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Abstract

Against the background of the policy interest in the interaction of monetary policy and macroprudential policy, we present empirical estimates of effects of macroprudential policies alongside monetary policy on banks' interest rate margins (net interest income/average assets). This is an important determinant of banks' profitability and accordingly their ability to accumulate capital, as well as a key aspect of the transmission mechanism of monetary policy. To our knowledge, such an analysis has not been undertaken in the research literature to date. The empirical results for a sample of over 1,300 banks from 15 advanced countries over 2000-13 suggest that the level and difference of interest rates and the yield curve affect the margin, in line with existing work. Meanwhile a number of macroprudential policy measures have an effect on the margin, firstly when they are introduced, secondly in levels and thirdly when leveraged in combination with the level of the interest rate. Some differences are found in the response of small and large banks to macroprudential policy but less so for monetary policy. We contend that these results are of considerable relevance to policymakers and regulators, notably in gauging the overall stance of macroeconomic policy.

Keywords: Macroprudential policy, monetary policy, short term interest rate, yield curve, bank interest margin.

JEL Classifications: E44, E58, G17, G28

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1. Introduction

In the macroprudential policy literature, there have been considerable debates on the interaction of macroprudential policy with a range of other policies, especially monetary policy. Constâncio (2015), for example, argued that macroprudential policy is essential in any economy because the business and financial cycles are not synchronised and monetary policy is not designed to deal with specific financial sector imbalances. This is supported by N'Diaye (2009), who, using a multi-country macroeconomic model for monetary policy analysis, saw that countercyclical prudential policy can help reduce output fluctuations and lessen the risk of financial instability. However, Agur and Demertzis (2015), using a bank-based model (profitability and leverage), concluded that there are times when monetary policy (expansionary interest rate policy) and macroprudential policies can partial offset each other and at the same time, monetary policy can affect financial stability adversely. They show that monetary policy rate setting affects banks' risk decisions through two channels, profit and leverage, with countervailing effects.

To cast further light on these issues, we explore the effects of monetary and macroprudential polices on banks using a model of banks' net interest margin with a sample of 1,300 banks from 15 advanced countries over 2000-13. Levels and changes in the margin are an important determinant of banks' profitability and accordingly their ability to accumulate capital with implications for financial stability. It is also a key aspect of the transmission mechanism of monetary policy, whereby for example recent low interest rates and flat term structures have been driven by monetary and quantitative easing and have affected bank margins, while also potentially stimulating lending.

To our knowledge, the effect of macroprudential policies on banks' margins, either separately or in the context of monetary policies, has not been explored in the literature to date. The paper is structured as follows: Section 2 provides a literature survey, Section 3 introduces the analytical framework and Section 4 shows the data and descriptive statistics. Section 5 shows the results and Section 6 shows robustness checks, while Section 7 concludes.

2. Literature survey

Constâncio (2015) argued that macroprudential policy is essential in any economy as the business and financial cycles are not synchronised, while monetary policy simultaneously affects all sectors of the economy and can therefore be an ineffective tool to cope with specific imbalances in the financial sector. Independently addressing financial stability concerns, macroprudential policy provides monetary policy with additional room for manoeuvre to better focus on ensuring price stability.

N'Diaye (2009) suggested that countercyclical prudential policy can help reduce output fluctuations and lessen the risk of financial instability, which can allow monetary authorities to achieve the same output and inflation objectives but with smaller adjustments in interest rates. In some instance, there could be a supporting role of macroprudential policy to monetary policy. He used a standard multi-country macroeconomic model for monetary policy analysis for the period. The macro side, model includes an IS curve, a Phillips curve, an Okun's law relationship, a monetary rule, a yield curve, a modified uncovered interest parity, a labour income relationship, and several identities. On the financial side, the model is tailored to three sectors: corporate, households, and banks and is set up to accommodate up to 4 economies.

Further, Beau et al (2012), using a DSGE model incorporating financial frictions, heterogeneous agents and housing, analysed the interactions between monetary and macroprudential policies and the circumstances under which such interactions call for their coordinated implementation. They saw that conflicts between both policies were rather limited, on average, over the business cycle during the period under review 1985 to 2010. These conflicts depend on the nature of the shocks impacting the economy.

Antipa and Matheron (2014) reviewed potential tensions between monetary and macroprudential policies given overlapping impacts. They used a DSGE model calibrated to Euro Area data with a financial friction manifested in a collateral constraint. Macroprudential policy affects this constraint cyclically and the work entails investigation of the zero lower bound for interest rates (ZLB). Results include the following. First, macroprudential policies can act as a useful complement to monetary policy during crises, by attenuating the decrease in investment and, hence, output. Second, forward guidance is very effective at the ZLB, by providing a substantial boost to demand and reducing the costs of private deleveraging at the same time. Third, countercyclical macroprudential policies do not undo the benefits of forward guidance, but rather sustain them.[1]

On the other hand, Agur and Demertzis (2015), using a bank-based model (profitability and leverage), found some potential tensions. They noted that bank-based models highlight the various types of channels through which monetary policy affects the financial sector. These include the incentives of banks to monitor, the screening of borrowers by banks, the skewness of bank returns and the impact on information asymmetries. It also relates to the incentives of bank loan officers or asset managers whose incentives deviate from profit maximization, the impact on nominal contracts between banks and creditors that cannot be made state-contingent and moral hazard when policy rates are used as a bailout mechanism. They saw that with the presence of macroprudential policy, there is at times a partial offsetting of monetary policy (expansionary interest rate policy) and at the same time, monetary policy can affect financial stability (e.g. the Latin debt crisis of the early 1980s and loose monetary policy in the 2000s leading up to the subprime crisis).

Turdaliev and Zhang (2019) outlined a small open-economy DSGE model featuring a banking sector, where financial frictions are explicitly modelled and two types of households with heterogeneous preferences over saving and borrowing. They estimated it for Canada and suggested a macroprudential approach to reducing household indebtedness is most appropriate, because monetary policy that reacts to household debt increases inflation volatility and lowers borrowers' welfare. In contrast, using macroprudential policies such as lowering the loan-to-value ratio limit increases borrowers' welfare.

Researchers have accordingly presented arguments showing where both policies can co-exist as well as work in conflict to each other. In the conflicting cases, policy makers may have to determine which policy is more effective in achieving the financial and economic objective of policy makers at the time. Additionally, there may be cases where both monetary and macroprudential policies may have to be suppressed to allow fiscal policy to be more effective

[1] We note that for a number of years from 2012 onwards, central banks in Switzerland, Sweden, Denmark, Japan and the euro area reduced their key policy rates below zero for the first time in economic history. In the wake of this, some banks, notably in the Eurozone, have charged negative rates for large corporate deposits, reflecting negative rates on the European Central Bank's Deposit Facility Rate (DFR) after July 2014. Altavilla et al (2019) show that this has not tended, at least in their estimation period up to 2018, to lead to a fall in funding, and that banks that offer negative rates provide more credit than other banks. They suggest that this shows that the transmission mechanism of monetary policy is not hampered.

in a declining economy. On the other hand, political consideration of the government should not undermine financial stability for political gains as the cost of financial sector failure can be very high. In this overall context, the strong appetite by policy makers for the development and incorporation of macroprudential policy in the regulatory framework makes their impact all the more important to evaluate.

The effect of monetary policy on the margin is a consequence of its impact on the interest rate structure, as well as on wider macroeconomic conditions. Central banks directly control short term rates, and influence long rates via their effect on market expectations of future short rates, and through direct purchases of long-term bonds intended to influence the long-term interest rate. The recent low short and long rates driven by monetary and quantitative easing are an example. The margin is not only important for financial stability but also for the impact of lending and deposit rates on the wider economy.

As regards empirical work on determinants of the margin, early work by Demirguc-Kunt and Huizinga (1999) using bank-level panel data for 80 countries over 1988-95 found a positive effect of the level of the short rate on banks' margins but they did not test for the yield curve or for first-differences. English (2002) studied the link of the yield curve to bank profits in ten countries, country-by-country, over 1979-2001 and found that a positive yield curve boosts bank margins in the US but there are significant negative effects in a number of other countries. Changes in short rates and the yield curve were not widely significant. Gambacorta (2008) studying large Italian banks, found that rises in short term interest rates affect deposit and loan rates similarly but the long-term effect is greater for the loan rate, thus boosting bank margins. Albertazzi and Gambacorta (2009) found the long rate to be significant in determination of margins but not the short rate in a study using aggregate data for banking sectors in 10 industrialized countries over the period 1981–2003.

As regards more recent work on interest rate effects on the margin, Alessandri and Nelson (2015) presented a model of a monopolistically competitive bank subject to repricing frictions and tested it in a sample of UK banks from 1992-2009. The model's expectation is that the margin will be positively related to the short term interest rate as banks raise loan rates due to their market power in the loan market and reduce lending quantities. A steeper yield curve should also boost the margin because the maturity of assets tends to exceed that of liabilities, while banks' monopoly power in loans exceeds that in the debt market (although in the long-run this should be limited to the term premium). In this context, note that the margin as measured does not include the offsetting profits from hedging or revaluations from holding trading instruments, both of which are part of non-interest income.

Their model also shows that there may be a short term negative effect from rising interest rates and yield curve differentials, an effect that had not been tested in earlier work. This short term effect might arise if interest rates are sticky in the short term (as in the model of Gerali et al 2010[2]) so banks are exposed to repricing and yield curve risks as identified by Basel Committee (2004, updated 2016). A rise in short rates might lead to narrower margins as the deposit rate rises relative to the loan rate in the short term (as loans are longer maturity than deposits). A change in the term structure might also reduce the margin as long-term debt might reprice faster than long-term loans.

In their empirical work, the dependent variable is the net interest margin defined as net interest income as a proportion of assets. As regards independent variables, besides the current level and difference of the short rate and the yield curve, Alessandri and Nelson (2015) used leverage and balance sheet growth as bank-level controls and GDP growth as a macro control, together with a profit-volatility measure and sector concentration. A lagged dependent variable was found to be significant and most estimation was by panel OLS with fixed effects (although estimates with system GMM were also presented). Bank-specific variables were lagged by one period to reduce issues of endogeneity, while the macro variables were taken as levels, being assumed to be exogenous to the individual bank.

They found indeed that the levels of the short rate and the slope of the yield curve are positively related to the margin, while differences (level or lag) are significant and negative. This is seen to confirm the hypothesis of repricing frictions. It implies the policy of close to zero short rates and the asset purchases of the period after 2008 would tend to reduce bank margins with potential adverse effects on financial stability. This is because banks' profits are reduced and hence capacity to accumulate capital by retentions. Meanwhile, although some results suggest interest rate effects apply to a measure of the overall return on assets, they are absent for the return on equity, which the authors suggest implies that higher leverage compensated for the fall in margins over the estimation period.

[2] In the DSGE model of Gerali et al. (2010) there is an imperfectly competitive banking sector with an imperfect pass-through from policy rates to loan rates due to pricing frictions, as also suggested by Alessandri and Nelson (2015). Banks limit the effect of transitory monetary policy shocks, mostly because of stickiness in bank interest rates.

Another recent study by Borio et al (2017) used data on 109 major international banks from 1995-2012. They again found a positive relation between both the level of the short rate and the yield curve slope and the net interest margin, which carries through to overall profitability. They also allowed for non-linearities in the relation of interest rates to bank profitability by means of squared terms for both short rates and the yield curve. They found that the impact on profitability declines with the level of interest rates and the slope of the yield curve, so the impact of interest rates on bank profitability is largest when they are low, as in the period since 2008.

Further mechanisms were suggested for the link of the short rate to the margin, notably the retail deposits endowment effect which is linked to imperfect adjustment of deposit rates (and the existence of zero interest sight deposit) which benefits banks when inflation and hence short rates are high, but which limits profitability when they are low. On the other hand, there may also be quantity effects on the margin when rates rise which are negative if loans are more price elastic than deposits. Changes in the yield curve slope may also have quantity effects via the volume of fixed rate mortgages.

As in Alessandri and Nelson (2015), estimation defined the margin as net interest income relative to total assets. As noted, the short rate and the yield curve were complemented by squares of them, to allow for non-linearities. Interest rate measures for international banks in the sample allow for the breakdown of their funding sources by currency. Controls were bank size, leverage ratios, liquidity to total assets, the share of short term liabilities, the cost-income ratio and bank asset volatility. As for Alessandri and Nelson (2015), the bank-specific variables were lagged and in this case the main estimates use GMM. The main results for the short rate and yield curve slope were as for that paper, namely a positive effect, while each of the quadratic terms were negative, implying a disproportionate effect on the margin when rates are low, greater than for the linear model of Alessandri and Nelson (2015).

Bikker and Vervliet (2017) sought to investigate the effect of low interest rates since the subprime crisis on the profitability of US banks, including the interest rate margin. Consistent with the above papers, they found that low short rates reduce the interest rate margin and there are also concavities increasing the effect at very low rates as in Borio et al (2017). This could relate to a zero lower bound for deposit rates. A low long rate also reduces the margin, albeit less powerfully than the short rate. They found that the effect of interest rates on overall profitability was recently offset by lower provisioning, thus potentially making banks more vulnerable to future loses, but they did not find evidence of greater risk-taking.

As noted, to our knowledge there are no published articles that focus on the effect of macroprudential policy on banks' margins, either alone or in combination with monetary policy. This is the major contribution of the current work. However, Davis et al (2020) do analyse the effect of macroprudential policy on banks' overall profitability, as shown by the return on average assets and the return on average equity, with empirical estimates for a sample of 6,010 global banks. These suggest that over 2000-2013, a number of measures of macroprudential policy had a negative and significant effect on banks' profitability, as well as the summary measure of total macroprudential instruments and the summary of macroprudential instruments focused on the borrower. Furthermore, they found that effect of macroprudential policy on banks' profitability varied between advanced and emerging market economies, with some differences also apparent between retail and universal banks.

Note, however, that we would not expect there to be identical effects of macroprudential policies on margins as on overall profitability, since the latter is also influenced by non-interest income, provisioning and non interest expenditures. All of which could also be influenced by macroprudential (and monetary) policies in contrasting ways; Genay and Podjasek (2014), for example, show how US banks have substituted between these sources of profitability in the light of low interest rates.

Concerning potential effects of macroprudential policies on margins, one may suggest the following on a priori grounds: Loan-to-Value Ratio might be expected to reduce the margin as high LTV loans would tend to have higher interest rates than lower leverage loans and other assets. Similar comments could be made for higher-risk customers excluded by debt-to-income ratio limits.

Capital based policies such as time-varying/dynamic loan-loss provisioning, general countercyclical capital buffer/requirement, leverage ratios and capital surcharges on SIFIs might be expected on the one hand to raise the margin as banks would need to generate more net income in order to set aside necessary reserves. On the other hand a countervailing factor is that risk based measures of capital adequacy aim to limit growth of risky assets which would tend to shrink margins. This aspect would not apply for the leverage ratio, however, since it is not risk-adjusted.

Limits on Interbank exposures could lower the margin since banks might be forced to seek more expensive forms of wholesale funding. Concentration limits should reduce margins as the policy seeks to exclude the most risky loans which gain high interest rates. Limits on foreign currency loans and on domestic currency loans directly limit specific types of assets and may thus raise the margin, especially if they promote risk-taking on other assets.

The effect of reserve requirement ratios, by obliging banks to hold more low-return assets than they would otherwise, is to reduce the margin unless there is an offsetting rise in risk in the rest of the asset portfolio. A levy/tax on financial institutions might be expected to lead banks to raise the margin to compensate for the lower profits that would otherwise be obtained. As regards the overall summary measures of macroprudential policy, we would expect them to accompany a fall in the margin if the overall aim of reducing high-margin lending growth is to be achieved.

3. Analytical framework

In light of the above papers, we first seek to establish the relationship between monetary policy, other control variables and bank margins (defined as net interest revenue as a percentage of average assets, as in the works cited above). With this as a basis we can test the effect of macroprudential policy on the margin with appropriate controls, and also interaction between macroprudential and monetary policies.[3]

The net interest margin (NIM) is a measure of how successful a bank is in its portfolio investment decisions, that is the bank's interest spread between interest revenue from investment (loans/securities/liquid assets) and their interest expenses paid to lenders (depositors/wholesale funders/bond holders) scaled by assets. It can be seen as a key subcomponent of measures of overall bank profitability such as the return on average assets (ROAA) and the return on average equity (ROAE) which also comprise non-interest income, non-interest costs and provisions. Net interest income is typically twice the size of non-interest income.

[3] In the research literature analysing the relation between monetary policy and the financial sector, two types of models are used, 1) Dynamic stochastic general equilibrium macro models (DSGE) and 2) Bank-based model. Our approach belongs in the Bank-based model approach. See Agur and Demertzis (2015).

We note that interest rates are not normally included as independent variables in banks' profitability models measured by ROAA and ROAE in the research literature (see the survey and references in Davis et al (2020)[4]) but the effect of interest rates on the net interest margin is well established, as in the work cited above.

Our NIM model is largely based on the work of Alessandri and Nelson (2015). Accordingly we use the 3-month interbank rate (Rate) as a proxy for the monetary policy interest rate, while the yield curve (YSlope) is calculated as the difference between a 10-year government bond rate and the 3-month rate ($Rate^{10y} – Rate^{3mth}$).[5] Also, we include the difference of the short term interest rate (*DRate)* and the yield curve slope (*DYSlope)* in level and first lag as well as the lagged dependent variable (NIM(-1)) in the model, not least in the light of significant autoregression in the margin. This permits a clear separation between short rate and yield curve slope effects, respectively. Hence our model (using annual data) is:

$$NIM_{it} = \alpha_{it} + \beta_1 NIM_{it-1} + \beta_2 Rate_{ir} + \beta_3 DRate_{ir} + \beta_4 DRate_{ir-1} + \beta_5 YSlope_{ir} + \beta_6 DYSlope_{ir} + \beta_7 DYSlope_{ir-1} + \beta_8 Internal_{it-1} + \beta_9 Macro_{ijt-1} + \beta_{10} Industry_{ijt-1} + \varepsilon_{it} \quad (1)$$

where *i* denotes the individual bank, *j* refers to the country in which bank *i* operates *t* indicates time period. *Rate* and *YSlope* are, as noted, entered in level, first difference and lagged first difference to allow for short and long-run effects. Note that we consider it appropriate to include current levels of the interest rate variables since the interest rate margin of an individual bank is not likely to affect central bank decisions, and hence issues of endogeneity are not likely to arise. Since as discussed below we tested a range of variables other than interest rates, the terms β_8, β_9 and β_{10} in equation (1) represent vectors of coefficients and not individual coefficients.

Indeed, we tested a wider range of non-interest controls than Alessandri and Nelson (2015) or Borio (2017). These are drawn from the literature on bank profitability (see for example Petria et al (2013) Goddard et al (2013), Chronopoulos et al (2015), Saona (2016) and Korytowski (2018)) as employed in Davis et al (2020). These controls come in three groups denoted internal, macro and industry. These are tested in lagged form given the potential issue of endogeneity that arise especially for the internal variables. The internal variables are

[4] Testing showed that the central bank rate was not significant as a determinant of either the return on average assets or the return on average equity.
[5] Borio et al (2017) also used a similar approach.

respectively; bank size (LNSIZE), which is the logarithm of total assets; leverage (CAPITALADEQ) the ratio equity/total assets; credit risk (CRISK) measured by non-performing loans/gross loans; liquidity risk (LRISK) shown by gross loans/deposits; management efficiency (COSTINC) as shown by cost-income ratio of total operating expenses/total income; and diversification (DIVSIF) which is the ratio of non-interest income to gross revenue.

Industry-wide variables are twofold. The BCRISIS variable captures the presence of a banking crisis as defined by Laeven and Valencia (2018). It is a dummy variable and it is coded one in the year the crisis starts until the year it was over and is otherwise zero. LINDEX is the chosen competition variable, the Lerner Index, which varies bank-by-bank. Note that we do not employ the Panzar-Rosse H statistic unlike Schaeck and Cihák (2012), Davis and Karim (2019) and others, owing to some technical issues arising with this measure. [6] Finally, the macro variables comprise real GDP growth (GDPG) and CPI Inflation (INFL).

All variables are winsorised at 99% to avoid an impact of outliers, as is common in the literature on individual banks such as Davis and Karim (2019). Estimation is by panel OLS with bank-level fixed effects and we used White (1980) cross-sectional standard errors and covariance (corrected for degrees of freedom) to reduce the impact of heteroscedasticity (as in Davis and Karim (2019)). Bikker and Vielvelt (2017) similarly used a panel OLS approach with fixed effects, as did Alessandri and Nelson (2015) in the bulk of their regressions. Given use of lags for bank-specific variables, we contend that this approach is more appropriate and reliable than GMM. And as also argued by Mirzaei et al (2013), the use of lagged instrumental variables for GMM would imply further loss of degrees of freedom that would vitiate our results by markedly reducing the size of the unbalanced panel dataset.

Empirical testing of the model was undertaken using banks from 15 advanced countries, namely Austria, Belgium, Canada, Finland, France, Germany, the Netherland, Ireland, Italy, Japan, Portugal, Spain, Switzerland, United Kingdom and the United States. The types of banks included are universal commercial banks, retail and consumer banks, banks, wholesale banks, and Islamic banks. Investment banks and private banks are excluded due to different balance sheet and income structure as are bank holding companies, to avoid double counting. As in Claessens et al (2013), the number of banks for each country covers at least the top 100 banks

[6] Notably, Shaffer and Spierdijk (2015) show that under a variety of conditions, an H Statistic exceeding zero may still be consistent with substantial market power in banking; a value over zero can arise in a variety of oligopoly settings, all consistent with a positive Lerner Index.

based on total assets, or less if fewer banks exist on the Fitch-Connect database. The banking data collected are unconsolidated, which also allows for the reporting of foreign bank subsidiaries in each country. All financial statement data are annual and in US dollars.

Estimation for a wider range of countries was not feasible because for many countries the 3-month interbank interest rate and/or 10-year government bond yield are not readily available. Other estimates and approximations of monetary policy interest rates were tried in order to expand the sample such as monetary authorities' overnight rate, the reserve requirements rate, money growth and the bank interest rate spread but these models were difficult to interpret or highly insignificant.

Following earlier work, we expect that both the level of interest rates and slope of the yield curve (long-run effects) should be positively associated with higher net interest margin, while the differences (short-run effects) are expected to be negative. We contend that our estimates for monetary policy alone advance on existing papers due to a wider country coverage and/or more banks in the sample.

4. Data and descriptive statistics

Our bank-level data are sourced from the Fitch-Connect database, while the macro variables are from the IMF IFS. Table 1 below shows the descriptive statistics of the net interest margin baseline model variables for the model for the period 2000-2013. NIM has a mean of 3.57 per cent of total assets with a sizeable variance. It is far larger than non-interest income whose ratio to average assets is 2.1 per cent. Credit risk (CRISK), non-performing loans/ gross loans, is on average 9 per cent, with a small variation between the banks. Management efficiency (COSTINC) averages 42 per cent of total income, while non-interest income (DIVSIF) represents about 34 per cent of gross revenue. Average GDP growth over the period was about 1.4 per cent and the inflation rate was about 2.0 per cent. The average short rate in the sample is 2.1%, while the yield curve is 3.7% implying an average long rate of 5.8%. Finally, the Lerner Index (LINDEX) is positive, suggesting some degree of market power for banks.

Table 1: NIM baseline model variables descriptive statistics for the period 2000-2013

Variables	Mean	Median	Max	Min	StdDev	Obs
NIM (NIR/TAA) (%)	3.57	2.54	29.48	-1.919	4.41	11,676
LNSIZE (log)	21.873	21.843	27.211	15.843	2.610	14,975
LEV	0.137	0.071	1.266	0.001	0.220	13,160
CRISK	0.087	0.028	1.162	0.006	0.189	7,543
LRISK	2.415	0.900	152.947	0.007	9.372	11,625
COSTINC	0.420	0.351	3.176	0.002	0.470	12,660
DIVSIF (%)	33.627	28.465	142.618	-55.785	30.610	12,908
LINDEX	0.290	0.260	0.998	-2.312	0.595	7,138
BCRISIS						
GDPG (%)	1.404	1.772	9.456	-6.600	2.290	26,670
INFL (%)	1.957	2.097	5.591	-1.207	1.238	26,670
RATE (%)	2.129	2.105	5.993	0.052	1.644	26,669
YSLOPE (%)	3.707	3.972	8.118	0.730	1.359	26,603

Data Source: Fitch Connect, IMF and author calculations. Banking Crisis (BCRISIS) is a dummy variable and it is coded one in the year the crisis starts until the year it was over and is otherwise zero. The values are a ratio unless otherwise stated. Max – maximum, Min – minimum, StdDev - standard deviation. The variables are winsorised at 99% and in level.

As shown in Appendix 1, Table A.1.1., none of the variables are highly correlated except for the negative correlation between management efficiency (COSTINC) and the Lerner Index (LINDEX) at -0.745. Focusing on the correlations with the dependent variable, those with the short rate and the yield curve are very low. There is a negative correlation with asset size and diversification of around -0.2 and a positive one of around 0.6 with credit risk.

For macroprudential data, we used the IMF GMPI database for 2000-13 as introduced in Cerrutti et al (2015, 2017). The dataset covers 119 countries annually over 2000 to 2013 and this constrains the length of our overall dataset. There are 12 survey instruments and 2 additional derived instruments as well as three summary instruments in the publicly available dataset. The database of individual tools includes only categorical as opposed to numerical values for the macroprudential policies (i.e. they show simply whether the policy is applied with one for “on” and zero for “off”, not the severity of application). We are showing the effectiveness of tools as applied in practice across the countries concerned, given the typical intervention undertaken.

We used this data set since it covers all the countries that are included in the empirical analysis and it is based on survey data collected from official reporting agencies to the IMF such as central banks and financial sector regulatory authorities.[7] It has been extensively used in earlier studies of the effectiveness of macroprudential policy such as Cerrutti et al (2017), Carreras et al (2018) and Davis et al (2017). The frequency in the dataset is yearly. Table 2 shows the list of instruments in the IMF dataset with a description of its effect.

Table 2: Instruments in the IMF Dataset of Macroprudential Tools (2015)

Instrument	**Abbreviation**	**Effect**
Survey Instruments		
Loan-to-Value Ratio	LTV	Constrains highly levered mortgage down payments by enforcing or encouraging a limit or by determining regulatory risk weights.
Debt-to-Income Ratio	DTI	Constrains household indebtedness by enforcing or encouraging a limit.
Time-Varying/Dynamic Loan-Loss Provisioning	DP	Requires banks to hold more loan-loss provisions during upturns.
General Countercyclical Capital Buffer/Requirement	CTC	Requires banks to hold more capital during upturns.
Leverage Ratio	LEV	Limits banks from exceeding a fixed minimum leverage ratio.
Capital Surcharges on SIFIs	SIFI	Requires Systemically Important Financial Institutions to hold a higher capital level than other financial institutions.

[7] In contrast, the later 2016 database (Cerrutti et al 2016) only covers 64 countries and omits a number of key macroprudential policies such as the debt-to-income ratio and taxes on financial institutions.

Limits on Interbank Exposures	INTER	Limits the fraction of liabilities held by the banking sector or by individual banks.
Concentration Limits	CONC	Limits the fraction of assets held by a limited number of borrowers.
Limits on Foreign Currency Loans	FC	Reduces vulnerability to foreign-currency risks.
Reserve Requirement Ratios	RR	Limits credit growth; can also be targeted to limit foreign-currency credit growth.
Limits on Domestic Currency Loans	CG	Limits credit growth directly.
Levy/Tax on Financial Institutions	TAX	Tax on revenues of financial institutions.
Derived and summary Instruments		
Loan-to-value ratio caps	LTVCAP	Restricts to LTV used as a strictly enforced cap on new loans, as opposed to a supervisory guideline or merely a determinant of risk weights.
FX and/or Countercyclical Reserve Requirements	RRREV	Restricts to RR which i) imposes a wedge of on foreign currency deposits or ii) is adjusted countercyclically
All variables aggregated in total	MPI	Sum of MPIF and MPIB
Borrower-targeted instruments(LTV_CAP plus DTI)	MPIF	Sum of LTV_CAP and DTI
Financial-Institution targeted instruments	MPIB	Sum of other instruments, including RR_REV rather than RR and excluding LTV

Source: Cerutti et al (2015). Version February 24th, 2015. Notes: each survey instrument and derived variable is a dummy that takes on two values: 0 for no policy and 1 for policy in effect. The summary variables may exceed 1 depending on the number of policies in effect. The database covers a sample from 2000 to 2013 with annual data.

5. Empirical results

5.1 Baseline model

As noted, we use the same definition of the margin as Alessandri et al (2015) and Borio et al (2017) which is net interest revenue divided by average assets. Such a measure is also comparable with results in the literature on bank profitability which focuses notably on the return on average assets. The NIM model was evaluated using the Hausman's test to decide the appropriate model, that is between fixed and random effects model. The results of the Hausman test suggested that fixed effects model is appropriate, (NIM - Hausman test, X^2: 74.687, p-value: 0.00). Further, in order to examine the joint significance of the fixed effects (banks and/ with time effects), the fixed effect models are tested using the Likelihood Ratio test. The results are supported by the high statistical significance of the Likelihood Ratio test at 1%, 5% and 10% for banks fixed effect but time fixed effects are insignificant[8]. Accordingly, the NIM model was estimated with bank-level fixed effects with White's cross-sectional standard errors and covariance (corrected for degrees of freedom) for the period 2000-2013.

Table 3 reports the empirical results for the baseline model (see equation 1 above). The model is estimated using 1,366 banks with 7,412 observations over the period 2000-2013. The F-test indicates that the variables included in the models are statistically significant for explaining changes in bank profitability. The lagged dependent variable of 0.326 is highly significant. All six of the interest rate and yield curve terms are significant. However, the banking and macro variables other than the log of bank assets (LNSIZE) were tested and found to be insignificant in the model. As such they are excluded and not reported.

This is partly consistent with Alessandri et al (2015) and Borio et al (2017), that also found limited effects of bank-specific variables on the margin once interest rates were included, although Bikker and Vervliet (2017), estimating a static model without lagged dependent variable found a range of these variables significant. In our work, the insignificance of macro variables suggests that the direct effect of interest rates is sufficiently strong to not leave scope for any indirect effect of monetary policy via the state of the economy, at least within our

[8] A separate estimate including time fixed effects is included as a robustness check in Section 6.

sample. Meanwhile the bank-level fixed effects capture a range of bank-specific factors. Looking again at Appendix 1 we find that the variables in the parsimonious equation have low correlations.

Table 3: Regression results for the baseline model over 2000-2013

Dependent variable: Net Interest Revenue/Average total assets		
	Literature/our expected relation	Coefficient (t value)
Constant		4.87*** (2.9)
NIM(-1)	+	0.326*** (5.6)
RATE	+	0.319*** (3.6)
DRATE	-	-0.101* (1.7)
DRATE(-1)	-	-0.098** (2.3)
YSLOPE	+	0.237** (2.5)
DYSLOPE	-	-0.206*** (3.4)
DYSLOPE(-1)	-	-0.099** (2.5)
LNSIZE(-1)	+	-0.152** (2.1)
R-squared		0.596
R-squared (adj.)		0.504
F-statistic		6.5
Standard error		3.25
Prob(F-statistic)		0
Periods included		12
Cross sections included		1366
Observations		7412
Fixed effects		Cross section

Notes: The model was estimated with bank-level fixed effects with White's cross-sectional standard errors and covariance (corrected for degrees of freedom). NIM is the net interest margin, defined as net interest revenue over average assets; RATE is the three-month interbank rate; YSLOPE is the difference between the ten year government bond yield and the three-month interbank rate; LNSIZE is the log of bank assets. "D" indicates a first difference. Independent variables' coefficient values are reported and the t-statistics are reported in parenthesis below each estimated coefficient. *** significant at 1%, ** significant at 5%, * significant at 10%. The variables were winsorised at 99%.

The results in Table 3 show that that the level of the short-term interest rate (RATE) and the yield curve (YSLOPE) are significant and contribute positively to banks' net interest margin (NIM). This is consistent with our expectation and the research literature of Alessandri and Nelson (2015) as well as Borio et al (2017) and Demirguç-Kunt and Huizinga (1999). The effect of the short rate is markedly greater than that of the yield curve, implying a positive net effect of both short and long rates. These effects are indicative of banks' market power in loan markets and also the "endowment effect", as argued above. As a corollary, when short term rates are low, there is downward pressure on the net interest margin as banks lower loan rates and expand credit provision. The significant and positive effect of the level of the yield curve slope (YSLOPE) on NIM suggests the positive impact declines when the steepness of the curve is low as with quantitative easing. The significant lagged dependent variable suggest that past net-interest margins affect current earnings. It implies that the long-run effect of each level variable is about 50% greater than the levels coefficient shown in the table.

There are also short-term dynamic effects when interest rates change (as in Alessandri and Nelson 2015). The effect of the difference and lagged difference in the short-term interest rate (DRATE) and yield slope (DYSLOPE) are all significant and negatively related to the NIM. The negative short-run impact of interest rate changes suggests the presence of repricing frictions whereby increases in short-term interest rates initially compress banks' margin and only in the long-run, when repricing becomes possible, will higher interest rates contribute to higher NIM (Alessandri and Nelson 2015). Also, in an increasingly competitive banking market, banks competing on interest rate margin to attract customers may not move first, especially when there is a change (increase/ decrease) in short-term interest rate. Finally, bank size (LNSIZE) has a significant and negative effect on profit measured by NIM. Larger banks have narrower margins, possibly due to a more competitive environment (see also de Bandt and Davis 1999). This is consistent with results for the US of Bikker and Vervliet (2017) and for global banks by Demirguc Kunt and Huizinga (1999).

5.2 Results for macroprudential instruments

The macroprudential instruments were tested one by one using the NIM baseline regression model (as shown in Table 3) over the period 2000-2013 for the countries in the sample. Initially, the macroprudential instruments were lagged by one period similar to the banks and country specific independent variables in the model. The macroprudential instruments were also estimated as a current level and in level and difference, in parallel to the interest rate and yield curve in Table 3. It can be argued as for monetary policy that the degree of endogeneity for policy and the NIM of an individual bank vis a vis policy for the banking sector is low, and so a level term may be acceptable. The same argument, as noted, applies to the short term interest rate and yield curve.

Table 4 below shows the effect of the macroprudential instruments on the net interest margin model shown in Table 3. As noted above, the individual instrument variables are zero-one for policy off-on with no gradation for severity of application. The coefficients depict the impact on the margin of an average application of the policy in the countries concerned. Meanwhile the summary variables exceed one if more than one policy is applied at a given time.

Table 4: Macroprudential instruments' impact on net interest margin for the period 2000-2013

	(1)	(2)	(3)		
Macroprudential instruments	**Lagged level only**	**Level only**	**Level**	**Difference**	**Lagged difference**
Loan-to-Value Ratio (LTV)	0.159 (0.8)	0.137 (0.7)	0.05 (0.2)	0.103 (0.6)	0.577*** (3.1)
Leverage Ratio (LEV)	-0.515 (0.8)	-0.512 (0.8)	-0.53 (0.7)	0.251 (0.9)	-0.175 (1.0)
Limits on Interbank Exposures (INTER)	-1.09*** (3.2)	-0.938** (2.4)	-1.2*** (3.6)	0.248 (0.5)	0.224 (0.5)
Concentration Limits (CONC)	-0.433 (0.6)	-0.515 (0.8)	-0.49 (0.6)	0.468 (1.4)	-0.165 (0.7)
Levy/Tax on Financial Institutions (TAX)	-0.819*** (2.6)	-0.68* (1.8)	-1.119** (2.1)	0.4 (0.8)	0.417 (0.8)
Limits on Foreign Currency Loans (FC)	0.159 (0.6)	0.332 (1.2)	0.484* (1.8)	-0.674*** (4.4)	-0.511*** (4.2)
Loan-to-value ratio caps (LTVCAP)	0.735*** (5.0)	0.668*** (2.9)	0.793*** (3.8)	-0.121 (0.5)	-0.029 (0.2)
All variables aggregated in total (MPI)	-0.235** (2.0)	-0.256* (1.9)	-0.273** (2.0)	0.116 (0.5)	-0.002 (0.1)
Borrower-targeted instruments (MPIB)	-0.269** (2.2)	-0.279** (2.0)	-0.297** (2.2)	0.106 (0.5)	-0.033 (0.2)
Financial-Institution targeted instruments (MPIF)	-0.317*** (2.7)	-0.319** (2.2)	-0.353*** (2.6)	0.099 (0.4)	0.03 (0.1)

Note: Estimation methods and control variables, including lagged dependent variables, are as in Table 3. The macroprudential instruments coefficient values are reported and the t-statistics are reported in parenthesis below each estimated coefficient. *** significant at 1%, ** significant at 5%, * significant at 10%. Debt-to-Income Ratio (DTI), Capital Surcharges on SIFIs (SIFI), General Countercyclical Capital Buffer/Requirement (CTC), Time-Varying/Dynamic Loan-Loss Provisioning (DP), Limits on Domestic Currency Loans (CG), and Reserve Requirement Measures (RR and RRREV) are excluded since they resulted in a near singular matrix which could be on account that they have not been used by many countries in the sample.

The results in Table 4 above suggest that the effect of some of the macroprudential instruments on banks' profitability measured by the net interest margin (NIM) is significant over the full sample period whether it is in lag (equation 1) or level (equation 2). We find a significant negative effect for both level and lag from limits on interbank exposures (INTER) and taxes on financial institutions (TAX) as well as all the summary variables all variables aggregated in total (MPI), borrower-targeted instruments (MPIB) and financial-Institution targeted instruments (MPIF). A positive effect is found only for loan-to-value ratio caps (LTVCAP). These are mostly in line with prior expectations (Section 2) except for results for LTVCAP and TAX.

Furthermore, in equation 3 with the level and the difference and lagged difference of the instruments, we have some additional significant effects for the difference, showing the short-run effect of the introduction of the policy. For limits on foreign currency loans (FC) the effects is to reduce the margin temporarily, although there is a weakly significant positive long-run effect in this case. There is also a difference effect for loan-to-value limits (LTV) to boost the margin temporarily, although the long-run effect as shown by the level remains insignificant. In all cases where the level or lag are significant in equations 1 and 2, it remains significant when the difference terms are included.

The introduction and maintenance of certain macroprudential policies is hence shown to impact on the margin both in the short and the long-run. We have found that in most cases the long-run effect of macroprudential policy is to narrow the margin and accordingly is to offset the long-run impact of monetary policy tightening (which widens it). In some cases, there is a short-run effect to accentuate (for FC) or offset (for LTV) the effect of increases in interest rates to narrow the margin.

Accordingly, if the aim of combined policy is to reduce credit growth (by higher interest rates and introduction of macroprudential policy measures) while not seriously affecting banks' profitability then to some extent this can be achieved, subject to potentially offsetting effects of macroprudential policy and monetary policy on other components of overall profitability. On the other hand, in the current environment of low interest rates and a flat yield curve that already puts pressure on bank margins, the negative additional impact of macroprudential policies risks to exacerbate the pressure on margins. This in turn reduces profits from which capital may be accumulated, with possible adverse implications for financial stability in the long-run.

5.3 Interaction between monetary and macroprudential policy

We now go on to look at the interaction between these two policies in respect of banks, since both are important for financial system stability. It will also help to understand further whether macroprudential policy is offsetting or complementing monetary policy.

First, we look at the individual relationship between both policies and their effect on the NIM. We look at the effect of the three-month interest rate (RATE) and the yield curve slope (YSLOPE), when macroprudential policy is included/ excluded from the NIM model. The estimations for the macroprudential instruments are in level to be consistent with the RATE since it is included in the model in level. Table 5 shows the summary results of the effects of monetary and macroprudential polices on the net interest margin when macroprudential policy is included/ excluded from the NIM model in levels (as in equation 2 in Table 4).

Table 5: Effects of monetary and macroprudential polices on the net interest margin for the period 2000-2013 (in level)

Variable	**RATE**	**YSLOPE**	**MPP**
Baseline model estimation excluding macroprudential instrument	0.319*** (5.6)	0.237** (2.5)	
Baseline model estimation including macroprudential instrument			
Loan-to-Value Ratio (LTV)	0.327*** (3.4)	0.241** (2.4)	0.137 (0.7)
Leverage Ratio (LEV)	0.302*** (3.2)	0.22** (2.2)	-0.512 (0.8)
Limits on Interbank Exposures (INTER)	0.216** (2.5)	0.173** (2.2)	-0.938** (2.4)
Concentration Limits (CONC)	0.308*** (3.2)	0.224** (2.2)	-0.515 (0.8)
Levy/Tax on Financial Institutions (TAX)	0.197*** (3.3)	0.17** (2.2)	-0.68* (1.8)
Limits on Foreign Currency Loans (FC)	0.324*** (3.5)	0.24** (2.5)	0.332 (1.2)
Loan-to-value ratio caps (LTVCAP)	0.353*** (3.8)	0.266*** (2.6)	0.668*** (2.9)
All variables aggregated in total (MPI)	0.208** (2.0)	0.157* (1.7)	-0.256* (1.9)
Borrower-targeted instruments (MPIB)	0.192* (1.9)	0.135 (1.4)	-0.279** (2.0)
Financial-Institution targeted instruments (MPIF)	0.198** (2.1)	0.153* (1.7)	-0.319** (2.2)

Note: Estimation methods and control variables, including lagged dependent variables, are as in Table 3. The coefficient values are reported and the t-statistics are reported in parenthesis below each estimated coefficient. *** significant at 1%, ** significant at 5%, * significant at 10%. The macroprudential instruments are in levels.

Table 5 shows that the interest rate coefficient in the equation without macroprudential policy is 0.319 with a t value of 5.6. Accordingly, the 95% confidence interval is from 0.433 to 0.205. The yield curve coefficient is 0.237 that with a t value of 2.5 which gives a confidence interval from 0.427 to 0.047.

When macroprudential instruments are included in the NIM model, there is some change in the effect of the three-month interest rate (RATE) on the margin, in most cases with decreases (the exceptions are LTV, LTV_CAP and FC with slight increases). The declines are particularly marked for the cases of interbank limits (INTER) and taxes on financial institutions (TAX) as well as the general effect of a range of policies namely all variables aggregated in total (MPI), borrower-targeted instruments (MPIB) and financial-Institution targeted instruments (MPIF). In all of these cases, the decline in the interest rate effect is close to or below the lower bound of the confidence interval. The beneficial effect of interest rates on the margin as markedly reduced in these cases, quite apart from the impact of the policies themselves on the margin. On the other hand, this implies that the adverse combined effect of low rates and macroprudential policies is reduced.

As regards the effect on the slope of the yield curve, there are again sharp declines for TAX, INTER, MPI and MPIF (not in this case outside the confidence interval). In contrast, the effect for MPIB is to render the slope effect insignificant.

These results suggest that macroprudential policy is having some effect via the size of short term interest rate and yield curve slope's impacts on banks' net interest margin, as well as having a significant direct effect in some cases. The change in the interest rate coefficients indicates possible omitted variables bias when the macroprudential variables are omitted, as in existing research.

We now go on to look at the interacted relationship effect between short-term interest rate (RATE) and macroprudential policy (MPP) and the impact it has on net interest margin. We use a leveraged coefficient for the combined relationship (monetary and macroprudential polices) to see whether their effects differ from the mean. We introduce the combined relationship of macroprudential policy and short-term interest rate as MPP* RATE in the NIM model. Leveraged coefficients were in levels as were the RATE and MPP variable. We use the NIM model in Table 3 to analyse the interaction between both policies. The results are in the following Table 6.

Table 6: Leveraged coefficients effect on net interest margin for the period 2000-2013

Variable	RATE	MPP	RATE*MPP
Baseline model estimation excluding macroprudential instrument	0.319*** (5.6)		
Baseline model estimation including macroprudential instrument and leveraged coefficient			
Loan-to-Value Ratio (LTV)	0.359*** (3.9)	0.356* (1.7)	-0.106*** (2.6)
Leverage Ratio (LEV)	0.412*** (4.3)	-0.343 (0.5)	-0.269*** (6.4)
Limits on Interbank Exposures (INTER)	0.22*** (3.0)	-1.078*** (2.8)	-0.0072 (0.1)
Concentration Limits (CONC)	0.337*** (3.5)	-0.385 (0.5)	-0.059* (1.7)
Levy/Tax on Financial Institutions (TAX)	0.206*** (3.2)	-0.757** (2.5)	-0.081 (1.0)
Limits on Foreign Currency Loans (FC)	0.33*** (3.5)	0.514* (1.9)	-0.504*** (3.0)
Loan-to-value ratio caps (LTVCAP)	0.356*** (3.9)	0.622*** (2.8)	0.122 (0.8)
All variables aggregated in total (MPI)	0.279** (2.3)	-0.185 (1.4)	-0.046* (1.9)
Borrower-targeted instruments (MPIB)	0.193* (1.8)	-0.268** (2.2)	-0.0038 (0.1)
Financial-Institution targeted instruments (MPIF)	0.179* (1.9)	-0.341*** (2.6)	-0.0354* (1.6)

Note: Estimation methods and control variables, including lagged dependent variables, are as in Table 3. The coefficient values are reported and the t-statistics are reported in parenthesis below each estimated coefficient. *** significant at 1%, ** significant at 5%, * significant at 10%. Other controls are as in Table 3.

As can be seen in Table 6 above, there are indeed some significant results for combined effects of macroprudential instruments and interest rates in the advanced countries. The leveraged coefficients on loan to value limits (LTV), leverage ratio limits (LEV),concentration limits (CONC), and foreign currency lending limits (FC) all have a significant negative effect on the NIM in combination with the interest rate. This is also the case for the summary variables MPI and MPIF. These results suggest that there is a smaller positive effect of interest rate on the NIM when the instruments are in operation, scaled by the level of the interest rate.

We suggest that the effect on the NIM is not zero because when credit is restricted by policies such as loan-to-value limits (LTV), leverage ratio (LEV), a concentration limit (CONC) and limits on foreign currency lending (FC), net interest income declines relative to the positive effect of interest rate on net interest margin. In terms of leverage (LEV) multiplied by the interest rate, which had a negative and significant effect on the NIM, this suggests a negative effect with the introduction of Basel III.

We note that the leveraged effect of LEV and CONC arises despite the levels coefficient being insignificant. This suggests that the combined effects of macroprudential instruments and interest rates are significant long-run determinants in banks' net interest margin even though the individual levels effects are not significant, whereas the levels coefficients for LTV and FC partly offset the negative combined effect.

Note that the leveraged coefficients have a major effect on the margin only when interest rates are positive. Accordingly, in the current environment of low short rates, the leveraged effect will not be sizeable. In this context, we show in Table 7 a ready-reckoner based on Table 6 for the individual macroprudential instruments and the short rate, showing the net long-run effect of the combined interest rate and macroprudential policy tools at three levels of the interest rate, namely 6% (showing a markedly tight policy), 3% (typical pre crisis) and 0.5% (typical post crisis). It is assumed that there is no change to interest rates, so the table shows the initial effect on margins from the macroprudential policy, and then the cumulative effect fed through the lagged dependent variable. We only calculate for significant coefficients of individual policies and bear in mind that the "policy-on" for the macroprudential instruments is one and the "policy off" is zero.

Table 7: Combined effect on the margin of macroprudential policy introduction at constant interest rate (percentage points)

	Initial effect of macroprudential policy: at different interest rates			Cumulative effect of macroprudential policy: at different interest rates		
	RATE=0.50%	**RATE=3%**	**RATE=6%**	**RATE=0.50%**	**RATE=3%**	**RATE=6%**
LTV	0.303	0.038	-0.28	0.450	0.056	-0.415
LEV	-0.1345	-0.807	-1.614	-0.199	-1.196	-2.391
INTER	-1.078	-1.078	-1.078	-1.590	-1.590	-1.590
CONC	-0.0295	-0.177	-0.354	-0.044	-0.263	-0.525
TAX	-0.757	-0.757	-0.757	-1.115	-1.115	-1.115
FC	0.261	-1.004	-2.522	0.387	-1.490	-3.742
LTVCAP	0.622	0.622	0.622	0.921	0.921	0.921

The table shows quite a marked variation in the overall effect on the margin from the combination of different macroprudential policies with a given interest rate. At 0.5% interest rates, most policies have a negative net effect, both initially and cumulatively, with the exceptions being loan-to-value limits (LTV and LTVCAP) and limits on foreign currency lending (FC). At 3% this is no longer true for FC, which is now negative, while the negative effect of the leverage ratio (LEV) and a concentration limit (CONC) is greater. At 6% it is only LTVCAP that has a positive effect, this is due to the absence of a leverage coefficient. The cumulative effect is greater depending on the size of the lagged dependent variable (which varies only slightly from 0.321 to 0.326 in the different equations).

Bear in mind that there is a positive effect of the interest rate, which is scaled by the level of the interest rate itself, and which is not included in Table 7. Calculations based on the estimate without macroprudential policy suggests that a sustained short rate level of 0.5% generates a 0.27% higher margin, while at 3% the effect is 1.6% and at 6% it is 3.2%. Table 7 shows that the effect of macroprudential policy is sufficient to fully offset these in some cases, putting downward pressure on margins.

6. Robustness checks

We ran four robustness checks to assess whether the results are stable to changes in the variable definitions, sample or specification. First, we replaced the three-month interbank rate in the level and the yield curve by the central bank policy rate. Second, we supplemented the bank dummies in the specification with time dummies. Third, we estimate separately for large and small banks. Fourth, we add a leveraged dummy for the 2008-2013 period for each macroprudential policy instrument to check whether the effect of macroprudential policies differed after the subprime crisis. Table 8 shows the results of re-estimation for the first three of these (the leveraged dummy uses Table 3 as a baseline).

Table 8: Regression results for the robustness checks over 2000-2013 (Dependent variable: Net Interest Revenue/Average total assets)

Robustness check	**Three-month interbank replaced by central bank rate**	**Time dummies as well as bank dummies**	**Large banks (above median log assets of 21.84)**	**Small banks (below median log assets of 21.84)**
Constant	5.101*** (3.1)	4.846*** (2.9)	2.383 (0.9)	2.501* (1.7)
NIM(-1)	0.328*** (5.5)	0.326*** (5.5)	0.256*** (3.1)	0.389*** (8.3)
RATE	0.307*** (3.4)	0.194* (1.8)	0.432** (2.4)	0.244*** (3.2)
DRATE	-0.132* (2.0)	-0.141 (1.3)	-0.121 (0.8)	-0.13* (2.7)
DRATE(-1)	-0.092* (1.7)	-0.112* (1.7)	-0.081 (0.7)	-0.233*** (6.7)
YSLOPE	0.263*** (2.8)	0.24*** (2.8)	0.33* (1.7)	0.085 (1.2)
DYSLOPE	-0.232*** (3.6)	-0.193*** (3.9)	-0.242* (1.9)	-0.174** (4.2)
DYSLOPE(-1)	-0.109** (2.2)	-0.136*** (2.8)	-0.158 (1.4)	-0.086** (2.0)
LNSIZE(-1)	-0.164** (2.3)	-0.142** (2.0)	-0.061 (0.6)	-0.022 (0.3)
R-squared	0.596	0.597	0.402	0.812
R-squared (adj.)	0.503	0.505	0.244	0.757
F-statistic	6.45	6.45	2.55	14.59
Standard error	3.26	3.25	3.97	2.23
Prob(F-statistic)	0	0	0	0
Periods included	12	12	12	12

Cross sections included	1350	1366	768	839
Observations	7350	7412	3715	3699
Fixed effects	Cross section	Cross section and period	Cross section	Cross section

Notes: The model was estimated with bank-level fixed effects with White's cross-sectional standard errors and covariance (corrected for degrees of freedom). Independent variables' coefficient values are reported and the t-statistics are reported in parenthesis below each estimated coefficient. *** significant at 1%, ** significant at 5%, * significant at 10%. The variables were winsorised at 99%.

We see from Table 8 that the baseline equation in Table 3 is not greatly changed by the substitution of the central bank rate for the three-month interbank rate, or by the addition of time dummies. The main changes are in the time dummies equation where the level effect of the interest rate is smaller and the current level first difference effect is not significant.

As regards the distinction of large and small banks, the overall interest rate and yield curve effects have the same sign for each variable (levels and differences) although the significant variables differ. We find that the level of the interbank rate is significant for both types of bank, although the long-run effect of interest rates on the margin is greater for large banks than small ones[9] (a similar difference was found for large and small UK banks in Alessandri and Nelson 2015). Large banks may have greater monopoly power in loan markets to pass on rate rises than small can, and may benefit more from the endowment effect. Furthermore, the level of the yield curve is only significant for the large banks (Alessandri and Nelson (2015) found a larger effect for large banks) consistent with greater monopoly power in loan relative to debt markets for large banks than for small ones.

Difference effects of the interbank rate are significant for small banks and not large ones suggesting repricing frictions are greater for small banks. Meanwhile changes in the yield curve are significant for both types of bank suggesting both face term debt that reprices faster than loans. The lagged dependent variable is highly significant for both sectors, and large for small banks, but the size variable is not, suggesting it captures the difference between size groups rather than within them.

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[9] The difference in coefficients on the level of the interest rate is greater than the offset from the size of the lagged dependent variable.

Table 9: Macroprudential instruments, impact on net interest margin for the period 2000-2013

	Three-month interbank replaced by central bank rate	Time dummies as well as bank dummies	Large banks (above median of 21.84 in log assets)	Small banks (below median of 21.84 in log assets)	Leveraged coefficient for the 2008-2013 period	
Macroprudential instruments	MPP	MPP	MPP	MPP	MPP	MPP* D0813
Loan-to-Value Ratio (LTV)	0.121 (0.6)	0.263 (1.2)	0.716*** (3.1)	-0.603** (2.2)	0.023 (0.1)	0.19 (1.2)
Leverage Ratio (LEV)	-0.765 (1.2)	-0.292 (0.4)	-2.04 (1.0)	-0.116 (0.5)	-1.365** (2.2)	0.987*** (5.6)
Limits on Interbank Exposures (INTER)	-1.153*** (3.4)	-1.08*** (3.0)	-2.697*** (3.6)	0.002 (0.1)	-1.19*** (3.4)	0.138 (0.6)
Concentration Limits (CONC)	-0.646 (0.9)	-0.322 (0.4)	-1.686 (0.8)	-0.018 (0.1)	-0.507 (0.7)	0.107 (1.0)
Levy/Tax on Financial Institutions (TAX)	-0.855*** (2.8)	-0.831** (2.4)	-1.978*** (2.7)	0.086 (0.5)	-0.841** (2.0)	0.023 (0.1)
Limits on Foreign Currency Loans (FC)	0.127 (0.5)	0.21 (0.9)	0.413 (1.1)	0.506** (2.3)	na	Na
Loan-to-value ratio caps (LTVCAP)	0.714*** (4.9)	0.789*** (5.2)	1.584*** (4.9)	0.042 (0.1)	1.471*** (3.9)	-0.747* (1.8)
All variables aggregated in total (MPI)	-0.283** (2.6)	-0.215* (1.7)	-0.724** (2.5)	0.024 (0.3)	-- 0.312*** (3.0)	0.093* (1.9)
Borrower-targeted instruments (MPIB)	-0.313*** (2.9)	-0.248* (1.9)	-0.824*** (2.9)	0.039 (0.5)	-0.253** (2.1)	-0.015 (0.2)
Financial-Institution targeted instruments (MPIF)	-0.367*** (3.4)	-0.307** (2.5)	-0.967*** (3.4)	0.033 (0.4)	-0.248** (2.1)	-0.079 (1.1)

Note: Estimation methods and control variables, including lagged dependent variables, are as in Tables 3 and 8. The macroprudential instruments coefficient values are reported and the t-statistics are reported in parenthesis below each estimated coefficient. *** significant at 1%, ** significant at 5%, * significant at 10%. Debt-to-Income Ratio (DTI), Capital Surcharges on SIFIs (SIFI), General Countercyclical Capital Buffer/Requirement (CTC), Time-Varying/Dynamic Loan-Loss Provisioning (DP), Limits on Domestic Currency Loans (CG), and Reserve Requirement Measures (RR and RRREV) are excluded since they resulted in a near singular matrix which could be on account that they have not been used by many countries in the sample.

Table 9 shows that the macroprudential policy effects (introduced as a current level) are little changed by the first two robustness checks. Apart from LTVCAP, the effects are slightly smaller in absolute terms for the time dummies' case, but the significant effects are the same in each case as the baseline in Table 4.

The effects differ between large and small banks. It is clear that most of the results for the sector as a whole are driven by the large banks. As in the full sample, their margins react negatively to limits on interbank exposures (INTER), taxes on financial institutions (TAX) and each of the three overall measures of macroprudential policy. They also link positively to caps on loan to value ratios (LTVCAP). There is also a contrast with the main results in that loan to value ratios are also significant and positive for large banks (LTV) while they are negative for small banks. The only other significant effect for small banks is a positive effect for foreign currency lending limits (FC). The wider effects on large banks is consistent with the overall aim of macroprudential policy to affect financial conditions at an economy wide level.[10]

As regards the leveraged dummy D0813, which is one for the period 2008-2013, the indication is that for INTER, TAX, MPIB and MPIF there is no difference between the pre- and post-crisis period, in terms of the relation of the instrument to the bank margin. However, in the case of the leverage ratio (LEV) which is insignificant over the full estimation period, we now find that there is a strongly negative effect in the pre-crisis period, which is largely cancelled out after the crisis. This may reflect the effect of Basel III. The loan to value caps policy (LTVCAP) has an

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[10] We repeated the bank-size exercise in Tables 8 and 9 for the largest banks (above the 75th percentile) and smallest banks (below the 25th percentile). See Appendix 2, Tables A.2.1 and A.2.2. Results are broadly similar to those shown above, with in this case that the smallest banks being somewhat more affected by the interest rate than the largest, while the results for macroprudential policies are similar to those in Table 9, with the exception that the smallest banks are not affected significantly by restrictions on foreign currency lending – their business is likely to be focused on the domestic currency.

opposite effect in that there is a strongly positive effect shown pre crisis, as in the full sample, but this is lower, albeit still positive, in the post crisis period. This may reflect differing competitive conditions in mortgage markets. Finally, the total effect of macroprudential policies (MPI) is negative throughout but somewhat less in the post crisis period.

On balance, we contend that the robustness checks tend to underpin the validity of the baseline results.

7. Conclusion

In conclusion, we suggest that there is shown to be a clear interaction between monetary and macroprudential policies in respect of banks' net interest margin, which in turn is an important aspect of the transmission mechanism of policy and potentially impacts on financial stability. There is a negative direct long-run effect of macroprudential policy on the margin for a number of macroprudential policies both individually and combined, and in some cases there is also an impact from introduction of macroprudential policies (i.e. also a short-run effect).

These policies will tend to offset the effect of higher interest rates on the margin, if both policies are introduced together in order to tighter credit. On the other hand, in the current environment of low interest rates that already puts pressure on bank margins, the negative additional impact of macroprudential policies risks to exacerbate the pressure on margins, that in turn reduces profits from which capital may be accumulated.

We find also that the presence of macroprudential policies affects the degree to which interest rates affect the margin, with the beneficial long-run effect being lower when several policies are in place. And there is a strong interaction effect of the policies, most of which strongly offset the impact of interest rates on the margin, both at low and high interest rates.

Overall, we have shown that macroprudential policies generally reduce the interest rate margin, consistent with a negative effect on overall profitability as found in Davis et al (2020), and there is an offsetting effect on monetary policy as measured by short-term interest rates and the yield curve. In the robustness checks there is some evidence of a lesser effect of macroprudential policies on the margin since the subprime crisis. Large banks' margins also appear to be more affected by macroprudential policies – and to some extent monetary policy - than those of small ones. Overall, however, the robustness checks underpin the validity of the baseline results.

We suggest that these results should be of considerable interest to policy makers seeking to assess the overall policy stance, given the impact of the interest margin and related bank lending and deposit rates on aggregate demand, notably consumption and investment. The implications for the interest margin are also relevant for financial regulators concerned about scope to accumulate retentions for building bank capital. There is a particular interest in these aspects given that low interest rates in the current conjuncture are shown to imply narrow bank margins, and also may entail asset price and lending developments that justify deployment of macroprudential policies.

Further research could seek to investigate interest rate and macroprudential effects on margins in emerging market economies, as well as the determination of other components of overall profitability, notably non-interest income. Is a negative impact of macroprudential policy on the margin offset by banks seeking higher non-interest income via fees and trading income? What is the effect of negative policy rates, which have been common since 2012, on the impact of macroprudential policy?

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Appendix 1

Table A1: Correlation matrix for the period 2000-2013 (all countries)

	NIM	RATE	YSLOPE	LNSIZE	LEV	CRISK	LRISK	COSTINC	DIVERSIF	LINDEX	BCRISIS	GDPG	INFL
NIM	1.000	0.023	-0.053	-0.215	0.054	0.598	-0.026	-0.012	-0.224	0.105	-0.012	0.016	-0.011
RATE	0.023	1.000	-0.636	0.108	-0.047	0.036	-0.005	-0.065	0.010	0.088	-0.227	0.510	0.484
YSLOPE	-0.053	-0.636	1.000	-0.042	0.061	-0.048	0.002	0.057	-0.011	-0.062	0.266	-0.492	-0.130
LNSIZE	-0.215	0.108	-0.042	1.000	-0.358	-0.110	-0.023	-0.384	-0.106	0.421	0.010	0.079	0.121
LEV	0.054	-0.047	0.061	-0.358	1.000	0.031	0.071	0.501	0.066	-0.488	0.060	-0.062	-0.002
CRISK	0.598	0.036	-0.048	-0.110	0.031	1.000	0.019	0.068	-0.006	0.026	-0.053	0.022	-0.043
LRISK	-0.026	-0.005	0.002	-0.023	0.071	0.019	1.000	-0.001	0.006	0.012	0.004	0.009	0.004
COSTINC	-0.012	-0.065	0.057	-0.384	0.501	0.068	-0.001	1.000	0.235	-0.745	0.020	-0.047	-0.079
DIVERSIF	-0.224	0.010	-0.011	-0.106	0.066	-0.006	0.006	0.235	1.000	-0.322	-0.059	0.014	-0.042
LINDEX	0.105	0.088	-0.062	0.421	-0.488	0.026	0.012	-0.745	-0.322	1.000	0.006	0.066	0.109
BCRISIS	-0.012	-0.227	0.266	0.010	0.060	-0.053	0.004	0.020	-0.059	0.006	1.000	-0.436	0.039
GDPG	0.016	0.510	-0.492	0.079	-0.062	0.022	0.009	-0.047	0.014	0.066	-0.436	1.000	0.313
INFL	-0.011	0.484	-0.130	0.121	-0.002	-0.043	0.004	-0.079	-0.042	0.109	0.039	0.313	1.000

Data Source: Fitch Connect, IMF and author calculations. Banking Crisis (BCRISIS) is a dummy variable. The variables are winsorised at 99% and in level.

APPENDIX 2

Table A.2.1: Regression results for the largest and smallest banks over 2000-2013 (Dependent variable: Net Interest Revenue/Average total assets)

Robustness check	**Largest banks (above 75th percentile log assets of 23.82)**	**Smallest banks (below 25th percentile log assets of 19.97)**
Constant	7.737 (1.3)	-0.01 (0.1)
NIM(-1)	0.236** (2.2)	0.352*** (6.6)
RATE	0.369* (1.8)	0.425*** (3.0)
DRATE	-0.051 (0.2)	-0.201*** (2.8)
DRATE(-1)	-0.2 (1.1)	-0.28*** (3.0)
YSLOPE	0.374 (1.5)	0.165* (1.7)
DYSLOPE	-0.218 (1.2)	-0.329*** (3.6)
DYSLOPE(-1)	-0.273* (1.7)	-0.145 (1.5)
LNSIZE(-1)	-0.27 (1.3)	0.133 (1.6)
R-squared	0.36	0.831
R-squared (adj.)	0.2	0.767
F-statistic	2.27	13.08
Standard error	3.93	2.53
Prob(F-statistic)	0	0
Periods included	12	12

Cross sections included	408	502
Observations	2088	1865
Fixed effects	Cross section	Cross section

Notes: The model was estimated with bank-level fixed effects with White's cross-sectional standard errors and covariance (corrected for degrees of freedom). Independent variables' coefficient values are reported and the t-statistics are reported in parenthesis below each estimated coefficient. *** significant at 1%, ** significant at 5%, * significant at 10%. The variables were winsorised at 99%.

Table A.2.2: Macroprudential instruments, impact on net interest margin for the period 2000-2013

	Largest banks (above 75th percentile log assets of 23.82)	**Smallest banks (below 25th percentile log assets of 19.97)**
Macroprudential instruments	MPP	MPP
Loan-to-Value Ratio (LTV)	0.52** (2.2)	-1.217*** (2.8)
Leverage Ratio (LEV)	-1.92 (1.3)	0.27 (0.5)
Limits on Interbank Exposures (INTER)	-2.578* (1.9)	0.404 (0.8)
Concentration Limits (CONC)	1.07 (0.6)	0.206 (0.4)
Levy/Tax on Financial Institutions (TAX)	-2.54** (2.1)	0.086 (0.2)
Limits on Foreign Currency Loans (FC)	0.488 (1.0)	0.645 (0.9)
Loan-to-value ratio caps (LTVCAP)	1.063*** (3.9)	0.142 (0.2)
All variables aggregated in total (MPI)	-0.806* (1.9)	0.134 (1.0)
Borrower-targeted instruments (MPIB)	-0.904** (2.0)	0.129 (0.9)
Financial-Institution targeted instruments (MPIF)	-1.06** (2.2)	0.133 (0.9)

Note: Estimation methods and control variables are as in Tables 3 and 8. The macroprudential instruments coefficient values are reported and the t-statistics are reported in parenthesis below each estimated coefficient. *** significant at 1%, ** significant at 5%, * significant at 10%. Debt-to-Income Ratio (DTI), Capital Surcharges on SIFIs (SIFI), General Countercyclical Capital Buffer/Requirement (CTC), Time-Varying/Dynamic Loan-Loss Provisioning (DP), Limits on Domestic Currency Loans (CG), and Reserve Requirement Measures (RR and RRREV) are excluded since they resulted in a near singular matrix which could be on account that they have not been used by many countries in the sample.