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Tomasz Chmielewski – Narodowy Bank Polski; tomasz.chmielewski@nbp.pl
Tomasz Łyziak – Narodowy Bank Polski; tomasz.lyziak@nbp.pl
Ewa Stanisławska – Narodowy Bank Polski; ewa.stanislawska@nbp.pl

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Contents

Abstract

The aim of this paper is to test whether the risk-taking channel of monetary policy transmission mechanism is active in Poland, an emerging market economy. Based on confidential bank-level data we construct novel measures of risk taken by banks. These measures do not require access to loan-level data, nor rely on data from surveys among credit officers. We find some evidence of the risk-taking behaviour of Polish banks, however, only in the segment of large loans to non-financial corporations we are able to conclude that increased risk of new loans represent supply-side phenomenon. We show that the loosening of monetary policy has different effects depending on the initial level of interest rates – the lower the interest rate is, the larger the increase in risk that is generated by the lowering of interest rate. This response is different across banks, with stronger reaction displayed by banks that are large, with low liquidity and with deposits being the most important funding source. Our results contribute to ongoing discussion on consequences of conducting monetary policy in the low interest rate environment as currently observed in many advanced and emerging economies.

JEL classifications: E44, E52, G21
Keywords: risk-taking channel, monetary policy, low interest rates

1 Introduction

Loosening of monetary policy typically makes banks grant more loans, as a result of the operation of the traditional interest rate and credit channels. As far as conventional view on the monetary transmission focuses on the quantity of loans, growing literature suggests that the risk profile of loans and the so-called risk-taking channel can be another significant dimension of the effects of monetary policy. The importance of this channel seems particularly large in the current environment of low interest rates, supplemented and supported in a number of economies with unconventional monetary policy measures. When banks perceive nominal interest rates on risk-free instruments, such as government bonds, as low and expect them to remain low for an extended period, they can be willing to search for yield (Rajan, 2006) and accept more risk for contractual or institutional reasons (Gambacorta, 2009; Borio and Zhu, 2012), increasing supply of loans more than it would result from the operation of conventional credit channel (Paligorova and Santos, 2017). Expectations that interest rates will remain low for a prolonged period – as signalled nowadays in communication by many central banks – constitute a crucial element activating the risk-taking channel. In such circumstances banks may not only offer an excessive amount of higher-risk loans, but also under-price these loans, not reflecting the real cost of risk (Paligorova and Santos, 2017).

Empirical research confirms the operation of the risk-taking channel, showing that low interest rates result either in a shift of lending towards more risky borrowers or in an increase in overall bank risk. In majority of those studies, analysis is conducted with the use of micro-data – either on the bank level or even for individual loan contracts. To measure the risk taken by banks different proxies are used. Many authors refer to survey data based on loan officer surveys (cf. Maddaloni and Peydró, 2011). A loosening of lending standards is interpreted as indicative of improved access to credit for low-quality borrowers. However, this assumption is dubious. As pointed out by Dell'Ariccia et al. (2017), typical lending surveys (e.g. the ECB's Bank Lending Survey, BLS or the Federal Reserve's SLOOS) provide information only about whether lending standards have changed relative to the recent past, not about the absolute level of strictness of lending criteria. Moreover, a decline in lending standards may reflect an improvement in the quality of the borrowers, not the increased willingness of banks to take more risk. Other studies testing the existence of the risk-taking channel use ex-post risk measures, such as non-performing loans, NPLs (Delis and Kouretas, 2011). The measures of this kind seem problematic due to the fact that they reflect ex-post realized risk, not the ex-ante risk taken by banks that is a key element in the risk-taking channel considerations. On the other hand, market-based risk measures (e.g. Expected Default Frequency, EDF – Gambacorta, 2009; Altunbas et al., 2014), although potentially forward-looking, reflect changes in total riskiness of banks (i.e. due to new lending and the change in risk of the pre-existing portfolio), making it cumbersome to isolate the effect of the current interest rate environment on the current risk-taking decisions of bank managers. Moreover, market-based measures rely on the validity of the efficient market hypothesis. If this assumption is not met, market-based measures might be biased due to waves of excessive optimism or pessimism in the financial markets.

As already mentioned, it is important to distinguish between the new risk taken by the bank (as a result of the current business decisions) and changes in the risk stemming from the legacy

loan portfolio (being a result of past decisions[1]). To construct a measure of new risk taken by banks some studies make use of confidential internal credit ratings of each loan (Ioannidou et al., 2008; Dell'Ariccia et al., 2017), credit spreads of individual loans (Delis et al., 2017) or other data based on credit registers, containing comprehensive bank-borrower level data on loan applications and outcomes (Jiménez et al., 2014). Such approaches, although potentially quite efficient, impose significant data requirements and therefore might not be feasible in some countries, including Poland, due to data constraints.

Although there is a considerable amount of evidence on the risk-taking channel in large advanced economies like US (e.g. Altunbas et al., 2014; Dell'Ariccia et al., 2017; Delis et al., 2017; Maddaloni and Peydró, 2011) or euro area (e.g. Altunbas et al., 2014; de Bondt et al., 2010), much less in known about small emerging economies that are structurally different than more advanced economies. We aim to fill this gap and to analyse the functioning of the risk-taking channel in the Polish banking sector. Since Poland joined the European Union in 2004, the economy experienced a significant financial deepening. Bank loans to non-financial sector in 2004 stood at approximately 25% of GDP, while in 2018 this ratio was more than 50%. On the top of that there was a sizeable shift in the composition of loan portfolio towards household loans. They constituted less than 50% of all loans to non-financial sector in 2004 vs. approximately 70% in 2018. In our empirical work we concentrate on the period since 2008, as the global financial crisis induced significant changes in bank behaviour as well as supervisory and regulatory approaches and practices. Another distinguishing feature of the Polish economy is that, in spite of historically low level of policy rate in recent years, Poland did not reach the lower bound as in the US or EU, which allowed the monetary policy authorities to avoid applying unconventional tools. Second novelty of this paper concerns the construction of the proxies for risk taken by banks that relies on confidential data from supervisory reporting that contains inter alia information on so-called "large exposures". In general, our proxies of risk take into account volumes of new loans granted to different NACE sections or business lines and precisely define ex-ante risks of those exposures. In terms of analytical set-up we propose a novel empirical specification for testing the existence of the risk taking channel – we explicitely test whether the bank reaction depends on the level of the interest rates by introducing terms that are non-linear with respect to the interest rate.

To our best knowledge our study is the first attempt to analyse the operation of the risk-taking channel in the Polish economy.[2] It should be mentioned that Kouretas et al. (2013) analyse the risk-taking channel in the panel of Central and Eastern European countries including Poland. Our paper is to certain degree related to Wróbel (2018) and Górajski et al. (2018). The former investigates the response of lending standards set by Polish banks to monetary policy shocks. The finding that lower monetary policy rate contributes to softening of lending standards is in line with operating of the risk-taking channel. The latter employs the same data of "large exposures" as we to construct conditional expected time to default, a credit risk

[1] In general, the risk of the pre-existing loan portfolio might be modified using securitisation or credit derivatives, but this concern can be addressed by treating such transactions as negative new lending.

[2] Some preliminary results on the risk-taking channel in Poland were presented in Chmielewski et al. (2018). The conclusions presented there differ to some extent from ours mainly due to the fact that in the present study the sample includes more observations from the period of short-term interest rate staying at its lowest level. In this paper we also use a more flexible econometric specification.

measure intended to inform about time of default of corporate loans under stress conditions. Based on this new measure the authors find that credit risk in the Polish banking sector is related to the GDP growth.

The paper is structured in the following way. Section 2 describes our motivation and way of thinking about the risk-taking channel. Section 3 presents data and methods applied in the study, with a particular focus on the construction of the measures of risks taken by banks. Section 4 presents the main results, while the final section concludes.

2 Stylised view on the risk-taking channel

The risk-taking channel implies that banks have incentives to increase the riskiness of their operations in response to prevailing low interest rate environment. The literature so far has offered neither a convincing theoretical model explaining this channel of monetary transmission, nor consensus about the economic processes behind this phenomenon. Two of them seem, however, the most important (Gambacorta, 2009). First, shareholders of banks and other financial institutions usually require managers of these entities to attain pre-set nominal rates of return, which tend to be relatively stable over time. Declining policy interest rates trigger a decrease in the rates of return on risk-free assets, therefore to attain the intended profits, agents seek riskier assets, ones that would generate higher yields. Second, a reduction of interest rates boosts the value of assets and collateral, resulting in lower assessment of default likelihood of potential borrowers and a fall of risk perceived by banks.

Our preferred economic story behind the risk-taking channel stresses the importance of incentives faced by bank senior managers (Fahlenbrach and Stulz, 2011). In particular, performance-based bonuses are a widespread phenomenon in the banking industry. However, inherent uncertainty related to future outcome of bank business activities imply that the "performance" is to a large extend a realisation from some stochastic process (therefore it is not fully a signal about an effort or competence). Therefore, given such randomness, a bank manager making some business decisions can only influence parameters of the process behind the random outcome. This randomness, however, is quite often neglected in contracts between shareholders and hired bank managers, resulting sometimes in adverse incentives for the latter.

Anecdotal evidence suggests that contracts between shareholders and bank managers quite often stipulate that a lump sum bonus payment is triggered if certain targets – set in terms of return on equity – are met (Cai et al., 2010). Such a framework incentivises the managers to achieve some profitability level within the constraints of bank equity (as the scope for risk-taking is limited by bank equity). Due to risk-return trade-off, a higher profitability target implies the necessity to increase the risk of bank operations. However, higher risk of bank operations implies a higher volatility of bank profits (DeYoung and Roland, 2001), affecting the probability of bank managers receiving a bonus payment. On the other hand, a low realisation of bank profits might imply reputational losses for the bank manager and a deterioration in prospects for future income. Therefore, the bank manager decision problem is to construct the bank risk profile in such a way that expected bonus payments are maximised. The net interest margin (NIM) constitutes an important part of banks' profit. In the low interest rate environment the NIM might be squeezed due to the zero lower bound for bank financing sources (Claessens et al., 2018) – i.e. with market interest rates going low, banks cannot further decrease interest rate costs for some instruments (e.g. non-financial sector deposits with interest rates already very close to 0), while interest income (e.g. for loans) is still decreasing.[3]

Bank business lines might have quite different NIM elasticities with respect to changes in the level

[3]Using a large sample of banks from 47 countries Claessens et al. (2018) find that a one percentage point interest rate drop implies an 8 basis points lower net interest margin, with this effect significantly larger (20 basis points) at low rates.

of interest rates. Since safer business lines (e.g. mortgage lending) tend to be associated with lower interest rate spreads (due to lower inherent credit risk) than more risky types of bank activity (e.g. consumer loans), the former ones are more vulnerable to profitability deterioration in the low interest rate environment. For a bank with relatively large importance of low-risk business lines, this could imply lower probability of bank managers receiving bonus payments. To restore previous level of expected bonus payments, bank management might be forced to allocate more resources to higher risk-higher return business lines, resulting in the type of behaviour summarised as the bank risk-taking channel.

Even if an increase in bank risk-taking in low interest rate environment is visible in the data, it is not straightforward to conclude that such a phenomenon has been driven by bank behaviour. An alternative explanation might be that the lower level of interest rates affects the structure of loan demand – i.e. some more risky non-financial sector agents decide to apply for loans only in a low interest rate environment. An empirical approach to determine whether changes in bank risk-taking is supply-side or demand-side driven depends on data available to a researcher. One possibility is to fully control for developments on the demand side of the credit market. This is possible e.g. if information on loan applications is available (e.g. Jiménez et al., 2014). If the structure of loan applicants population is similar in low interest rate and high interest rate periods, the conclusion could be that any resulting changes in bank risk-taking is due to bank active decision to change the structure of loan applicants accepted. However, having an access to full information on loan applications is a quite rare situation. Another approach is to use bank-level data and to test whether there is any systematic relationship between bank characteristics and bank risk-taking behaviour at different levels of interest rates. Given data limitations, it is the approach we use in this paper.

Operating in a low interest rate environment is a challenge common for all banks active in a given economy. Therefore, all the banks face challenges related to lower profitability of their business and incentives to improve profits by gravitating towards more risky business profile. The question is whether there are any factors that could prevent a bank from taking more risk to shift the distribution of potential profits to the right.

Having capital buffers, i.e. bank equity above the level implied by capital requirements, is a necessary condition for increasing risk exposure by a bank.[4] Banks with low capital buffers might be restricted in their capacity to take more risk. On the other hand, lower interest rate levels might result in lower credit risk for existing borrowers (as they have to use smaller fractions of their cash flows to service debt), therefore releasing some economic capital for new risk-taking. The net effect is here ambiguous, but it is important to control for capital buffers in empirical specification.

Another important factor might be the bank size. First, big banks might enjoy implicit "too big to fail" subsidy, making it easier for them to move to more risky activities (Davies and Tracey, 2014). Second, large banks are more likely to finance large infrastructure projects for which financing might be not viable when interest rates are high. Therefore, larger banks might be more likely to have a change in customer structure when interest rates go low. On the other

[4]This statement needs to be qualified, though. For banks using standardised approach to calculating capital requirements for credit risk it is possible to increase risk taken by substituting lower-risk borrowers with high-risk borrowers within the same risk weight class.

hand, big banks might have access to a wider spectrum of potential funding sources, allowing them to have better control over interest costs, so decreasing the incentive to increase risk-taking to restore profitability.

Source of funding, including the importance of deposit funding, might be another variable influencing bank reaction to low market interest rates. On the one hand, banks with large share of non-financial sector deposits might encounter problems with further lowering of interest costs when deposit interest rates are already close to zero (Eggertsson et al., 2019). On the other hand, banks with dominating market-based funding sources might have initially lower net interest margins, so might be more susceptible to any negative profitability shocks. The net effect of a given amount of deposit funding on potential occurrence of bank risk-taking channel is therefore ambiguous.

Bank liquidity is often a factor considered among determinants of bank reaction to different shocks, including monetary policy shocks. A larger share of liquid instruments in bank assets might be a signal of high risk aversion of the bank management (as liquid assets can be used as a cushion in case of adverse shocks hitting a bank), even if it is worsening bank profit generation capacity. If it is the case, risk averse bank managers would be less willing to take additional risk to improve profitability. Moreover, valuation of fixed coupon financial instruments (like e.g. liquid government bonds) will increase with interest rates going down, hence improving profits and mitigating incentives to beef up profits by taking more credit risk.

Empirical studies suggest that the above characteristics have, indeed, impact on banks' risk-taking. Capital buffers, smaller deposit ratios and smaller liquidity are usually found to decrease risk taken by banks (e.g. Khan et al., 2017; Laeven et al., 2016; Acharya and Naqvi, 2012), while in the case of bank size the evidence is mixed (e.g. Laeven et al., 2016; Boyd and Runkle, 1993; de Haan and Poghosyan, 2012).

3 Data and methods

3.1 Data sources

We conduct the analysis on disaggregated, bank-level data. Employing individual bank data facilitates identification of the risk-taking behaviour among banks. Our panel includes large commercial banks operating in Poland, with assets of each bank accounting for at least 1% of the total sector assets. They cover about 84% of the sector in terms of assets. The choice to omit the smallest banks stems from the fact that they have negligible impact on the aggregate behaviour of the sector. If they were included, they would affect estimates in the same degree as the bigger banks. As the final goal of our analysis is to draw macroeconomic and policy-relevant conclusions, we attempt to limit this effect.

The analysis covers period from 2008q3 to 2018q1. During this time span the ownership structure of the banking sector underwent some changes resulting from mergers and takeovers. We take practical approach to these events and treat merger or takeover as a creation of a new entity only if it led to a relatively large increase in bank's assets.[5] Our final effective sample consists of 26 banks and 39 periods (quarters). The panel is unbalanced.

The most important source of data is a financial reporting by banks passed on to Narodowy Bank Polski (Polish central bank, NBP) on regular basis within the supervisory reporting framework. This includes confidential data on bank loans granted to individual firms, obligatorily reported if the exposures exceed 500 thousand PLN (ca. 125 thousand EUR, so-called "large exposures"). We exploit the fact that reports on large exposures include information about loan loss reserves which might serve as a proxy for quality of loans. Another important feature of the reports is the fact that in the case of corporations they contain the activity type code of a debtor.[6] It allows us to assess riskiness of providing credit to a given sector of the economy. This information is an important part of one of our measures of risk taken by a bank.

Apart from bank-level and firm-level financial data we employ a set of macroeconomic indicators from Statistics Poland (GUS) and an indicator of default probability of corporations (excluding banks) provided by Bloomberg.

3.2 Defining risk measures

As already mentioned, the risk is measured at individual bank level. In our approach the risk taken by a bank in a given quarter is measured as a risk-weighted sum of growth of loans

[5] In our sample we identify 16 mergers and takeovers, out of which 9 resulted in increase in assets of acquirer by more than 50%. In such a case we treat the merger as establishing a new bank. In the remaining cases we adjust the dynamics of bank loans at the merger or takeover quarter.

[6] A classification code according to the Polish Classification of Activity PKD, harmonized with NACE.

relative to bank assets, according to the following formula:

$$\Delta R_{i,t} = \frac{\sum_{j=1}^{J} w_{i,j,t-1} \Delta L_{i,j,t}}{L_{i,t-1}} \tag{1}$$

where $\Delta R_{i,t}$ denotes risk taken by i-th bank in period t, $\Delta L_{i,j,t}$ – quarterly growth of loans classified to j-th category in i-th bank, $w_{j,t}$ – risk weight attributed to j-th category of loans, $L_{i,t}$ – volume of loans. In the light of this measure, increasing riskiness of bank's activity is associated with extending more loans and/or allocating new loans into more risky segments of the market.

We calculate three versions of the risk measure which differ from each other in terms of classification of loans and risk weights. In the first case, ($\Delta R^1_{i,t}$), we take into consideration only large loans to non-financial corporates (so called "large exposures" defined for banking supervisory purposes) and categorize them according to sections of NACE Rev.2.0. Risk weights attributed to each section are calculated as the ratio of loan loss reserves to total loans. They are time-varying but not bank-specific. In the two remaining cases we look at the total portfolio of loans to the non-financial sector and categorize loans into six business lines, i.e.: investment loans to non-financial corporations, other loans to non-financial corporations, loans to sole enterprises, housing loans to individuals, consumption loans to individuals, other loans to households.[7] Loans within a business line are assumed to be characterized by broadly similar risk levels. In the case of measure $\Delta R^2_{i,t}$ the risk of a given loan category is approximated by the ratio of loan loss reserves to total loans, similarly as in the previous measure, but in this case the risk weights are bank-specific. Finally, in the third measure ($\Delta R^3_{i,t}$) we use risk weights, which have more ex-ante character. In this approach we assume that a more risky business line should bring more profit. Therefore net interest margin of bank's business line minus minimum required return should be positively related to expected future losses.[8] Details of calculation of risk weights are described in Appendix 1.

In order to avoid problems caused by extreme observations, the risk measures were winsorized prior to employing them in the model. Figures 1a, 1b and 1c show the evolution of new risk measures for a median bank over the whole sample.

[7] Business line definitions are imposed by the supervisory reporting framework.

[8] Along the same lines Delis et al. (2017) employ loan spread as an indicator of ex-ante measure of individual corporate loan risk.

3.3 Empirical specification

In order to assess whether the risk-taking channel is active in Poland we estimate the following model:

$$\Delta R_{i,t} = \alpha_i + \beta i_{t-1} + \sum_{j=1}^{4} \beta_j^* B_{i,t-1}^j i_{t-1} + \eta i_{t-1}^2 + \sum_{j=1}^{4} \eta_j^* B_{i,t-1}^j i_{t-1}^2 + \\ + \sum_{j=1}^{4} \delta_j B_{i,t-1}^j + \sum_{j=1}^{4} \gamma_j M_{t-1}^j + \lambda \Delta R_{i,t-1} + \sum_{j=1}^{3} \mu_j Q_t^j + \varepsilon_{i,t} \quad (2)$$

in which risk taken by a bank ($\Delta R_{i,t}$) is regressed on its lagged value, a nominal interest rate (i), the squared nominal interest rate, interactions between bank characteristics and the interest rate as well as the squared interest rate, the set of control variables and quarterly dummy variables (Q_t^j). The set of control variables consists of both macroeconomic variables (M_{t-1}^j) and individual bank characteristics ($B_{i,t-1}^j$). The former include the output gap (obtained with the Hodrick-Prescott filter), core inflation excluding foodstuffs and energy, the quarterly change in nominal effective exchange rate (increase means appreciation) and default probability of corporations. The latter group of control variables consists of the total assets (in log), the liquidity ratio (liquid assets[9] relative to total assets), the capital buffer (the ratio of excess bank capital over regulatory requirement to assets) and the total deposits to total liabilities ratio. All control variables are introduced with a one-period lag to avoid potential endogeneity problems. The bank-level characteristics are normalized with respect to median in a given quarter (assets and capital buffer) or median in the whole sample (other variables).[10]

We measure monetary policy with the nominal interest rate. We use a four-quarter moving average of the 3-month money market rate (WIBOR 3M) in order to account for sluggishness of processing loan applications. In order to capture a non-linear character of the risk-taking phenomenon the specification includes also the squared interest rate. The interest rate and the squared interest rate are interacted with the bank characteristics. The interaction variables are crucial for our strategy to identify the risk-taking channel. It is due to the fact that we are going to identify supply-side factors affecting risk-taking by banks rather than demand factors, reflected, at least to some extent, in the estimated coefficients on the interest rate and the squared interest rate.

The set of macro control variables is rather standard. The output gap and inflation control for cyclical changes in the demand for loans. The importance of the exchange rate stems from various reasons. Firstly, calculating risk measures we considered loans in all currencies, therefore changes in the exchange rate affect directly the volume loans expressed in the local currency. Secondly, as enterprises are exposed to the exchange rate risk, fluctuations in the exchange rate affect their future financial condition, which is most clearly visible in the case of importers and exporters. Moreover, when firms mismanage their FX hedging activities, this can result in

[9] To liquid assets belong: cash, operations with the central bank except reserve requirements, current accounts and overnight deposits from financial institutions, debt securities issued by central banks and central government institutions.

[10] Normalization with respect to the median in a given quarter is intended to remove trend in assets and capital buffer.

changes in their liabilities towards banks being counterparties for FX derivative transactions. Such a problem occurred in Poland after a rapid exchange rate depreciation in 2008 (for details, see e.g. Box 2 in NBP, 2009). Lastly, changes in the exchange rate affect also default probability of households (mostly due to FX mortgage loans) and this, via portfolio effects, might also influence bank lending decisions in general. The intention of including default probability of corporations is mainly to capture the effect of the global financial crisis.

We complement the set of macro control variables with bank-specific indicators. Bank size, liquidity and capital position are the main characteristics important from the monetary transmission mechanism perspective and are standard in the bank lending channel literature. The deposits ratio reflects financing conditions of a bank which affect, among others, its effective funding costs.[11]

In order to address the problem of potentially omitted macro variables that could result in biased estimates, we additionally estimate a model in which macro variables are substituted with time dummies capturing the impact of all period-specific factors:

$$\Delta R_{i,t} = \alpha_i + \sum_{j=1}^{4} \beta_j^* B_{i,t-1}^j i_{t-1} + \sum_{j=1}^{4} \eta_j^* B_{i,t-1}^j i_{t-1}^2 + \sum_{j=1}^{4} \delta_j B_{i,t-1}^j + \lambda \Delta R_{i,t-1} + \varepsilon_{i,t} \qquad (3)$$

Such a specification is preferred when it comes to assessing differences among banks, however, it does not allow to infer about the impact of the interest rate on banks' risk, the variable crucial for our analysis. Large differences in estimates from both specifications could signal that some of the macro factors affecting risk taken by banks are ommited in the benchmark model.

When it comes to the choice of the estimation method, after careful consideration we decided to employ a bias-corrected fixed effect estimator (Everaert and Pozzi, 2007; Vos et al., 2015). In dynamic panel models the fixed effect estimator suffers from bias due to the violation of the weak exogeneity assumption, with the size of this bias diminishing as T grows large (Nickell, 1981). The bias-corrected fixed effect (BCFE) estimator corrects for this bias and allows to avoid some problems related to use of alternative GMM estimators in applications when T is relatively large compared to N as in our case ($T = 39$, $N = 26$).

[11] As a part of robustness checks we tested a wider set of macroeconomic and bank-specific variables (the slope of the yield curve, index of property prices, share price index, share of mortgages in total loans, share of foreign currency mortgages in total loans), but the estimates turned out non-statistically significant or the results were unintuitive.

4 Main findings

Estimation results (Table 1) reveal that all the measures of risk taken by banks respond to changes in the short-term interest rate with the magnitude dependent on the initial level of interest rate. The non-linear character of the relationship between risk and the interest rate approximated by the quadratic function together with the negative sign of an estimated coefficient value for the interest rate and the positive sign for the squared interest rate, imply that interest rate reductions lead to higher risk of new loans and, as expected, the size of this effect is larger when interest rates are low. On the contrary, interest rate increases discourage banks from taking more risk, but as the level of interest rate rises, the impact is weaker.[12] This observation, however, does not necessarily imply that in the environment of low interest rates banks change their policy and supply of credit towards riskier borrower, because it can be also related to demand factors, i.e. to the fact that in such circumstances riskier borrowers increase their demand for credit.

A more direct confirmation of the operation of the risk-taking channel is provided by the model, in which the first measure of risk (ΔR^1) is applied. In this case the response of risk of new loans to changes in the short-term interest rate is heterogeneous across banks with different size (in terms of total assets), different deposits-to-liabilities ratios and different degrees of liquidity. Estimation results of the model with time effects confirm that the above bank characteristics are indeed important in analysing the risk-taking behaviour (Table 2). It suggests that supply-side factors do play a role in the overall response of risk of large corporate exposures to changes in monetary policy. Interestingly, interactions of the above bank characteristics with both the interest rate and its squared value are statistically significant. In particular, a statistical significance of the squared interest rate is in line with the risk-taking channel literature indicating that this channel of monetary transmission is active in the environment of low nominal interest rates.

When it comes to the second measure of bank risk (ΔR^2), we find that the reaction of risk to an interest rate change depends on bank's liquidity, but the estimates of related parameters are statistically significant only at 10% level. For the third risk measure (ΔR^3) we find a homogeneous reaction of all banks, so we are not able to confirm that negative interdependence between risk and interest rates is supply driven. What these two risk measures have in common, is that they comprise loans to the whole non-financial sector, contrary to the first risk measure which includes loans only to the non-financial corporates. It suggests that it is not the whole credit activity that is affected by the risk-taking channel, but this channel is active mainly in the portfolio of large loans to non-financial corporates.

As the evidence on operation of the risk-taking channel is the most compelling for the corporate sector, in the remaining part of this section we discuss the results for the first measure of risk (ΔR^1). Figure 2 illustrates differences in the response of risk of new loans across banks. It presents the impact of monetary policy loosening on risk taken by three types of banks – the median bank and the banks with analysed characteristics corresponding to 25th or 75th percentiles of their distribution across all banks in the sample. It can be noticed that inde-

[12] Theoretically, after reaching a certain high level of interest rate, the impact of interest rate increases on risk would become positive, as implied by the quadratic function.

pendently of the type of analysed banks, the smaller the short-term interest rate is the larger the increase of the risk taken by banks caused by loosening of monetary policy is.

Responding to expansionary monetary policy larger banks seem to take more risk relative to smaller banks. This finding is consistent with the fact that large banks are more active in financing large investment projects and display higher profitability than smaller banks as well and they might enjoy implicit "too big to fail" benefits. As far as the sources of funding are concerned, the increase of risk taken in response to a reduction of nominal interest rate seems stronger in banks with a larger share of non-financial sector deposits than in banks with market financing. It reflects the fact that deposits are perceived as a more stable source of financing than short-term debt (Ivashina and Scharfstein, 2010). Finally, the risk-taking behaviour is more pronounced in banks with low liquidity than in highly liquid banks. This result confirms a firmly established observation that more liquid banks are less affected by interest rate changes in supplying loans (Kashyap and Stein, 2000; Dell'Ariccia et al., 2017).

In the next step of our analysis we estimate the importance of the risk-taking channel in individual banks in our sample, considering their characteristics, especially size, liquidity and the dominant source of financing. We assess changes in the risk of new loans to lowering the short-term nominal interest rate from 5% to 4% (Figure 3a), from 3% to 2% (Figure 3b) and from 1% to 0% (Figure 3c). It can be observed that the distribution of implied changes in risk of new large exposures after a loosening of monetary policy moves clearly to larger values as the initial level of the interest rate gets lower. It means that the risk-taking channel has been active in Poland.

Finally, to assess quantitative relevance of this channel we analyse the impact of typical reductions of the NBP interest rates, i.e. by 25 or 50 bp., on the measure of risk taken by the median bank, comparing it with standard deviation of risk. In this way we address the question if changes in risk taken by banks generated by monetary policy can be treated as substantial source of variation of total risk. This comparison (Figure 4) indicates that even for very low interest rates the impact of typical interest rate reductions is significantly lower than usual variation of the measure of new risk taken by banks. However, the strength of the risk-taking channel is not negligable, especially in the low interest rate environment.

Trying to explain why the relevance of the risk-taking channel has been modest in Poland so far, we formulate the following hypotheses, which at the same time show that under certain conditions the channel could gain even more quantitative significance in the future.

Firstly, we can argue that the level of policy interest rates observed at the end of our sample (1.5%) is not low enough as to significantly limit the interest margin of banks, and as a result, their profitability. This means that the bank management bodies do not feel under strong pressure to achieve a significant and rapid improvement in financial results, e.g. by increasing the risk incurred. However, it should be remembered that the introduction of regulatory changes and one-off events in the future could lead, regardless of the impact of monetary policy, to a fall in banks' profitability and their potential response in terms of striving to increase revenues, which could increase their propensity to take on risk.

Secondly, the limited importance of the risk-taking channel may be related to the preferences

of banks. The banking sector in Poland is well supplied with capital. High capital buffers might reflect banks' prudence rather than be a symptom of taking on higher risk not included in the standard capital requirements. The fact that in periods of a deteriorating situation for enterprises, expressed in the increased probability of their default, banks reduced the scale of risk that they took on (see Table 1) may also be evidence of banks' prudence. At the same time it should be noted that the behaviour of some smaller banks with weaker capital positions, could be different. However, the size of these institutions does not significantly impact at the level of the whole sector, and the development of the variables at this level is most important from the point of view of conducting monetary policy.

5 Conclusion

In this paper we proposed a novel approach to measure the new risk taken by banks, capturing both changes in volumes of loans directed to different sectors of the economy and risks of those exposures. Using alternative measures of risk we tested the operation of the risk-taking channel in the Polish banking sector. In doing so, we used a novel non-linear specification of the estimated models.

Another important feature of this paper is its focus on a banking sector in a converging economy. In Poland, the real convergence process interacted with financial deepening. Therefore, banks have faced strategic choices whether (or to what extent) they should approach previously "unbanked" (and implicitly – riskier) customers. On the other hand, higher incomes and profits of existing borrowers (both households and firms) have increased their borrowing capacity. These two major factors increased – comparing to a situation in more developed economies – banks' flexibility in shaping the risk profile of their loan portfolios.

The main contribution of our results is that we find a robust evidence that the risk-taking channel operates in the segment of large corporate loans in Poland, even if its quantitative relevance is modest. Taking under consideration the whole portfolio of loans to the non-financial sector, we also find negative relationship between interest rate and risk taken by banks, however we are not able to unambiguously claim that is a supply driven phenomenon.

Another important conclusion concerns substantial asymmetrical features of the risk-taking channel with respect to the level of the short-term interest rate as well as heterogeneity of this effects across banks. Loosening of monetary policy has different effects depending on the initial level of interest rates – the lower the interest rate is, the larger increase of risk the lowering of interest rate generates. This response is also different across banks, with larger reaction displayed by large banks, banks with low liquidity and banks with deposits being the most important funding source.

References

Acharya, V. and H. Naqvi (2012). The seeds of a crisis: A theory of bank liquidity and risk taking over the business cycle. *Journal of Financial Economics 106*(2), 349–366.

Altunbas, Y., L. Gambacorta, and D. Marques-Ibanez (2014, March). Does monetary policy affect bank risk? *International Journal of Central Banking 10*(1), 95–136.

Borio, C. and H. Zhu (2012). Capital regulation, risk-taking and monetary policy: a missing link in the transmission mechanism? *Journal of Financial Stability 8*(4), 236–251.

Boyd, J. H. and D. E. Runkle (1993). Size and performance of banking firms: Testing the predictions of theory. *Journal of Monetary Economics 31*(1), 47–67.

Cai, J., K. Cherny, and T. Milbourn (2010). Compensation and risk incentives in banking and finance. *Economic Commentary 2010*(13).

Chmielewski, T., M. Kapuściński, A. Kociecki, T. Łyziak, J. Przystupa, E. Stanisławska, and E. Wróbel (2018). Monetary transmission mechanism in Poland. What do we know in 2017? Working Paper 286, Narodowy Bank Polski, Economic Research Department.

Claessens, S., N. Coleman, and M. Donnelly (2018). Low-for-long interest rates and banks' interest margins and profitability: Cross-country evidence. *Journal of Financial Intermediation 35*, 1–16.

Davies, R. and B. Tracey (2014). Too big to be efficient? The impact of implicit subsidies on estimates of scale economies for banks. *Journal of Money, Credit and Banking 46*(s1), 219–253.

de Bondt, G., A. Maddaloni, J.-L. Peydró, and S. Scopel (2010, February). The euro area Bank Lending Survey matters: empirical evidence for credit and output growth. Working Paper Series 1160, European Central Bank.

de Haan, J. and T. Poghosyan (2012). Size and earnings volatility of US bank holding companies. *Journal of Banking & Finance 36*(11), 3008 – 3016.

Delis, M. D., I. Hasan, and N. Mylonidis (2017, February). The risk–taking channel of monetary policy in the U.S.: Evidence from corporate loan data. *Journal of Money, Credit and Banking 49*(1), 187–213.

Delis, M. D. and G. P. Kouretas (2011). Interest rates and bank risk-taking. *Journal of Banking & Finance 35*(4), 840–855.

Dell'Ariccia, G., L. Laeven, and G. A. Suarez (2017). Bank leverage and monetary policy's risk-taking channel: Evidence from the United States. *The Journal of Finance 72*(2), 613–654.

DeYoung, R. and K. P. Roland (2001). Product mix and earnings volatility at commercial banks: Evidence from a degree of total leverage model. *Journal of Financial Intermediation 10*(1), 54 – 84.

Eggertsson, G. B., R. E. Juelsrud, L. H. Summers, and E. G. Wold (2019, January). Negative nominal interest rates and the bank lending channel. Working Paper 25416, National Bureau of Economic Research.

Everaert, G. and L. Pozzi (2007). Bootstrap-based bias correction for dynamic panels. *Journal of Economic Dynamics and Control 31*(4), 1160 – 1184.

Fahlenbrach, R. and R. M. Stulz (2011). Bank CEO incentives and the credit crisis. *Journal of Financial Economics 99*(1), 11 – 26.

Gambacorta, L. (2009). Monetary policy and the risk-taking channel. *BIS Quarterly Review* (December), 43–53.

Górajski, M., D. Serwa, and Z. Wośko (2018, May). Measuring expected time to default under stress conditions for corporate loans. *Empirical Economics*.

Ioannidou, V. P., S. Ongena, and J. L. Peydró-Alcalde (2008). *Monetary policy, risk-taking, and pricing: Evidence from a quasi-natural experiment.* Tilburg University.

Ivashina, V. and D. Scharfstein (2010). Bank lending during the financial crisis of 2008. *Journal of Financial Economics 97*(3), 319 – 338.

Jiménez, G., S. Ongena, J.-L. Peydró, and J. Saurina (2014). Hazardous times for monetary policy: What do twenty-three million bank loans say about the effects of monetary policy on credit risk-taking? *Econometrica 82*(2), 463–505.

Kashyap, A. K. and J. C. Stein (2000). What do a million observations on banks say about the transmission of monetary policy? *American Economic Review 90*(3), 407–428.

Khan, M. S., H. Scheule, and E. Wu (2017). Funding liquidity and bank risk taking. *Journal of Banking & Finance 82*, 203–216.

Kouretas, G., C. Tsoumas, A. A. Drakos, et al. (2013). Ownership, institutions and bank risk-taking in Central and Eastern European countries. Technical report, EcoMod.

Laeven, L., L. Ratnovski, and H. Tong (2016). Bank size, capital, and systemic risk: Some international evidence. *Journal of Banking & Finance 69*, S25–S34.

Maddaloni, A. and J.-L. Peydró (2011). Bank risk-taking, securitization, supervision, and low interest rates: Evidence from the Euro-area and the US lending standards. *The Review of Financial Studies 24*(6), 2121–2165.

NBP (2009, June). Financial Stability Report. Technical report, Narodowy Bank Polski.

Nickell, S. J. (1981, November). Biases in dynamic models with fixed effects. *Econometrica 49*(6), 1417–1426.

Paligorova, T. and J. A. Santos (2017). Monetary policy and bank risk-taking: Evidence from the corporate loan market. *Journal of Financial Intermediation 30*, 35–49.

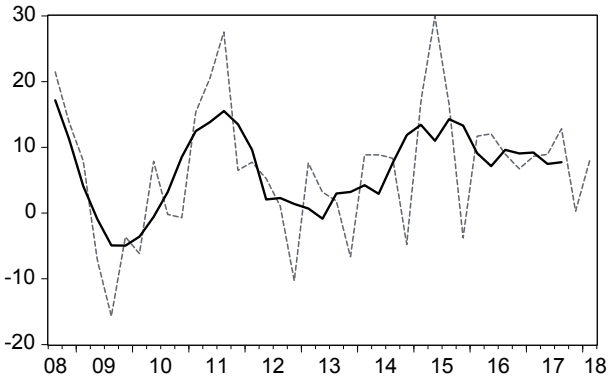
Rajan, R. G. (2006). Has finance made the world riskier? *European Financial Management 12*(4), 499–533.

Vos, I. D., G. Everaert, and I. Ruyssen (2015, December). Bootstrap-based bias correction and inference for dynamic panels with fixed effects. *Stata Journal 15*(4), 986–1018.

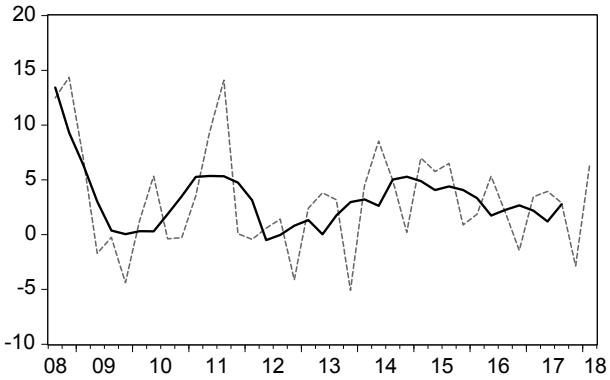
Wróbel, E. (2018). What is the impact of central bank on banks' lending policy with respect to the corporate sector? Evidence from SLOOS for Poland. *Bank & Credit 49*(6), 595–638.

Figure 1: Measures of risk

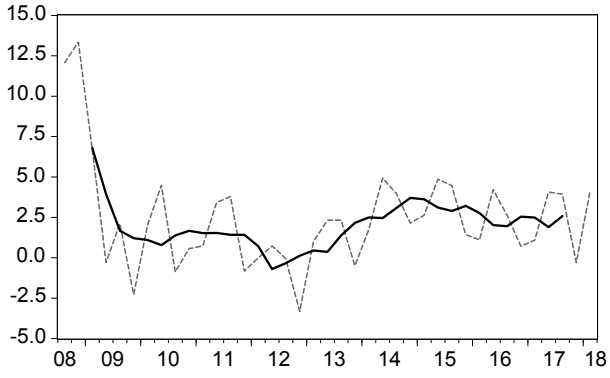
(a) ΔR^1



(b) ΔR^2

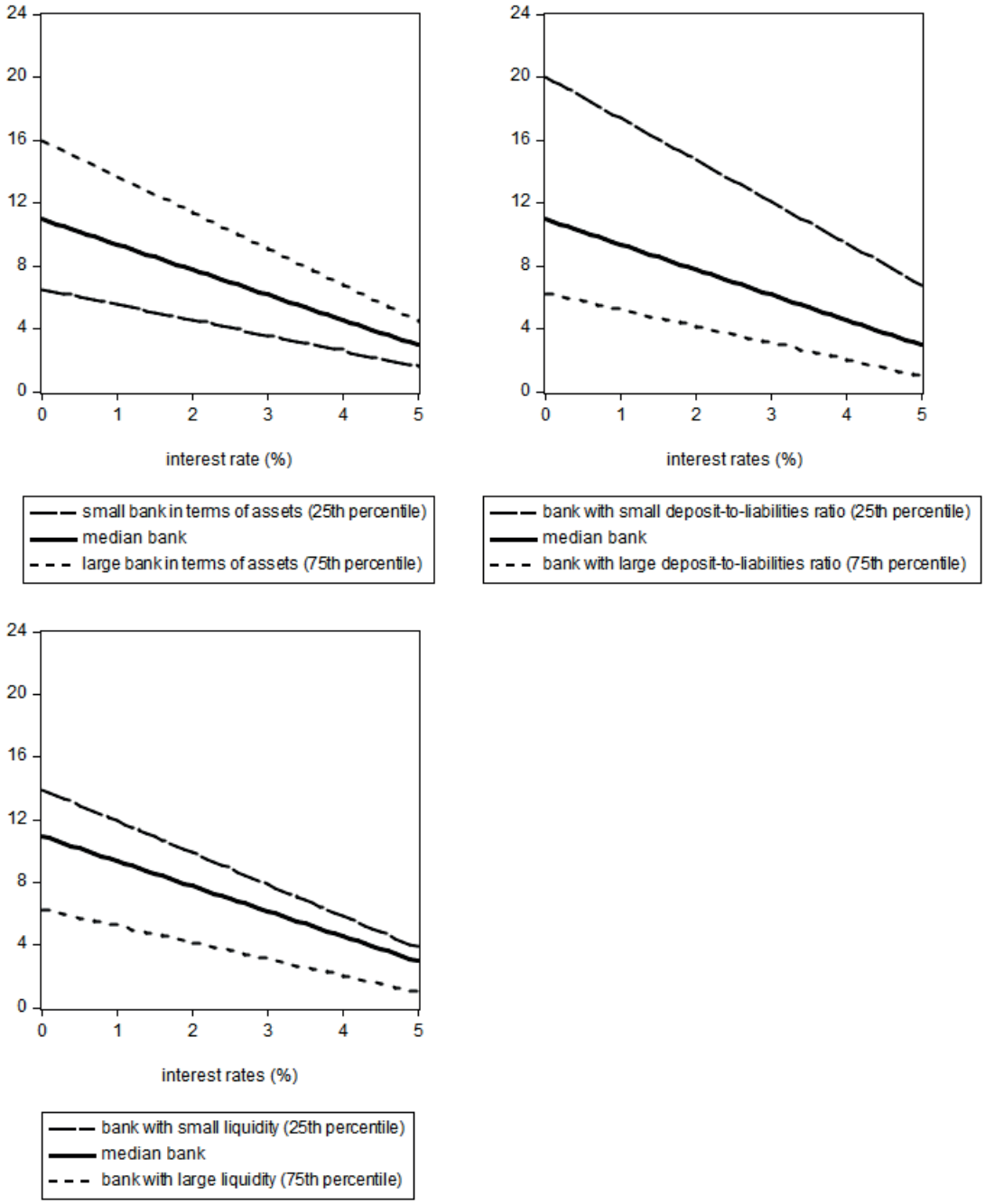


(c) ΔR^3



Note: Median across banks in the sample. Dotted line denotes risk measure, while solid line denotes its moving average.
Source: own calculations based on NBP data.

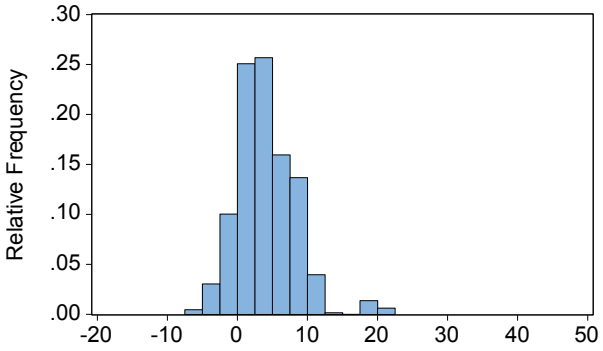
Figure 2: Change in risk measure ΔR^1 after the reduction of interest rate by 100 bps for different levels of the interest rate



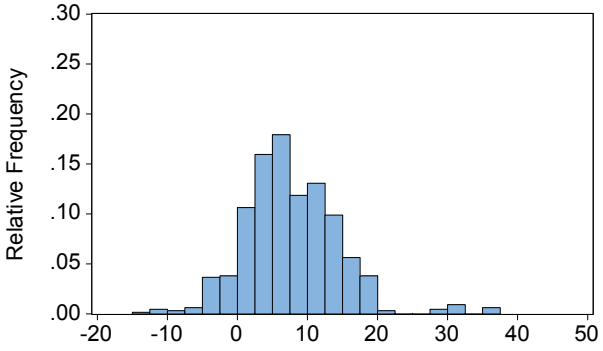
Source: own calculations based on NBP data.

Figure 3: Distribution of changes in risk measure ΔR^1 in individual banks after the reduction of interest rate by 100 bps for different levels of interest rate

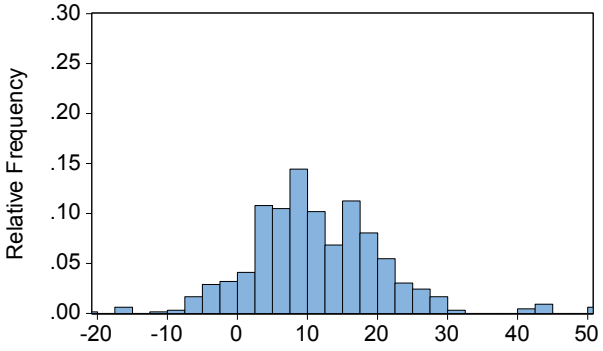
(a) Interest rate equal to 5%



(b) Interest rate equal to 3%

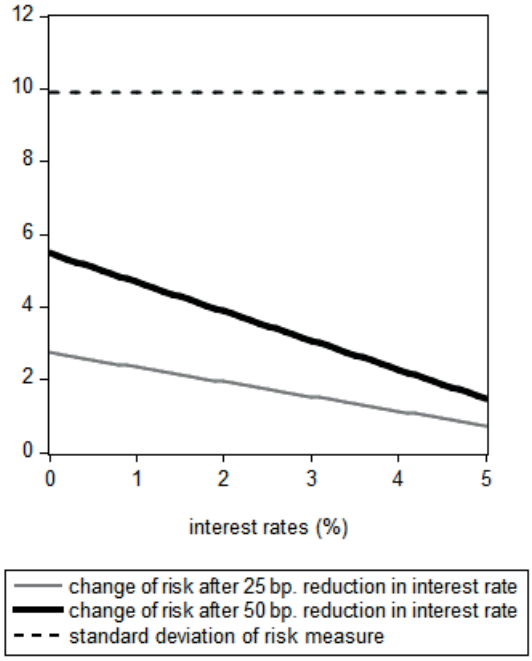


(c) Interest rate equal to 1%



Source: own calculations based on NBP data.

Figure 4: Quantitative relevance of the risk-taking channel



Notes: Change in the risk measure ΔR^1 after the reduction of interest rate by 25 and 50 bps for different levels of the interest rate. Source: own calculations based on NBP data.

Table 1: Estimation output – specification with macro controls

	$\Delta\ R^1$	$\Delta\ R^2$	$\Delta\ R^3$
nominal interest rate			
i	-10.97***	-4.35**	-2.54**
i^2	1.60***	0.69***	0.37**
interest rate interacted with bank characteristics			
$i \times asstes$	-8.10**	-3.03	-0.80
$i \times liquidity$	0.63**	0.37*	-0.03
$i \times capital\ buffer$	0.29	1.60	0.64
$i \times deposit\ ratio$	0.52***	0.14	0.06
squared interest rate interacted with bank characteristics			
$i^2 \times assets$	1.12**	0.46	0.11
$i^2 \times liquidity$	-0.09**	-0.05*	0.00
$i^2 \times capital\ buffer$	-0.11	-0.33	-0.12
$i^2 \times deposit\ ratio$	-0.06**	-0.02	-0.01
bank characteristics			
$assets$	9.71	4.61	2.35
$liquidity$	-1.01*	-0.47	0.08
$capital\ buffer$	0.63	-0.95	-0.51
$deposit\ ratio$	-1.07***	-0.2	-0.1
control macro variables			
$output\ gap$	2.21***	0.89**	0.31
$core\ inflation$	13.34***	0.52	1.23
ΔNER	0.39*	0.67***	0.30***
$default\ prob.\ of\ corporations$	-82.85***	-19.26***	-9.92***
quarterly dummies			
$q1$	13.18***	8.09***	2.22***
$q2$	13.73***	8.19***	3.95***
$q3$	10.10***	5.39***	1.77***
lagged dependent variable			
ΔR_{t-1}	0.06	0.43***	0.61***
N	635	650	620

Note: Boostrap-based bias corrected fixed effect estimator. Standard errors (bootstrapped, allowing for cross-sectional heteroscedasticity) in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: own calculations.

Table 2: Estimation output – specification with time effects

	$\Delta\ R^1$	$\Delta\ R^2$	$\Delta\ R^3$
interest rate interacted with bank characteristics			
$i \times asstes$	-7.50**	-0.53	0.63
$i \times liquidity$	0.65*	0.35	-0.04
$i \times capital\ buffer$	0.44	0.31	-0.17
$i \times deposit\ ratio$	0.51***	0.00	-0.01
squared interest rate interacted with bank characteristics			
$i^2 \times assets$	1.04**	0.12	-0.06
$i^2 \times liquidity$	-0.09**	-0.05	0.01
$i^2 \times capital\ buffer$	-0.12	-0.15	-0.01
$i^2 \times deposit\ ratio$	-0.05**	0.00	0.00
bank characteristics			
$assets$	9.11	-2.87	-3.24
$liquidity$	-1.04*	-0.44	0.09
$capital\ buffer$	0.21	1.03	0.73
$deposit\ ratio$	-0.94***	0.06	0.02
lagged dependent variable			
ΔR_{t-1}	-0.01	0.37***	0.49***
N	635	650	620

Note: Boostrap-based bias corrected fixed effect estimator. Standard errors (bootstrapped, allowing for cross-sectional heteroscedasticity) in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Source: own calculations.

Appendix 1: Risk weights of loans

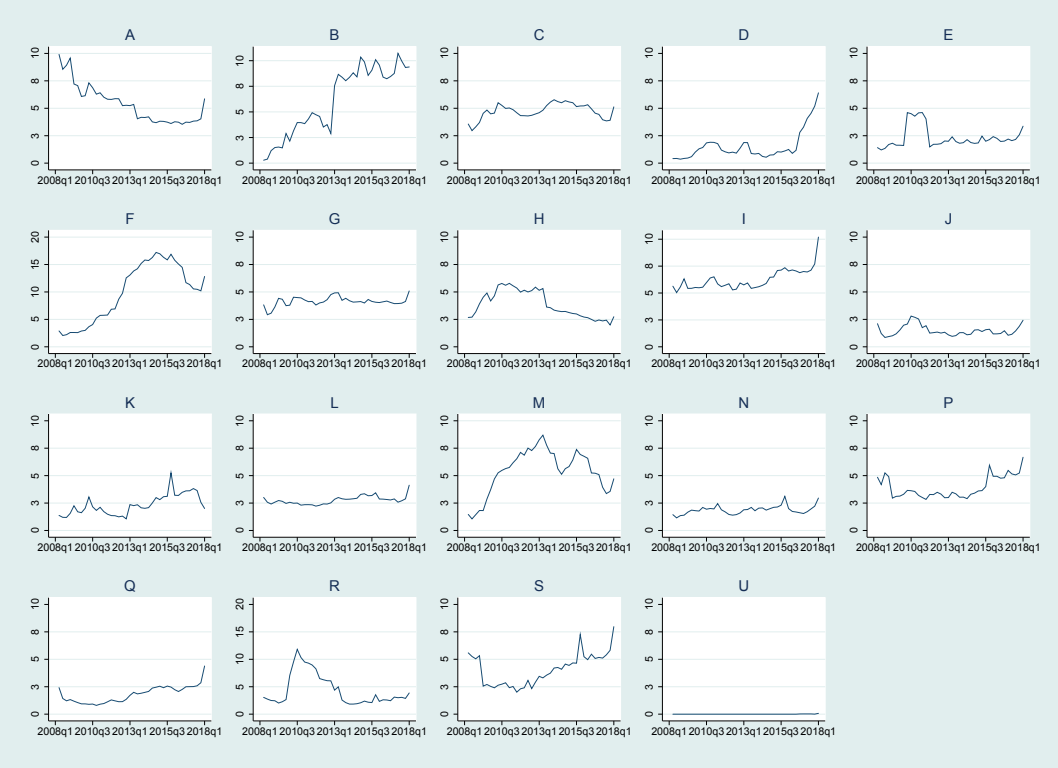
Assessing riskiness of given category of loans, we refer to a loan loss ratio (loan loss reserves to total loans) calculated it for each section of NACE Rev. 2 (the highest level of this classification, denoted with alphabetical code) based on granular data from reports on "large exposures" (our first measure of risk) or for business lines isolated from banks' financial reporting (our second and third measure of risk).

For this purpose we gather information on all "large exposures" (volume of loans and level of reserves created to offset future losses on these loans) as well as classification code of debtor according to NACE Rev. 2 or NACE Rev. 1.1 reported by all banks in the Polish banking sector.[13] Next, we unify classification by recoding older classification codes to new ones with use of correspondence tables published on CSO website. Based on this data we calculate loan loss ratios for each section. Out of 21 sections of activity distinguished in NACE Rev. 2, no loans were attributed only to 2 of them: T (Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use) and U (Activities of extraterritorial organizations and bodies). Figure A shows loan loss ratios by sections over 2008q3–2018q1 period, while the structure of large exposures is given in Figure B.

Figure Ca and Cb display risk weights attributed to business lines (loan loss ratio and implied expected loss), while Figure D shows structure of loans by business lines.

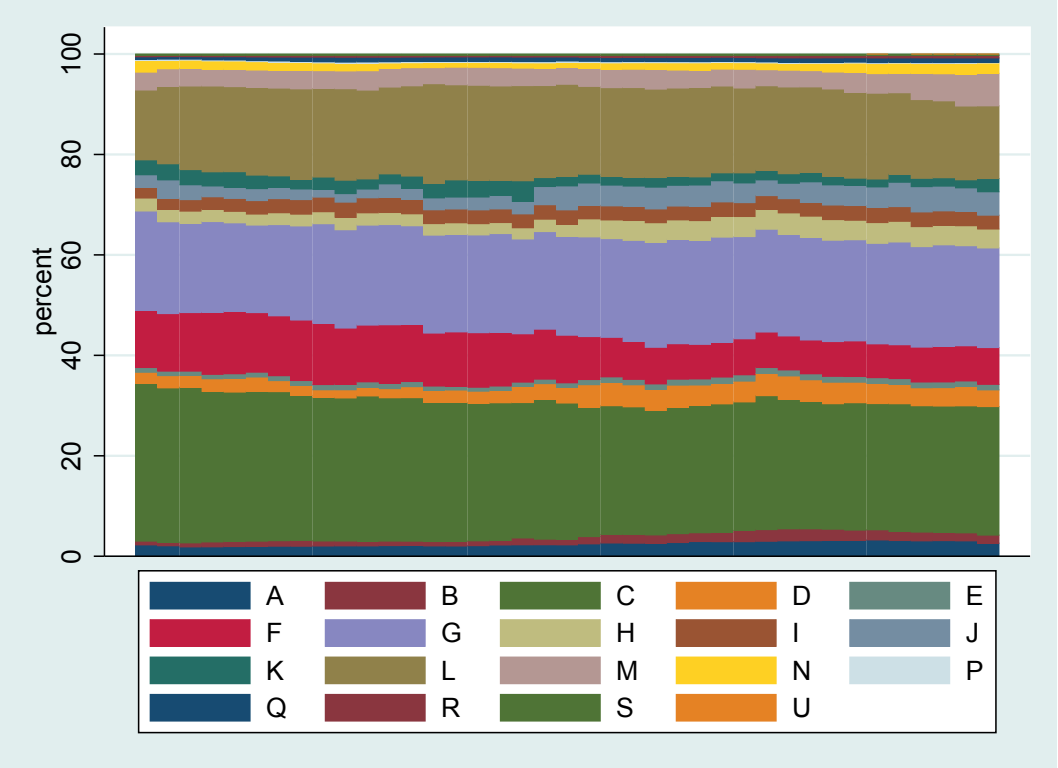
[13]NACE Rev. 2 has bounded since January 2008 with the first year being transitory.

Figure A: Risk weights of loans by NACE sections (ratio of loan loss reserves to total loans, in %)



Note: A – Agriculture, forestry and fishing; B – Mining and quarrying; C – Manufacturing; D – Electricity, gas, steam and air conditioning supply; E – Water supply, sewerage, waste management and remediation activities; F – Construction; G – Wholesale and retail trade; repair of motor vehicles and motorcycles; H – Transportation and storage; I – Accommodation and food service activities; J – Information and communication; K – Financial and insurance activities; L – Real estate activities; M – Professional, scientific and technical activities; N – Administrative and support service activities; O – Public administration and defence; compulsory social security; P – Education; Q – Human health and social work activities; R – Arts, entertainment and recreation; S – Other service activities; U – Activities of extraterritorial organizations and bodies.
Source: own calculations based on NBP data.

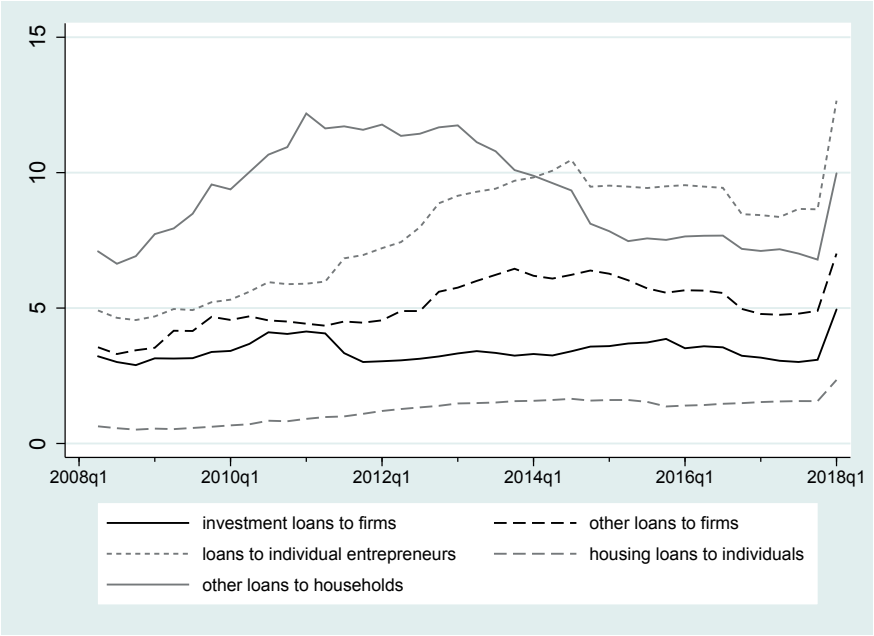
Figure B: Structure of loans by NACE sections (aggregated, in %)



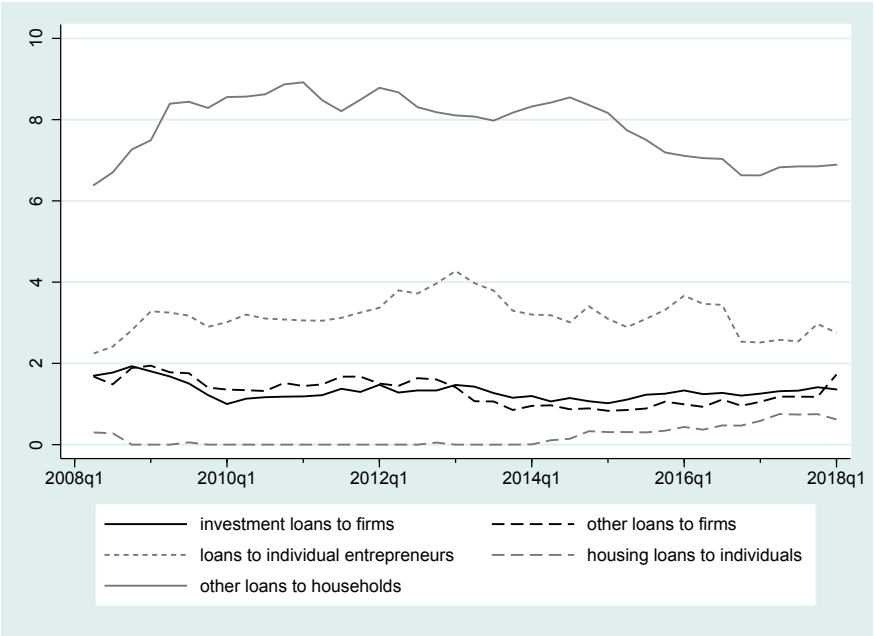
Note: Aggregated data.
Source: own calculations based on NBP data.

Figure C: Risk weights of loans by business lines

(a) Ratio of loan loss reserves to total loans (in %)

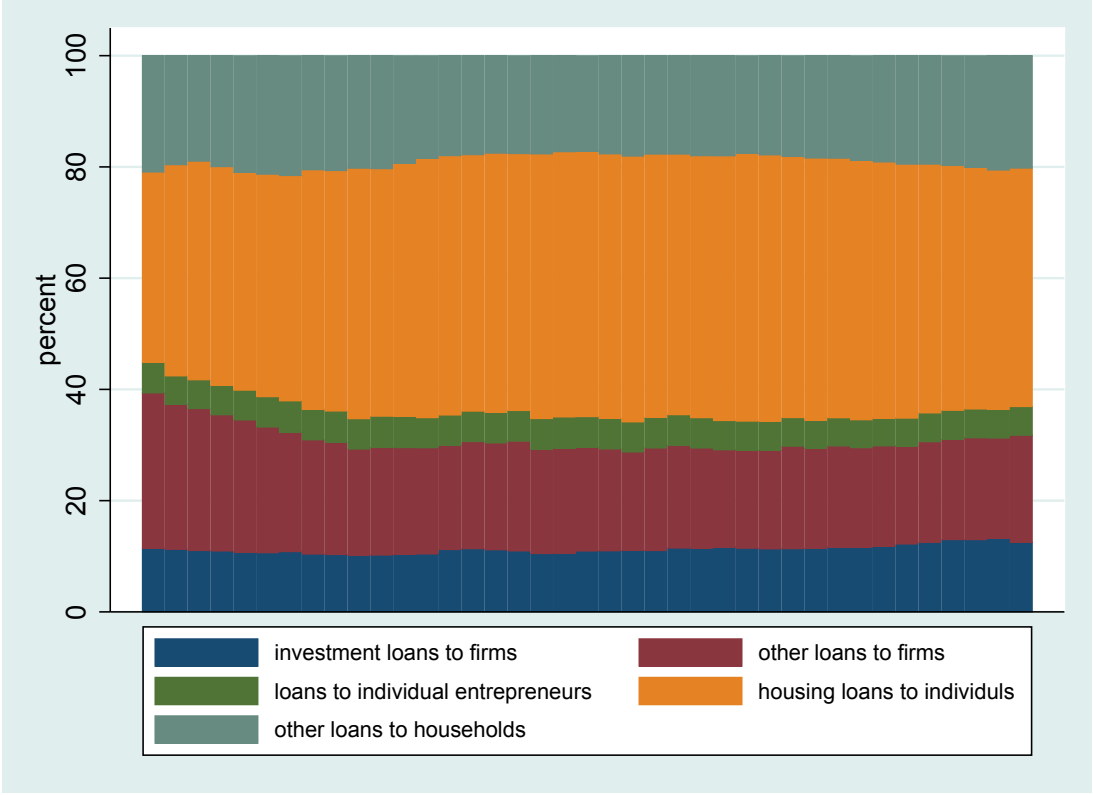


(b) Implied expected loss (in %)



Note: Median value across banks.
Source: own calculations based on NBP data.

Figure D: Structure of loans by business lines (in %)



Note: Aggregated data.
Source: own calculations based on NBP data.

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