Risk-taking channel – does it operate in the Polish banking sector?

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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 that do not require access to loan-level data, nor rely on data from surveys among credit officers. Contrary to studies for advanced economies, we find only weak evidence on risk-taking behaviour of Polish banks. In particular, it seems that banks grant more risky loans in periods when interest rates are lower than implied by the Taylor rule, whereas they do not adjust riskiness of their loans portfolio in response to low nominal or real interest rates. 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
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Preliminary draft. The views expressed in this paper are those of the authors and do not necessarily represent those of Narodowy Bank Polski. Any remaining errors are ours.

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1 Introduction

Loosening of monetary policy typically makes bank grant more credit, as a result of the operation of the traditional interest rate channel 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).

There are different detailed explanations of the above effects. Two of them seem the most important. 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.

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 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 relative to money market rates (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.

The aim of our study is to analyse the functioning of the risk-taking channel in the Polish banking sector. We attempt to capture its specific features and its evolution over time. In the period under consideration, i.e. 2004-2017, Poland experienced a significant financial deepening. Bank loans to non-financial sector in 2004 stood at approximately 25% of GDP, while in 2016 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 2016. To our best knowledge our study is the first attempt to analyse the operation of the risk-taking channel in the Polish economy.[2] Another 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 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.

The paper is structured in the following way. Section 2 presents data and methods applied in the study, with a particular focus on the construction of the measures of risks taken by banks. Section 3 presents the main results, while in section 4 we analyse robustness of the results. The final section concludes.

[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] 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.

2 Data and methods

2.1 Data sources

We conduct the analysis on disaggregated, bank-level data. Employing individual bank data facilitates identification of risk-taking behavior among banks. Our sample is limited to largest 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 small banks have negligible impact on the aggregate behaviour of the sector while they affect estimates in the same degree as bigger ones. As the final goal of our analysis is to draw macroeconomic and policy-relevant conclusions, we would like to limit this effect.

The analysis covers period from 2004q1 to 2017q1. 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 creation of a new entity only if it led to relatively large increase in bank's assets. Banks with less than 8 observations are removed from the analysis. Our final sample consists of 26 banks and 53 periods (quarters). The panel is unbalanced.

The most important source of data is a financial reporting by banks passed on to Narodowy Bank Polski on regular basis within the supervisory reporting framework. This includes confidential data on bank's 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, as well as an activity type code of a debtor (in the case of corporations).[3] It allows us to asses riskiness of providing a credit to given sector of the economy, 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 probability of default of corporations (excluding banks) provided by Bloomberg.

2.2 Defining risk measures

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

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

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

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, $A_{i,t}$ – bank's assets. Alternatively, risk-weighted growth of loans might be related to bank's capital which is more in line with financial stability view.[4] In the light of this measure, increasing riskiness of bank's activity is associated with (i) extending more loans, (ii) allocating new loans into more risky segments of the market.

In the baseline analysis we calculate two versions of the risk measure with different classification of loans. 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 a ratio of loan loss reserves to total loans. They are time-varying but not bank-specific. In the second case, $(\Delta R^2_{i,t})$, we look at the total portfolio of loans to the non-financial sector and categorize loans into six business lines, characterized by broadly similar risk levels within a business line. These business lines are as follows: 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.[5] 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 risk weights are bank-specific.

As a robustness check, we use different risk weights, which have more ex ante character. In this approach we assume that a more risky business line should bring more profit. Therefore higher net interest margin of bank's business line minus minimum required return – which we interpret as an implicit expected loss on the business line – should be positively related to expected future losses. Along the same lines Delis et al. (2017) employ loan spread as an indicator of ex-ante measure of individual corporate loan risk. Applying the implicit expected loss on the business line as a risk weight leads us to the third version of our risk measure $(\Delta R^3_{i,t})$. Due to data availability this measure covers a shorter period, starting in 2007q4. Details of calculation of risk weights are described in Appendix 1.

In order to avoid problems caused by extreme observations, risk measures were winsorized prior to employing them in the model.

The Figure 1 below show evolution of new risk measures for a median bank over the whole sample.

2.3 Defining periods of low interest rates

To define the periods of low interest rates we use a variety of measures suggested in empirical literature. They include: nominal short-term interest rate (WIBOR 3M), real short-term interest rates obtained with different proxies for expected inflation (i.e. survey-based measures of enterprises', consumers' and financial sector analysts' inflation expectations), deviations of the

[4] Results not shown. Lead to the same conclusions.

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

real short-term interest rates from their trends based on Hodrick-Prescott filter as well as Taylor residuals, i.e. deviations of the short-term interest rate from its level consistent with different specifications of the Taylor (1993) rule. In the empirical testing of the risk- taking channel only the latter measures of monetary policy play a statistically significant role – in the case of the former ones we do not find any evidence of the operation of the risk-taking channel. Residuals from the monetary policy rules seem to us, however, adequate indicators of monetary policy given that they reflect the exoghenous part of monetary policy that is not related to economic conditions (cf. Maddaloni and Peydró, 2011; Dell'Ariccia et al., 2017; Delis et al., 2017).

To extract Taylor residuals we estimate 3 versions of the monetary policy rule, i.e. the Taylor rule with interest rate smoothing, the conventional backward-looking Taylor rule and the conventional forward-looking Taylor rule:

$$i_t = \kappa_0 i_{t-1} + (1-\kappa_0)[\kappa_1 + \kappa_2(\pi_t - \pi_t^{tar}) + \kappa_3 y_t] + \varepsilon_t \tag{2}$$

$$i_t = \kappa_1 + \kappa_2(\pi_{t-1} - \pi_t^{tar}) + \varepsilon_t \tag{3}$$

$$i_t = \kappa_1 + \kappa_2(\pi_{t+1} - \pi_t^{tar}) + \varepsilon_t \tag{4}$$

where i denotes the short-term interbank market interest rate (WIBOR 3M), π denotes core inflation (net of foodstuffs and energy), π^{tar} is the NBP inflation target, while y stands for the output gap. The output gap is statistically significant only in the monetary policy rule with interest rate smoothing, therefore we do not use it in the remaining specifications. Table 1 contains estimation results, while Figure 2 presents short-term interest rate and its deviations from the monetary policy rules.

2.4 Empirical specification

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

$$\Delta R_{i,t} = \alpha_i + \beta i_t + \sum_{j=1}^{4} \lambda_j \Delta R_{i,t-j} + \sum_{j=1}^{5} \gamma_j M_{t-1}^j + \sum_{j=1}^{6} \delta_j B_{i,t-1}^j + \sum_{j=2}^{4} \mu_j Q_t^j + \varepsilon_{it} \tag{5}$$

in which risk taken by a bank (ΔR_{it}) is regressed on its own lagged values, a measure of monetary policy tightness (a deviation of a nominal interest rate from the level implied by the Taylor rule), a set of control variables – related to macroeconomic environment (M_{t-1}^j) and characteristics of individual banks ($B_{i,t-1}^j$) – and quarterly dummy variables (Q_t^j). The set of control variables consists of both macroeconomic variables and individual bank characteristics. The former include the output gap (obtained from the Hodrick-Prescott filter), the quarterly change in nominal effective exchange rate (increase means appreciation), the slope of the yield curve (the difference between the 2-year Treasury bond yield and 1-month money market rate, WIBOR), the volatility of 2-year Treasury bond yield (realized volatility within a quarter) and the default probability

of corporations.[6] The second group of control variables consists of total assets (in log), the liquidity ratio (liquid assets[7] to total assets), the capital buffer (the ratio of excess bank capital over regulatory requirement to assets), the total deposits to total liabilities ratio, the loans to assets ratio, and the housing loans to total loans ratio. All control variables were introduced with a one-period lag to avoid potential endogeneity problems. The bank-level characteristics were normalized with respect to median in a given period (assets) or median in the whole sample (other variables).

The set of macro control variables is rather standard. The output gap measures 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 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 next control variable, slope of the yield curve informs about prospective monetary policy and economic activity. The intention of including in specification volatility of 2-year Treasury bond yields and default probability of corporations was to capture changes in risk not related to monetary policy. Inter alia, they account for the impact of the global financial crisis on borrowers' risk.

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 its capabilities to extend loans. Including loans ratio allows to control for growing importance of bank loans in financing of corporations and households, while the housing loans ratio accounts for the fact that this segment of loans was rapidly expanding in 2004–2008, inducing some banks to change their main area of activity.

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 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

[6] The default probability of corporations is calculated by Bloomberg for listed companies based on fundamental and market data with use of a quantitative model. As a measure of borrowers' risk we take median default probability of companies, excluding banks, over a 1-year horizon.

[7] 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.

problems related to use of alternative GMM estimators in applications when T is relatively large compared to N as in our case ($T = 52$, $N = 26$).

3 Main findings

In this section we describe estimation results for our two baseline measures of the risk taken by banks and residuals of the Taylor rules as a monetary policy measure. Nominal interest rates and real interest rates are considered in the next section and so is the third measure of risk, calculated on a shorter sample.

Table 2 reveals that excessively loose monetary policy goes together with higher risk taken by banks. Estimated value of parameter has negative sign and is statistically significant at conventional significance levels in all but one specifications.

Trying to assess the economic importance of the risk-taking effect, we decompose our measure of new risk into the part explained by monetary policy and the residual part, not directly related to monetary policy (Figure 3). It seems that the deviations of the short-term interest rate from its fundamental level impact on the risk taken on by banks only to a small extent. In particular, in the period since the onset of the global financial crisis, when NBP interest rates were dropped to the lowest levels on record, monetary policy inclined banks to take on less rather than more risk. Taking into account the course of economic processes so far, we therefore find no confirmation of the importance of the risk-taking channel in Poland. This finding is in line with the analysis for a panel of Central and Eastern European countries that provided no evidence on the existence of the risk-taking channel in this group of economies (Kouretas et al., 2013).

Trying to explain why, unlike in certain other economies, no symptoms of the operation of the risk-taking channel have been so far observed in Poland, we formulate the following hypotheses, which at the same time show that under certain conditions the channel could gain significance in the future.

Firstly, it could be supposed that the currently observed level of policy interest rates (1.5%) is not so low 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 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, in the case of the risk-taking channel, a threshold effect may occur, i.e. this channel may be activated when interest rates fall to a sufficiently low level. If this was really the case, the lack of observations of the risk-taking channel in the data for the Polish banking sector would mean that the measurements of monetary policy restrictiveness employed in the study had not reached the activation threshold. However, it cannot be ruled out that in the future, regardless

of the decisions regarding the conduct of monetary policy, structural changes in the economy and the financial system could cause a shift in such an activation threshold. For this reason, it is worth monitoring the possible appearance of the risk-taking channel as new data arrives.

Thirdly, the absence of a functioning 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 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 may also be evidence of banks' prudence. However, it should be noted that the behaviour of some smaller banks more poorly-equipped in capital, 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.

4 Extensions and robustness check

4.1 Other measures of monetary policy tightness

Empirical papers on the risk-taking channel of monetary policy often report that their results are robust to application of various measures of the monetary policy stance (eg. Altunbas et al., 2014). However, in Poland this is not the case. As presented in Figure 2, residuals from the Taylor rules indicate that the period of lax monetary policy occurred before 2010, while nominal interest rates have reached its historically low level in 2015 (and stayed there from then on). Given the problem with identifying the periods of loose and tight monetary policy from perspective of banks' attitude toward risk, it is important to check whether our results reported in the previous section hold when employing other measures of monetary policy stance.

Table 3 shows estimation results for short-term nominal interest rate and deviations of real interest rate from its natural level as a monetary policy measure.[8] In all the cases parameters' estimates are not statistically significant, indicating no relationship between monetary policy and risk-taking behavior of banks. Therefore, the impact of monetary policy on the bank risk-taking, resulting from estimates presented in the previous section, should be interpreted as the largest approximation (the worst-case scenario).

4.2 Alternative risk measure

So far we have presented the estimation results for two out of three risk measures described in section 3. Now we turn to the last measure, which has more ex ante character, but covers a

[8]The presented results refer to the real interest rate calculated with survey inflation expectations of non-financial corporates. However, we tried other measures of inflation expectations – survey expectations of consumers and survey expectations of professional forecasters – as well as the actual future CPI inflation as deflator with no effect on conclusion.

shorter time span. The results are to great extent consistent with the previous ones. Namely, they suggest negative relationship between risk taken by banks and monetary policy only if the latter is measured as deviations of interest rates from the level indicated by Taylor rule with interest rate smoothing (Table 4). In other cases (other specifications of the Taylor rule, nominal interest rate, real interest rate) the estimation results clearly show no such link.

5 Conclusion

In this paper we proposed a novel way 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, defined in the objective manner. Using alternative measures of risk we tested the operation of the risk-taking channel in the Polish banking sector.

Our estimates suggest that – depending on the measure of monetary policy applied – the risk-taking channel in Poland is either absent or relatively weak. More specifically, our proxies for the ex-ante risk react neither to nominal nor real short-term interest rates, however, the impact of Taylor residuals, i.e. the exogenous part of monetary policy, on risk is statistically significant. Since the outbreak of the financial crisis, when nominal NBP interest rates were lowered, reaching all-time lows, Taylor residuals usually have stayed close to zero, being even positive in some monetary policy rule specifications. It means that monetary policy have recently inclined banks to reduce risk rather than encouraging them to take on more of it.

We offer different explanations for a weak evidence on the functioning of the risk-taking channel in the monetary transmission mechanism in Poland. First, even if the nominal short-term interest rate has been relatively low recently, their level (1.5%) can be still excessively high to make banks search for yield at the price of accepting more risk. Second, high capital buffers held by banks suggest that they are risk-averse, making the risk-taking behavior less likely. Third, the period of low nominal short-term interest rates accounts only for approximately one fourth of the sample period, therefore revealing the operation of the risk-taking channel can be problematic from the statistical view point.

The latter observation implies that extending the sample period with new observations from the environment of low interest rates constitutes the most important extension of this paper.

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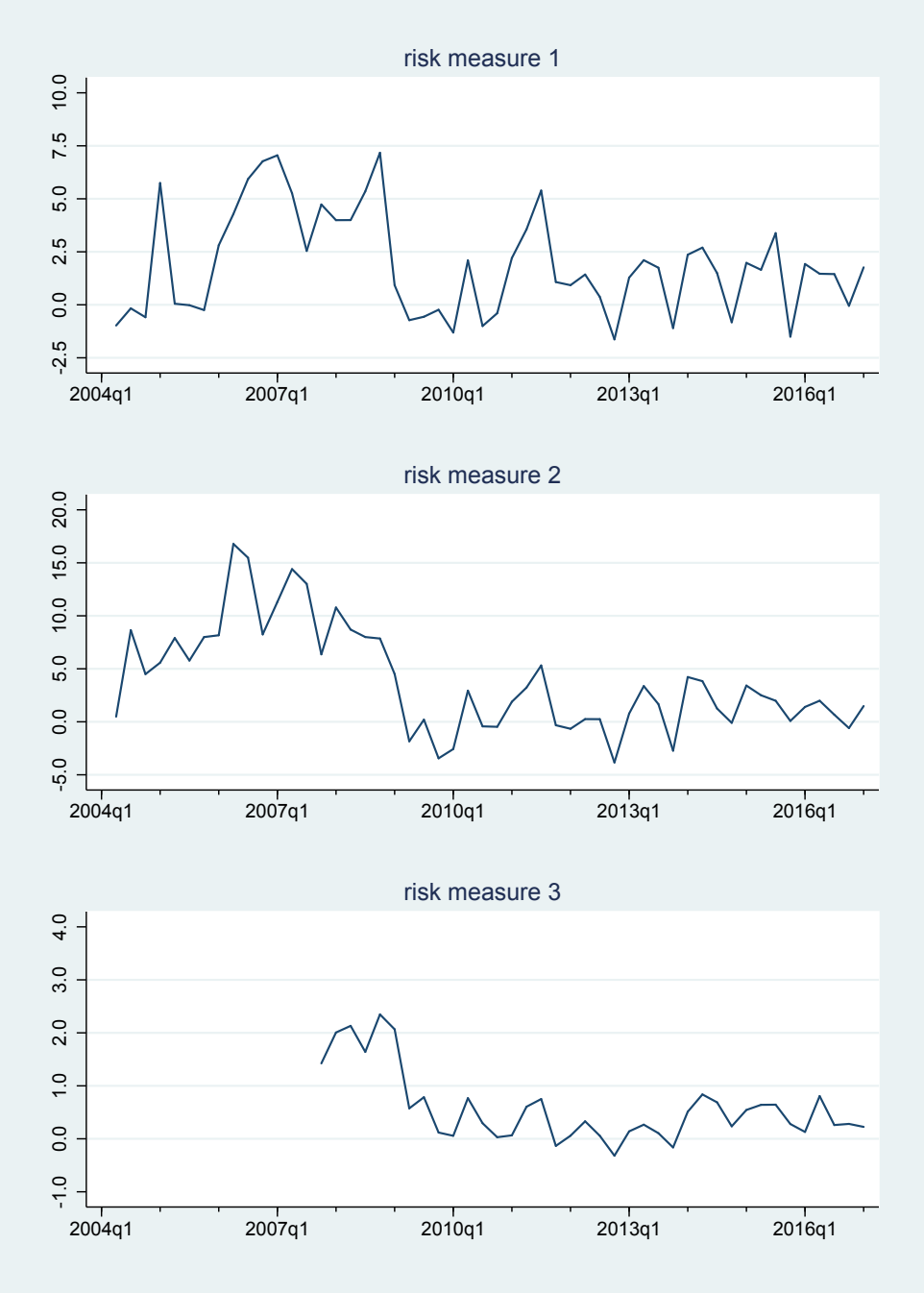
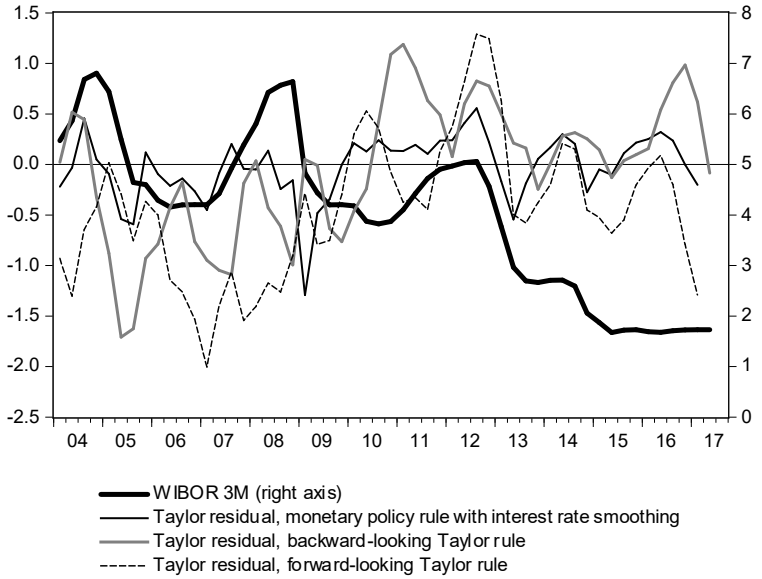
Figure 1. Measures of risk



Note: Median across banks in the sample.
Source: own calculations based on NBP data.

Figure 2. Short-term interest rate (WIBOR 3M) and its deviations from monetary policy rules



Note: Source: own calculations based on NBP data.

Figure 3. Impact of low interest rates on new bank risk-taking

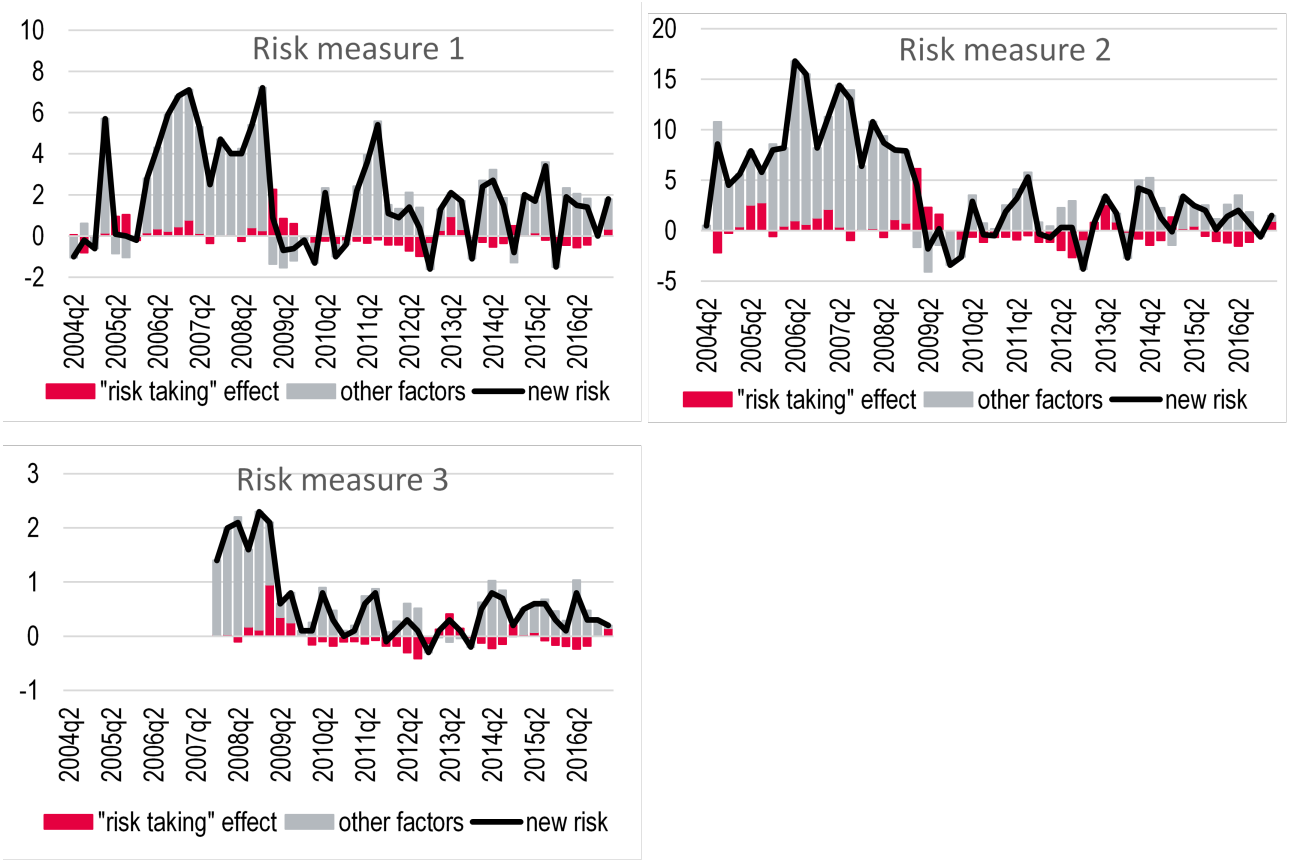


Table 1. Estimated monetary policy rules

	MPR with interest rate smoothing	Backward-looking Taylor rule	Forward-looking Taylor rule
κ_0	0.713***	x	x
	(0.009)		
κ_1	0.070***	0.074*	0.074***
	(0.001)	(0.001)	(0.001)
κ_2	1.217***	1.209***	1.041***
	(0.056)	(0.023)	(0.043)
κ_3	0.208***	x	x
	(0.039)		
R-squared	0.97	0.78	0.44

Note: All the above rules were estimated as a part of the Small Structural Model of Monetary Policy (MMPP) (Chmielewski et al., 2018). Estimating the model we use the Generalized Method of Moments (GMM) with past values of dependent variables (main endogenous variables of the model, i.e.: output gap, nominal effective exchange rate and core inflation) used as instruments. The results of the Hansen J-test show that the null hypothesis of valid overidentifying restrictions cannot be rejected. Newey-West HAC standard errors are reported in the parentheses. *, ** and *** represent statistical significance at the 10%, 5% and 1% levels, respectively.

Table 2. Estimation output – monetary policy measure: deviations from Taylor rule

	Taylor rule with interest rate smoothing		Backward–looking Taylor rule		Forward–looking Taylor rule	
	ΔR^1	ΔR^2	ΔR^1	ΔR^2	ΔR^1	ΔR^2
monetary policy rate (t)	-1.749**	-4.753**	-0.580	-1.712**	-0.758**	-1.609***
	(0.864)	(2.067)	(0.495)	(0.674)	(0.311)	(0.574)
output gap (t-1)	0.004	0.298	-0.006	0.297	-0.172	-0.133
	(0.393)	(0.621)	(0.335)	(0.587)	(0.377)	(0.630)
ΔNER (t-1)	0.171***	0.285**	0.143***	0.202	0.182***	0.301**
	(0.0414)	(0.127)	(0.0356)	(0.131)	(0.0420)	(0.128)
slope of yield curve (t-1)	1.233**	0.812	1.182**	0.694	0.749	-0.294
	(0.543)	(0.824)	(0.555)	(0.763)	(0.554)	(0.815)
volatility of bond yields (t-1)	22.23	-6.986	34.49**	27.15	31.61**	21.02
	(15.22)	(26.32)	(13.75)	(18.60)	(14.16)	(17.44)
default prob. of corporations (t-1)	-17.43***	-23.00***	-17.74***	-24.06***	-14.78***	-17.52**
	(5.076)	(7.449)	(4.936)	(7.355)	(5.051)	(7.851)
assets (t-1)	-2.567	-1.445	-2.603	-1.733	-2.971	-2.040
	(1.753)	(3.935)	(1.954)	(3.498)	(2.005)	(3.486)
liquidity (t-1)	-0.0717	0.108	-0.060	0.143	-0.061	0.131
	(0.0745)	(0.129)	(0.076)	(0.140)	(0.079)	(0.120)
capital buffer (t-1)	-0.088	0.138	-0.068	0.192	-0.113	0.0775
	(0.148)	(0.271)	(0.158)	(0.264)	(0.147)	(0.269)
deposits ratio (t-1)	0.092*	0.058	0.092*	0.057	0.086*	0.042
	(0.049)	(0.082)	(0.051)	(0.077)	(0.051)	(0.078)
loans ratio (t-1)	-0.120**	-0.096	-0.111*	-0.065	-0.111*	-0.076
	(0.056)	(0.092)	(0.059)	(0.099)	(0.060)	(0.091)
housing loans ratio (t-1)	0.091**	0.086	0.099**	0.111	0.099**	0.093
	(0.04)	(0.068)	(0.048)	(0.070)	(0.051)	(0.064)
risk (t-1)	0.289***	0.420***	0.290***	0.416***	0.289***	0.412***
	(0.052)	(0.095)	(0.049)	(0.096)	(0.049)	(0.093)
risk (t-2)	0.146***	0.161*	0.148***	0.163*	0.144***	0.160*
	(0.048)	(0.089)	(0.056)	(0.092)	(0.050)	(0.090)
risk (t-3)	0.089*	-0.079	0.090*	-0.074	0.085*	-0.079
	(0.052)	(0.085)	(0.054)	(0.087)	(0.050)	(0.087)
risk (t-4)	0.154***	0.324***	0.152***	0.319***	0.149***	0.318***
	(0.053)	(0.080)	(0.049)	(0.084)	(0.052)	(0.079)
N	820	820	820	820	820	820

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

Table 3. Estimation output –monetary policy measure: nominal interest rate (WIBOR 3M) and real interest rate

	Nominal interest rate		Real interest rate	
	ΔR^1	ΔR^2	ΔR^1	ΔR^2
monetary policy measure (t)	0.525	0.431	0.823	0.793
	(0.382)	(0.671)	(0.761)	(0.948)
output gap (t-1)	-0.354	-0.128	-0.338	-0.0107
	(0.512)	(0.918)	(0.586)	(0.811)
ΔNER (t-1)	0.133***	0.249*	0.126***	0.227
	(0.033)	(0.147)	(0.041)	(0.160)
yield slope (t-1)	1.230**	0.615	1.571**	0.927
	(0.563)	(0.798)	(0.664)	(0.801)
volatility of bond yields (t-1)	34.83**	28.23	34.44**	24.75
	(13.90)	(19.57)	(13.69)	(18.84)
default prob. of corporations (t-1)	-19.19***	-23.44***	-20.04***	-24.27***
	(5.258)	(8.812)	(7.061)	(8.621)
assets (t-1)	-2.294	-1.008	-2.446	-1.690
	(1.892)	(3.634)	(2.127)	(3.644)
liquidity ratio (t-1)	-0.051	0.128	-0.036	0.151
	(0.074)	(0.158)	(0.083)	(0.146)
capital buffer (t-1)	0.025	0.180	0.025	0.166
	(0.143)	(0.297)	(0.152)	(0.338)
deposits ratio (t-1)	0.101**	0.071	0.095*	0.069
	(0.051)	(0.090)	(0.055)	(0.085)
loans ratio (t-1)	-0.107**	-0.098	-0.099	-0.077
	(0.054)	(0.105)	(0.064)	(0.097)
housing loans ratio (t-1)	0.100**	0.083	0.114**	0.081
	(0.047)	(0.081)	(0.0546)	(0.088)
risk (t-1)	0.293***	0.428***	0.295***	0.419***
	(0.051)	(0.093)	(0.048)	(0.095)
risk (t-2)	0.153***	0.169*	0.152***	0.159*
	(0.054)	(0.091)	(0.051)	(0.090)
risk (t-3)	0.0950*	-0.0707	0.102*	-0.0692
	(0.052)	(0.086)	(0.060)	(0.083)
risk (t-4)	0.158***	0.321***	0.158***	0.317***
	(0.050)	(0.088)	(0.055)	(0.080)
N	820	820	820	820

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

Table 4. Estimation output – alternative risk measure (ΔR^3), various monetary policy measures

	Deviations from Taylor rule			Nominal IR	Real IR
	with smoothing	backward-looking	forward-looking		
monetary policy measure (t)	-0.741***	-0.132	-0.111	0.253	0.100
	(0.235)	(0.150)	(0.164)	(0.202)	(0.106)
output gap (t-1)	0.323***	0.255**	0.255**	0.086	0.174
	(0.112)	(0.120)	(0.121)	(0.115)	(0.113)
Δ NER (t-1)	0.090***	0.084***	0.093***	0.079***	0.086***
	(0.0259)	(0.031)	(0.030)	(0.030)	(0.027)
yield slope (t-1)	0.278**	0.229*	0.179	0.323**	0.224
	(0.136)	(0.128)	(0.140)	(0.157)	(0.144)
volatility of bond yields (t-1)	13.00***	19.39***	18.97***	20.88***	20.61***
	(4.601)	(4.962)	(5.052)	(4.708)	(4.774)
default prob. of corporations (t-1)	-1.171	-1.311	-0.834	-2.389*	-1.534
	(1.181)	(1.330)	(1.174)	(1.244)	(1.027)
assets (t-1)	-1.917	-1.949	-1.935	-2.215*	-1.863
	(1.292)	(1.198)	(1.339)	(1.145)	(1.155)
liquidity ratio (t-1)	0.000	0.002	0.000	0.002	0.002
	(0.028)	(0.035)	(0.029)	(0.033)	(0.032)
capital buffer (t-1)	-0.027	-0.024	-0.032	-0.012	-0.003
	(0.126)	(0.124)	(0.131)	(0.132)	(0.131)
deposits ratio (t-1)	0.023	0.023	0.021	0.024	0.029
	(0.029)	(0.031)	(0.029)	(0.028)	(0.028)
loans ratio (t-1)	-0.099	-0.099	-0.101	-0.101	-0.101
	(0.0793)	(0.081)	(0.080)	(0.077)	(0.081)
housing loans ratio (t-1)	0.031	0.030	0.029	0.031	0.031
	(0.022)	(0.019)	(0.023)	(0.022)	(0.022)
risk (t-1)	0.344***	0.345***	0.344***	0.339***	0.345***
	(0.116)	(0.110)	(0.121)	(0.109)	(0.113)
risk (t-2)	0.064**	0.068***	0.067**	0.061**	0.073***
	(0.027)	(0.023)	(0.031)	(0.025)	(0.027)
risk (t-3)	0.049	0.046	0.047	0.050	0.049
	(0.150)	(0.157)	(0.158)	(0.138)	(0.152)
risk (t-4)	0.014	0.008	0.010	0.004	0.006
	(0.108)	(0.100)	(0.102)	(0.101)	(0.0974)
N	519	519	519	519	519

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

Appendix 1: Risk weights of loans

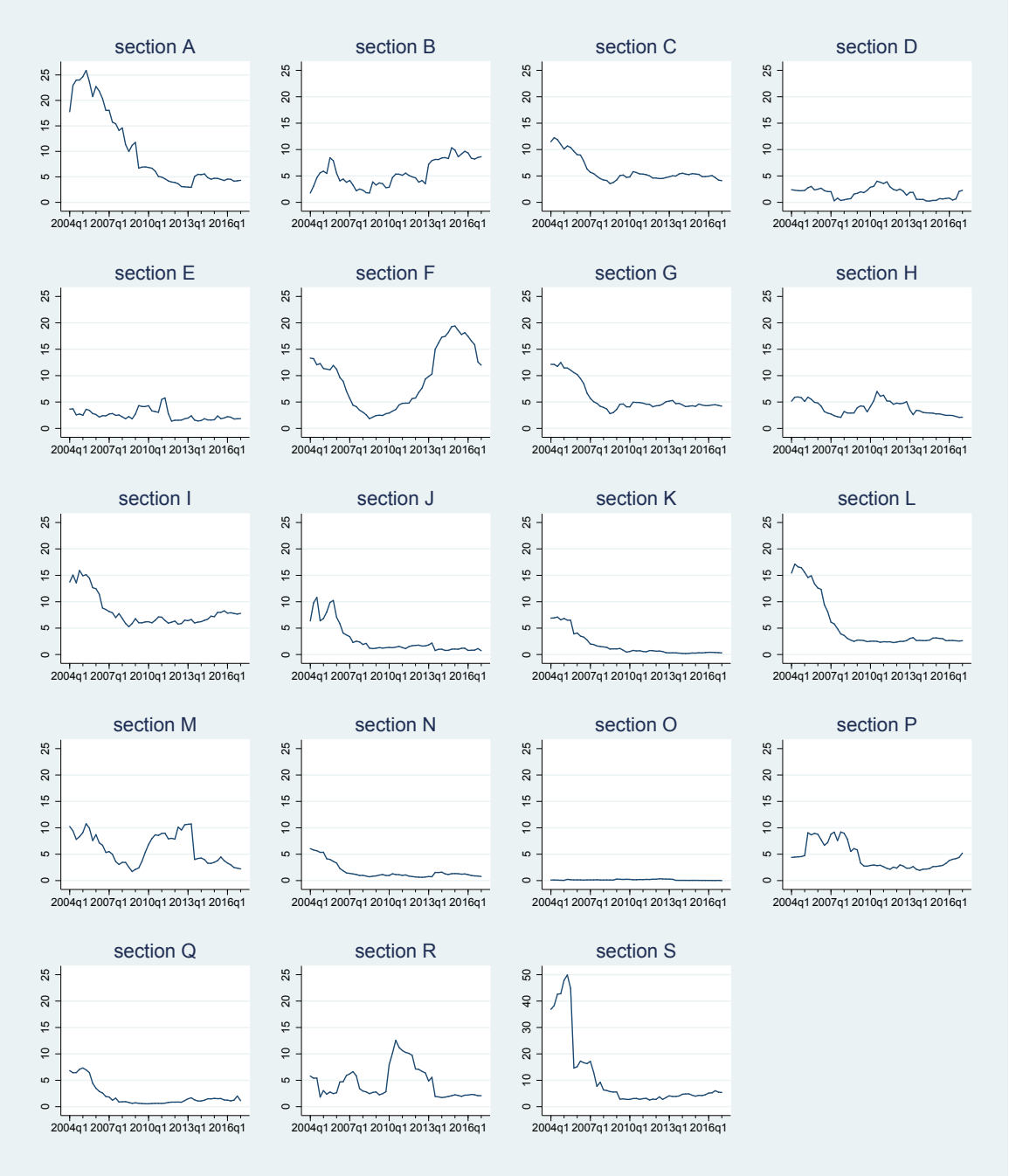
Assessing riskiness of given category of loans, we refer to a loan loss ratio (loan loss reserves to total loans) calculated it for each section of NACE Rev. 2 (the highest level of this classification, denoted with alphabetical code) based on granular data from reports on "large exposures" (our first 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.[9] 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 B shows loan loss ratios by sections over 2004q1–2017q1 period.

Next two figures display loan loss ratio and implied expected loss of business lines (Figure B and Figure C, respectively). Loan loss ratio of business lines is available for the whole analyzed period, while expected implied loan loss only for shorter sample. Also definitions of business lines differ slightly in both cases. These differences stem from changes in financial reporting in 2008 and 2010, which precluded calculation of implied loan loss prior to 2008.

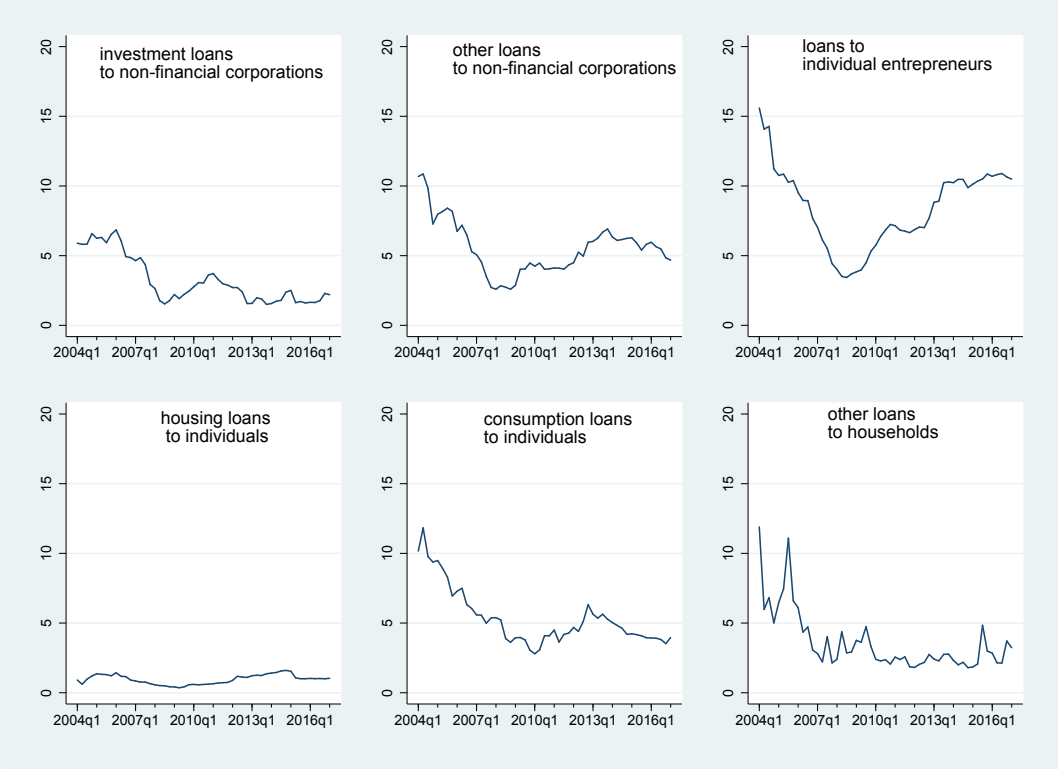
[9] NACE Rev. 2 has bounded since January 2008 with the first year being transitory.

Figure A. Risk weights of loans by sections of PKD 2007 (ratio of loan loss reserves to total loans, in %)



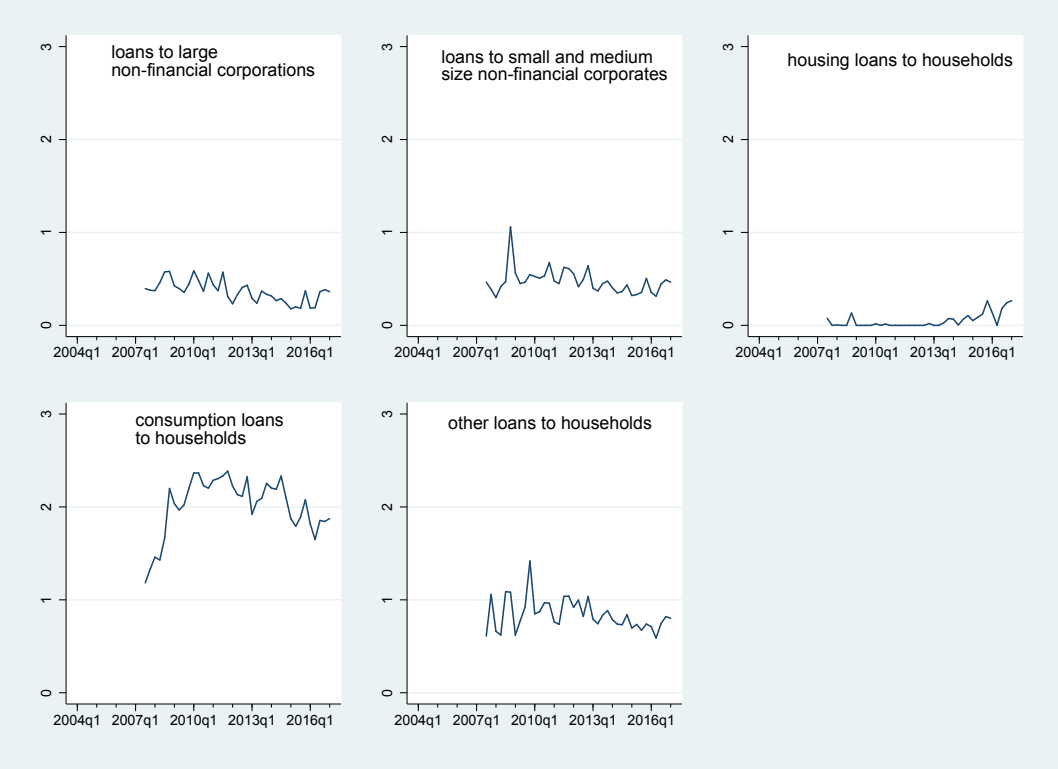
Note: A – Agriculture, forestry and fishing; B – Mining and quarrying; C – Manufacturing; D – Electricity, gas, steam and air conditioning supply; E – Water supply, sewerage, waste management and remediation activities; F – Construction; G – Wholesale and retail trade; repair of motor vehicles and motorcycles; 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 defense; compulsory social security; P – Education; Q – Human health and social work activities; R – Arts, entertainment and recreation; S – Other service activities;
Source: own calculations based on NBP data.

Figure B. Risk weights of loans by business lines (ratio of loan loss reserves to total loans, in %)



Note: Median across banks in the sample.
Source: own calculations based on NBP data.

Figure C. Risk weights of loans by business lines (implied expected loss, in %)



Note: Median across banks in the sample.
Source: own calculations based on NBP data.