0.01	0.00	0.00	0.00	0.00	-0.01	-0.00	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
Δ Impaired loans	-0	-0.01	-0.02	-0	-0	-0.03	-0	-0.06	-0.05	-0.01
	(0.01)	(0.01)	(0.01)**	(0.01)	(0.01)	(0.01)***	(0)	(0)***	(0.01)***	(0.01)
Δ Minimum total capital ratio	0.04	0.01			0.05	0.18	0.02	0.47	0.38	-0.01
	(0.03)	(0.03)			(0.03)	(0.05)***	(0.03)	(0.02)***	(0.04)***	(0.04)
Total capital ratio-				-0						
minimum total capital ratio				(0)						
Δ Liquidity					-0					
					(0)					
AR	0.7	0.71	0.73	0.71	0.7	0.42	0.72			0.64
	(0.02)***	(0.03)***	(0.01)***	(0.02)***	(0.02)***	(0.02)***	(0.02)***			(0.02)***
Observations	8422	3694	10608	8423	8419	8422	8422	8422	8422	7828
R-squared	0.42	0.46	0.39	0.42	0.42	0.29	0.43	0.59	0.29	0.41
Size	All	Large	All	All	All	All	All	All	All	All
M&A adjustment	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	New unit
Winsorizing	0.05	0.05	0.05	0.05	0.05	0.01	0.1	0.05	0.05	0.05
Moving average	No	No	No	No	No	No	No	Yes	No	No

*** p<0.01, ** p<0.05, * p<0.1

Table 20: Estimation output, models for total capital ratio

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C	11.91	10.44	13.74	11.99	16.31	11.42	12.01	14.36
	(1.02)***	(0.52)***	(1.01)***	(1.02)***	(1.94)***	(0.79)***	(1.01)***	(1.14)***
Treated	-2.98	1.64	-2.51	-2.96	-4.14	-2.46	-3.03	-2.81
	(0.29)***	(0.19)***	(0.29)***	(0.29)***	(0.56)***	(0.23)***	(0.29)***	(0.33)***
Treatment*treated	0.60	-2.59	0.81	0.62	-3.56	1.01	0.41	-0.75
	(0.39)	(0.29)***	(0.38)**	(0.39)	(0.73)***	(0.30)***	(0.38)	(0.46)
Minimum total capital ratio	0.81	0.35	0.68	0.80	0.52	0.78	0.81	0.57
	(0.11)***	(0.05)***	(0.11)***	(0.11)***	(0.21)**	(0.09)***	(0.11)***	(0.13)***
Δ Impaired loans	-2.41	-2.37	-3.3	-2.4	-1.2	-3.01	-2.24	-1.8
	(0.32)***	(0.28)***	(0.32)***	(0.32)***	(0.6)**	(0.25)***	(0.31)***	(0.32)***
Return on assets			-14.27					
			(0.89)***					
Δ Liquidity				-0.2				
				(0.14)				
Observations	8362	3691	8362	8359	8362	8362	8362	7769
R-squared	0.62	0.67	0.64	0.62	0.41	0.68	0.63	0.66
Size	All	Large	All	All	All	All	All	All
M&A adjustment	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based
Winsorizing	Upper 0.025	Upper 0.025	Upper 0.025	Upper 0.025	Upper 0.005	Upper 0.05	0.05	Upper 0.025

*** p<0.01, ** p<0.05, * p<0.1

Table 21: Estimation output, models for mean risk weight

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C	58.35	62.18	61.56	58.32	58.91	58.14	58.44	57.67
	(0.20)***	(0.31)***	(0.27)***	(0.20)***	(0.21)***	(0.19)***	(0.19)***	(0.20)***
Treated	-3.46	-3.60	-4.54	-3.43	-3.95	-3.34	-3.51	-2.41
	(0.39)***	(0.39)***	(0.38)***	(0.39)***	(0.42)***	(0.38)***	(0.38)***	(0.43)***
Treatment*treated	-1.92	-10.56	-1.76	-1.87	-2.91	-1.84	-1.65	-1.07
	(0.50)***	(0.60)***	(0.48)***	(0.50)***	(0.54)***	(0.49)***	(0.49)***	(0.57)*
Δ Impaired loans	5.89	8.7	5.31	5.93	6.08	5.73	5.68	5.23
	(0.43)***	(0.58)***	(0.44)***	(0.43)***	(0.46)***	(0.42)***	(0.42)***	(0.42)***
Δ Minimum total capital ratio	4.06	-2.07		5.13	2.66	4.2	5.23	-4.02
	(2.2)*	(2.13)		(2.27)**	(2.37)	(2.15)*	(2.15)**	(2.31)*
Return on assets			4.16					
			(1.24)***					
Total capital ratio-minimum total capital ratio			-0.33					
			(0.02)***					
Δ Liquidity				-0.43				
				(0.19)**				
Observations	8339	3691	8339	8338	8339	8339	8339	7769
R-squared	0.77	0.86	0.78	0.77	0.74	0.77	0.77	0.80
Size	All	Large	All	All	All	All	All	All
M&A adjustment	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based	Model-based
Winsorizing	Upper 0.025	Upper 0.025	Upper 0.025	Upper 0.025	Upper 0.005	Upper 0.05	0.05	Upper 0.025

*** p<0.01, ** p<0.05, * p<0.1

Table 22: Results of Parallel-trends and Granger causality tests

	Parallel-trends test (t-statistic)				Granger causality test (F-statistic)			
	Treatment* treated	Month end* treatment* treated	Month end* treatment* treated lender	Month end* treatment* treated borrower	Treatment* treated	Month end* treatment* treated	Month end* treatment* treated lender	Month end* treatment* treated borrower
Demand for NBP bills, main operations	2.07**	-0.38			0.69	0.11		
Demand for NBP bills, fine-tuning operations	0.28	1.48			0.42	NA		
Reserve maintenance		-2.12**				0.93		
Deposit facility		-0.6				0.29		
ON rate			1.06	-1.08			0.5	1.67*
ON lending		0.14				0.66		
ON borrowing		-0.09				1.32		
Interest rate on deposits from households	0.88				0.86			
Interest rate on deposits from non-financial corporations	-5.75***				0.49			
Interest rate on loans for consumption	9.95***				0.86			
Interest rate on loans for house purchases	0.69				0.43			
Interest rate on loans to sole proprietors	2.29**				0.35			
Interest rate on loans to non-financial corporations	-2.65***				0.55			
Volume of loans	-1.01				0.66			
Volume of loans for consumption	-0.53				0.43			
Volume of loans for house purchases	-2.09**				0.28			
Volume of loans to sole proprietors	-1.02				0.17			
Volume of loans to non-financial corporations	0.97				1.17			
Return on assets	-0.38				0.36			
Total capital ratio	-1.43				0.57			
Mean risk weight	2.42**				0.09			

*** p<0.01, ** p<0.05, * p<0.1

Table 23: Estimates of average treatment effect on the treated, instrumental variables estimation

	Treatment* treated		Month end* treatment* treated		Month end* treatment* treated lender		Month end* treatment* treated borrower	
Demand for NBP bills, main operations	-5.11	(0.26)***	-0.28	(0.38)				
Demand for NBP bills, fine-tuning operations	-0.47	(0.14)***	0.14	(0.22)				
Reserve maintenance			-0.19	(0.04)***				
Deposit facility			-0.07	(0.02)***				
ON rate					0.05	(0.01)***	-0.05	(0.01)***
ON lending			-0.03	(0.01)**				
ON borrowing			-0.10	(0.01)***				
Interest rate on deposits from households			0.17	(0.06)***				
Interest rate on deposits from non-financial corporations			-0.47	(0.05)***				
Interest rate on loans for consumption			-1.19	(0.37)***				
Interest rate on loans for house purchases			0.73	(0.09)***				
Interest rate on loans to sole proprietors			0.49	(0.18)***				
Interest rate on loans to non-financial corporations			-0.16	(0.10)*				
Volume of loans			-0.00	(0.00)				
Volume of loans for consumption			-0.00	(0.00)				
Volume of loans for house purchases			-0.00	(0.00)				
Volume of loans to sole proprietors			0.00	(0.00)				
Volume of loans to non-financial corporations			0.00	(0.00)				
Return on assets			-0.00	(0.01)				
Total capital ratio			-3.32	(0.46)***				
Mean risk weight			-0.94	(0.58)				

*** p<0.01, ** p<0.05, * p<0.1

Figure 1: Number of banks

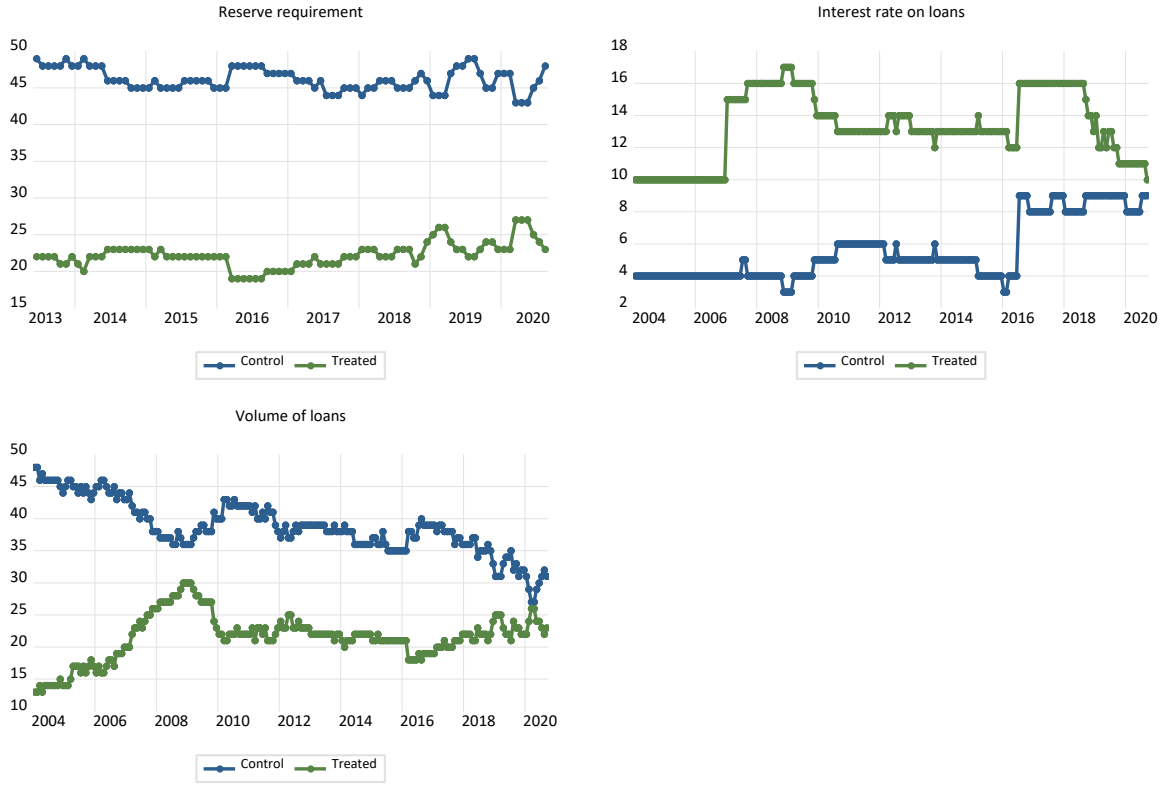


Figure 2: Graphical diagnostics for parallel trends 1

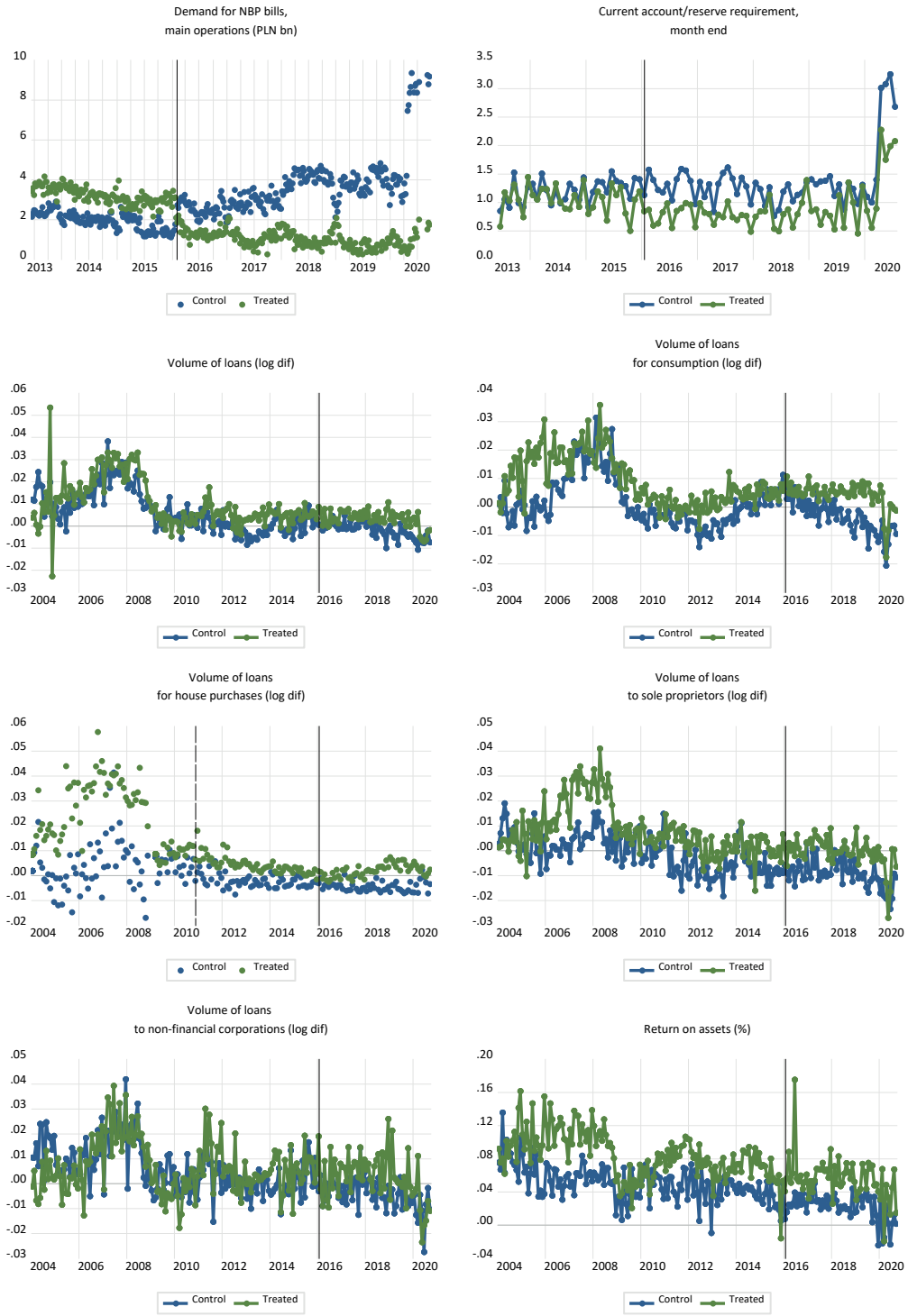


Figure 3: Graphical diagnostics for parallel trends 2

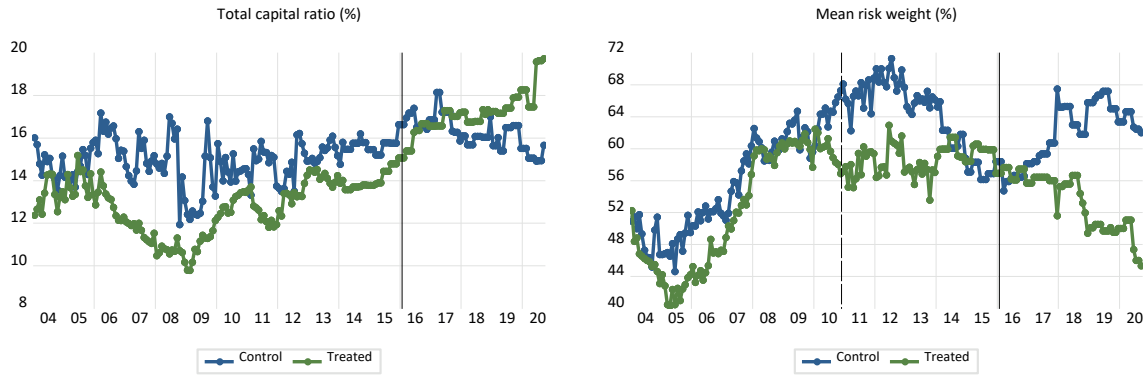


Figure 4: Graphical representation of Granger causality test results 1

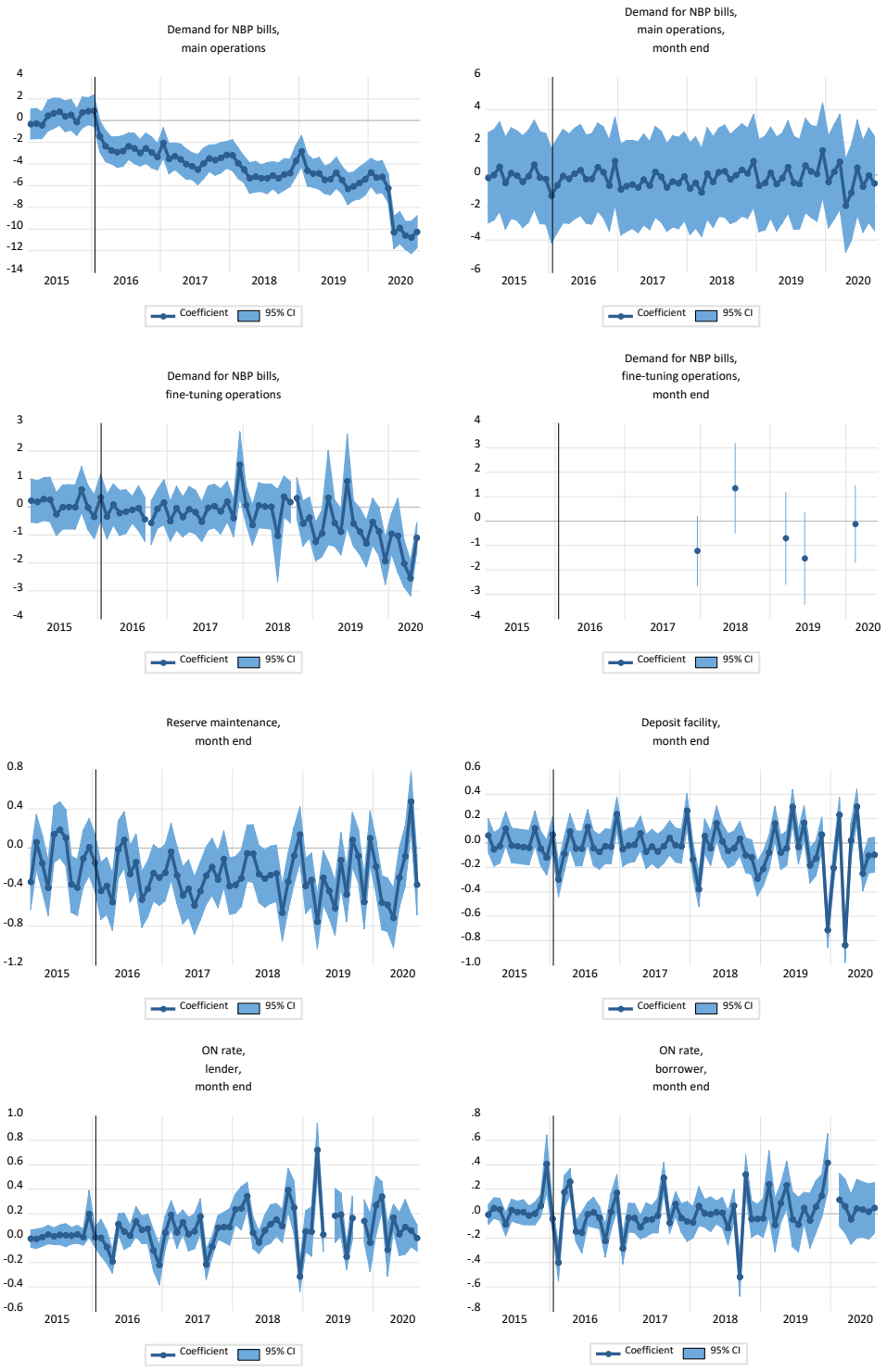


Figure 5: Graphical representation of Granger causality test results 2

Figure 6: Graphical representation of Granger causality test results 3

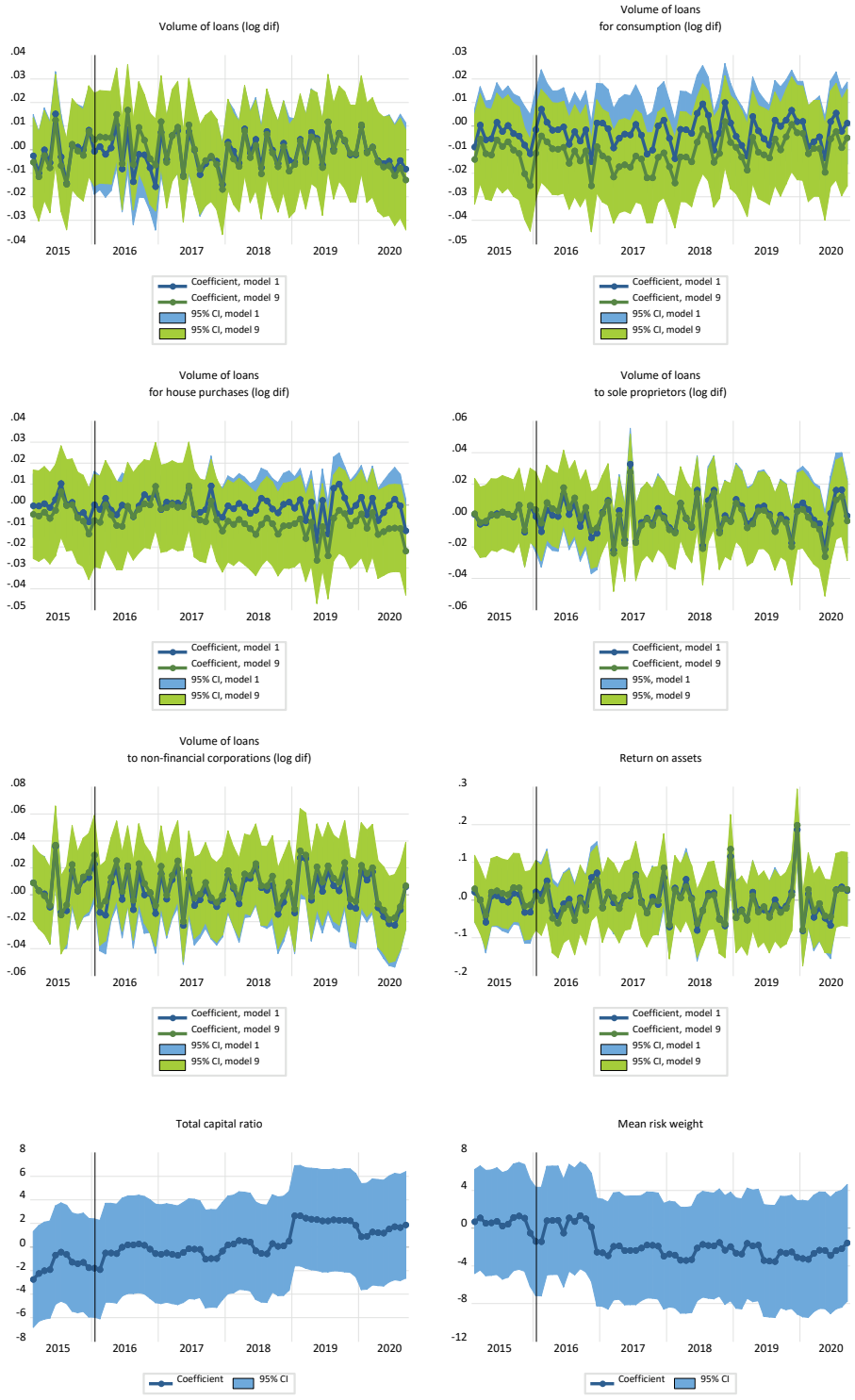


Figure 7: Data and graphical representation of Granger causality test results, assets and treasury securities

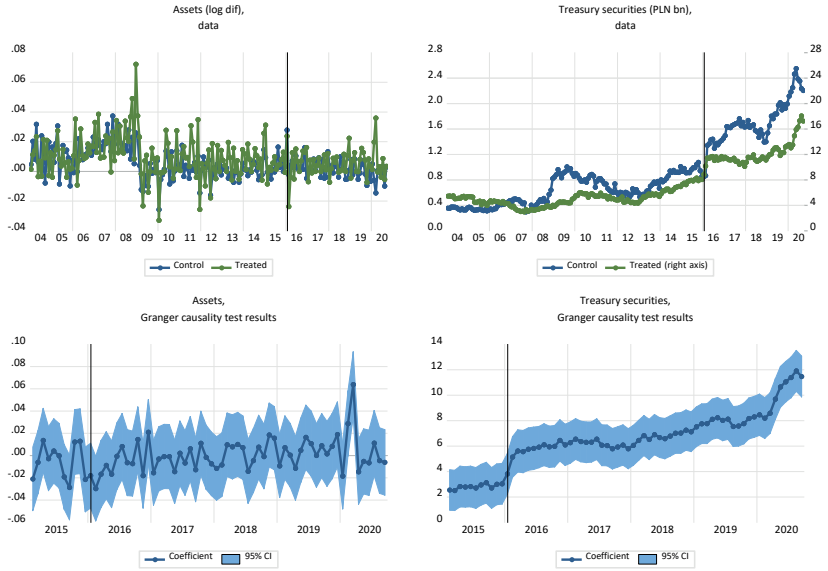
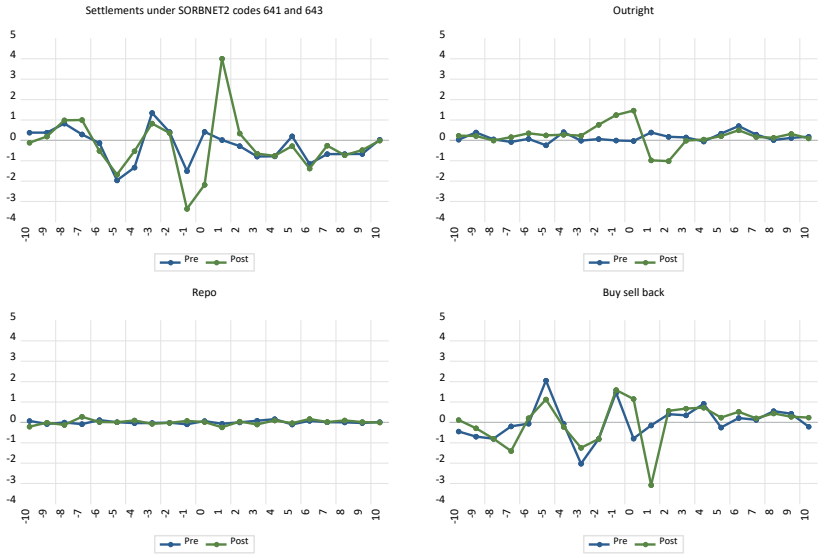


Figure 8: Window dressing in transactions on Treasury securities (PLN bn)



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