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Macroprudential policy, bank competition and bank risk in East Asia

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Abstract
We assess the relation of macroprudential policy and competition to bank risk for a sample of 1373 banks from 13 East Asian countries, using the IMF iMaPP dataset of macroprudential policy from 1990 to 2018. To our knowledge, this is the first paper to include both macroprudential policy and individual bank market power, as well as their interaction, as determinants of bank risk. On the one hand, we find direct effects of both macroprudential policy and competition on risk, in line with the existing literature. On the other hand, we detect important interaction effects. Notably in the developing and emerging East Asian countries, the interactions between competition and macroprudential measures often show a lesser response to such measures in terms of risk reduction for banks with more market power. We suggest that this links in turn to ability of such banks to undertake risk-shifting in response to macroprudential policy. We also find for banks in advanced East Asian countries—and in wider samples—some tendency in the long term for banks facing intense competition to take relatively more risks in face of macroprudential measures, in line with the traditional "franchise value" view of bank competition and risk taking. These findings have important implications for regulators.

Keywords Macroprudential policy · Bank risk · Z-score · Bank competition

JEL Classification E44 · E58 · G17 · G28

Introduction

Macroprudential policies, which seek to limit financial imbalances and generate robustness in the financial sector, have become an essential complement to monetary policy since the subprime crisis. However, macroprudential policies did exist before 2007 as well. Notably, East Asian countries were among the first to adopt macroprudential policies in the wake of the earlier Asian crisis of 1997. As an illustration of this, using the IMF [32] database of macroprudential policy actions, we find the average annual amount of macroprudential tightening over 1990–2006 was 0.48 for East Asian banks and 0.18 elsewhere.[1] Accordingly, an East Asian sample of banks is likely to provide a more robust empirical assessment of macroprudential policies than a

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[1] This calculation is based on the aggregate measure of tightening which is named as "iMaPP Index" in Table 4. See also Table 5 below for further illustration of the employment of macroprudential policies in East Asia.

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global sample or one from a region that adopted such policies more recently.

Research on the effects of macroprudential policy has tended to focus on the impact on bank credit and house prices, mainly at a macro level. Till recently, relatively few papers on macroprudential policy effects have used micro data, and those were largely focused on lending growth measures. Most recently, a few papers have seen the logic that by affecting banks' management decisions and shifting banks away from their desired trade-off of risk and return, it is likely that macroprudential policy has an impact on bank risk. They generally find that at least some macroprudential policies act to reduce risk taking at an individual bank level. Such an effect is to be expected in light of the typical objectives of macroprudential policy, namely to enhance the system's resilience, prevent systemic risk and tame boom-bust credit cycles. But these papers typically do not allow for a complementary role for competition, either as an additional variable in the risk equation or an interaction with macroprudential policies.[2] This is, to our knowledge, the first paper to focus on the relation of macroprudential policy and competition jointly to bank risk, both by entering these variables separately in the equation and also assessing their interaction.

Using the IMF iMaPP dataset of macroprudential measures and accompanying data from the Fitch-Connect database of banks' financial statements we construct a sample of 1373 banks from 13 East Asian countries using annual data over 1990–2018 to assess these relations. The paper also distinguishes short and long-run effects of macroprudential policy as well as competition, in contrast to most of the existing literature, and has a more detailed breakdown of policies. A number of robustness checks are provided which underpin the results.

Among our results, we find that in addition to a significant negative effect of competition on risk, macroprudential policies also affect bank risk in East Asian countries. Although a beneficial effect of such policies on bank risk is observed in general, there are a number of cases where policies were deleterious (increasing risk). Certain capital-based policies reduce risk in the long run, while some loan-based policies tend to increase it. Meanwhile, there are a number of interactions between competition and macroprudential measures, indicating policy effects are not neutral across banks in terms of market power. In the developing and emerging East Asian countries, policy measures often elicit lesser risk reduction in banks with more market power. We suggest that is due inter alia to the ability of such banks to undertake risk-shifting in response to macroprudential policy. On the other hand, we find advanced East Asian country banks which face intense competition respond to macroprudential restrictions by taking relatively more risks in the long run. This is consistent with a desire of competitive banks to maintain profitability by risk taking. Similar tests for a sample of global and European banks in the "Broader samples" section display similar outcomes to the advanced East Asian countries.

We contend that our work has considerable relevance to regulators, by showing which types of bank in terms of market power are most likely to seek to limit the effects on risk of macroprudential policy. It also gives an indication of which policies have historically been effective or ineffective in limiting risk, in a number of discrete regions. Indeed, the implication is that policymakers should take into account the competitiveness of their domestic banking system not only in setting the level but also choosing among various macroprudential policies. Some macroprudential policies' lack of effectiveness is reinforced by an uncompetitive banking system and in other cases it is reinforced by a competitive one. Other studies of macroprudential policy and risk fail to capture these implications, since they omit the treatment of competition, policy and risk that we provide.

The paper is structured as follows: the "Literature review" section provides a literature survey, focusing on the one hand on work on competition, capital and risk and on the other hand on estimates of macroprudential policy effects, which together form the background for our work. The "Methodology" section introduces the methodology and the "Data and descriptive statistics" section shows the data and descriptive statistics. The "Results" section presents the results and the "Robustness checks" section shows robustness checks, while the "Broader samples" section shows some comparative global and European estimates, and the "Conclusions" section concludes.

Literature review

Our work brings together two areas of empirical research that have to date been largely separate, namely the determination of risk at a bank level, including bank competition and capital as independent variables, and the effects of macroprudential policy on bank risk.

Bank competition, capital and risk

To begin with a summary point, the bank competition-risk literature is divided between those works which support "competition-fragility," that more competition leads to higher risk, and "competition-stability," which suggests more competition leads to lower risk.

According to the "competition-fragility" or "franchise value" approach [34], institutions in an uncompetitive

[2] Such an approach of omitting competition is itself a paradox, given the broad and established literature on bank competition and risk that we note in the section entitled "Bank competition, capital and risk."

banking system have incentives to avoid risk, because a banking licence is valuable in such a context, with restricted entry and probably large capital cushions. When deregulation arises, the value of the licence declines, as excess returns are competed away both by new entrants (including from abroad, where permitted) and by more intense competition between existing players. This situation gives incentives to increase balance-sheet risk to recover the previous level of profitability, since banks effectively shift risks to depositors (or deposit insurers). A key study finding "competition-fragility," whose approach to modelling we follow in this paper, is that of Beck et al. [11] with a global sample of individual banks. They found cross-country variation in the relationship between bank competition and bank stability measured by the Z-score, linked to market, regulatory and institutional features.[3] Other empirical work supporting "competition-fragility" includes studies by Yeyati and Micco [44] of Latin American banks and Davis and Karim [22] for European banks.[4]

An alternative view is that of "competition-stability," that increased competition reduces risk in the banking system [14]. The argument is that, on the one hand, lower lending rates in competitive banking markets increase borrowers' scope for repayment, while on the other hand, higher lending rates in uncompetitive markets lead to adverse selection, with only riskier borrowers seeking funds, and moral hazard inducing borrowing firms to take greater risks. Moreover, large banks may be harder to supervise. Empirical studies supporting this view include Anginer et al. [9] with a global sample of individual banks.

However, although there has been extensive work on bank risk and its link to competition, the number of empirical papers with both competition and capital as independent variables is more limited, while none to our knowledge look at the interrelation of competition and macroprudential policy.

One study that does include both competition and capital is Tabak et al. [42], who used a sample of banks in Latin American countries over 2003–2008 and the Z-score as a dependent variable. They found an inverse U-shaped relation of competition to risk: high and low competition benefit stability, while average competition generates instability.[5] Larger banks tend to benefit more in terms of stability from competition. Higher capital leads to greater stability (i.e. a higher Z-score) of all banks in less competitive markets but only large banks benefit in markets with average and high competition.

Kick and Prieto [35] looked at the determinants of bank distress within Germany over 1994–2010, with a focus on the effect of competition at a bank, county and state level. They found that at a bank level, market power enhances stability, but at a county or state level the relation of competition to risk was negative. Capital is one of the control variables but is not a focus of the analysis. De-Ramon et al. [26] found that higher competition in the UK leads to lower capital ratios, although the negative effect on stability may be offset if there is higher profitability, despite increased competition.

An Asian study of risk and competition for banks in 14 Asia Pacific countries (a mix of advanced and emerging countries) over 2003–2010 by Fu et al. [28] found a significant negative association between the Lerner index and individual bank risk but also illustrate the significant positive relationship between the concentration ratio and bank fragility. Capital requirements were not significant. Meanwhile, Soedarmono et al. [41] found the opposite effect for emerging Asian countries' banks over 1994–2009. A higher degree of market power was linked to greater insolvency risk as measured by the Z-score. Although banks in less competitive markets hold more capital, this is not sufficient to offset the impact on default risk of higher risk taking. This contrasting result suggests that there may be major differences between Asian banks' behaviour depending on levels of country development.

Finally, Davis et al. [23] showed in a panel VAR using macro data across over 100 countries, that more intense competition (measured by a country-level Lerner index), tends to increase banking sector risk, as well as leading to a reduction in bank capital, leaving banks less robust. Their GMM panel estimation results largely supported "competition-fragility," i.e. a positive relation of competition to risk controlling for capital; both the leverage ratio and risk adjusted capital adequacy measures controlling for competition were significant predictors of risk but signs varied across risk measures. The leverage ratio was as relevant as the risk-adjusted capital ratio and there were some differences in results between advanced countries and emerging market economies.

[3] They found that an increase in competition will have a larger impact on banks' fragility in countries with stricter activity restrictions, lower systemic fragility, better developed stock exchanges, more generous deposit insurance and more effective systems of credit information sharing.

[4] Davis and Karim [22] did, however, find competition-stability for the long run effect of competition as measured by the H statistic.

[5] This empirical result contrasts with theoretical work that suggests under certain conditions a U-shaped relation between competition and risk, with both high and low competition as measured by number of banks being potentially adverse [38].

Macroprudential policy and bank risk

Meanwhile, most work on macroprudential policy effects has used macro data to trace impacts of policy on house prices and credit, adding macroprudential policies one at a time to a baseline equation with relevant control variables. Key papers include Cerutti et al. [17], Kuttner and Shim [36], Carreras et al. [16], Akinci and Olmstead-Rumsey [5], Alam et al. [6] and Bergant et al. [12]. Alam et al. [6], for example, found that loan-targeted instruments have a significant impact on household credit, and a milder dampening effect on consumption.

As regards studies using micro (bank level) data, Claessens et al. [20] looked at the effectiveness of macroprudential policy in reducing bank asset growth; Davis et al. [25] tested the effects of macroprudential measures on bank profitability; and Davis et al. [24] estimated macroprudential policy effects on the interest rate margin, the main subcomponent of profitability in advanced countries. All three studies found macroprudential policy had major effects on key elements of bank performance.

Several recent papers using micro data also focus on the effect of macroprudential policies on risk for individual banks, but none relate to the link to competition—there is typically no competition variable either at bank or market level among the control variables, in contrast to the literature cited in the "Bank competition, capital and risk" section. This suggests a possible issue of omitted variables bias. Notably, Altunbas et al. [7] assessed the impact of macroprudential policy on two measures of individual bank risk, the change in the expected default frequency and the change in the Z-score. The sample covered 3,177 individual banks in 61 countries over 1990–2012. They found a significant negative effect of broad categories of macroprudential policies on risk. The negative effect on risk is greatest in an upturn and for banks that are small, poorly capitalised and with more wholesale funding.

Gaganis et al. [30] sought to assess how macroprudential policy and corporate governance might jointly impact on bank risk, measured by the Z-score, distance to default and probability of default. They used a sample of 365 banks in 50 countries over 2002–17. They found that macroprudential policy interacts positively with the quality of corporate governance (measured by banks' commitment and effectiveness towards following corporate governance principles) in determining risk taking. The better is corporate governance in this sense, the greater the reduction in risk-taking from macroprudential policies, although this interaction effect was only found in advanced countries and not in emerging market economies.

Ely et al. [27] sought to show the transmission mechanism of macroprudential policies to risk at a bank level. Their sample covers 16,255 global banks from 45 countries over 2000–2014 (over half are from the US). The dependent variable is the Z-score and its decomposition into the return on assets and the equity ratio; the control variables include the HHI index of loan concentration at a national level but not a measure of individual bank market power. They found that macroprudential tools addressing contagion such as limits on interbank exposures and concentration have a positive effect on bank stability, as do some borrower-based tools. On the other hand, policies that limit domestic and foreign currency loans tend to increase risk. Mixed results were found for capital-based policies.

Gonzalez [29] with a sample of 2511 banks from 52 countries over 2000–2013, showed that there is a relation of changes in macroprudential policy to competition as well as risk. However, the paper did not allow for interaction of competition and macroprudential policy in determination of bank risk, nor is competition itself included in the bank risk equation. Tighter loan-supply and liquidity-based policies were related to higher bank competition, while a tightening of capital and tax-based policies related to lower bank competition. The overall effect of macroprudential tightening is meanwhile to reduce bank risk as measured by the Z-score.

Whereas the above papers looked at individual bank risk, Meuleman and Vander Vennet [39] investigated the impact of macroprudential policies on systemic risk for EU banks from 2000 to 2017, using the Marginal Expected Shortfall measure of Acharya [1]. They found that whereas macroprudential policies—notably controls on credit expansion and exposure limits—do reduce the component of systemic risk related to individual bank risk, the component related to risks arising from systemic linkages is aggravated by some policies. For some retail banks, this was seen as linked to risk-shifting behaviour, whereby in response to limits on exposures to certain counterparties or a need to disinvest in certain assets enforced by macroprudential policies, banks may shift their exposures to make them more vulnerable to market or business cycle shocks.

Bank risk, macroprudential policy and competition

In light of these works, and the gaps in the literature, our aim is to assess how competition and macroprudential policy act and interact in East Asian banks to affect bank risk, with capital as a further control variable. In the context of work cited above, we do expect an effect of competition, capital and macroprudential policy on risk. More specifically, it is clear that there is a link from competition to risk, which is usually seen as positive since high competition is generally seen to entail greater risk taking (In the "Bank competition, capital and risk" section). Also, it has been found that macroprudential policies affect bank risk, generally but not

always, by reducing it (in the "Macroprudential policy and bank risk" section).

It can then be argued that the way macroprudential policy typically affects bank risk is by limiting portfolio and activity choices, limiting the extent to which banks can pursue higher-risk activities. This may be by quantity or price restrictions across the whole balance sheet (as for capital measures) or specific types of lending (as for mortgage loan to value limits). It may also be via restrictions on interbank activity or limits to other forms of wholesale funding, as noted by Altunbas et al. [7]. Banks are thereby shifted from their desired trade-off of risk and return, and will wish to return to it, which may entail an offsetting rise in risk. The question then is whether the scope and incentive to act in this manner depends on the market power that the bank has.

Regarding interactions of competition and macroprudential policy, there are three possible hypotheses:

- *Hypothesis One* is that there is no interaction effect, all banks respond similarly in terms of risk reduction to macroprudential policy, given the control variables included, regardless of market power.
- *Hypothesis Two* is that banks with high levels of market power respond less in terms of risk reduction to macroprudential policy than those with low market power.
- *Hypothesis Three* is that banks with low levels of market power respond less in terms of risk reduction to macroprudential policy than those with high market power.

As regards possible reasons for such differing responses, our prior expectation, in line with the discussion of Keeley et al. [34] noted above, is that uncompetitive banks seek to avoid risk so will respond to macroprudential policy more than competitive banks. The latter will aim to attain high levels of balance sheet risk to maintain profitability and thus seek to circumvent effects of macroprudential policy on risk taking by appropriate risk-shifting, as suggested by Meuleman and Vander Vennet [39]. This is in line with the *Hypothesis Two* cited above.

On the other hand, we acknowledge the possibility that uncompetitive banks may be in a better position to maintain risk taking than competitive ones, following *Hypothesis Three*. Market power may enable such banks to more readily adjust internally to offset the effects of policy by risk-shifting. This effect may link in turn to moral hazard generated by the safety net of deposit insurance and lender of last resort for banks with market power that, if they are large, consider themselves "too big to fail.". Other mechanisms may relate to higher lending rates offered by banks in strong market positions which may lead to adverse selection, with only riskier borrowers seeking funds and moral hazard inducing borrowing firms to take greater risks, as suggested by Boyd and De Nicolo [14]. And banks with market power may have weaker corporate governance, which as noted by Gaganis et al. [30] may weaken the effects of macroprudential policy. Banks with stronger market positions, if they are large, may be harder to supervise.

In either case, the mode of risk-shifting in response to macroprudential tightening may be for example that loan growth limits may reduce household lending if that is their focus but may raise corporate lending and securities holdings [2]. A further effect may be to shift financial activities outside regulatory parameters [19] and increase cross-border borrowing by domestic or foreign banks [4, 17].

Methodology

We utilise the bank Z-score as a risk measure. It captures a bank's distance from insolvency as measured by Z-score = (ROA + (Capital/Assets))/SD(ROA), where ROA is the return on assets and SD is the standard deviation over a rolling three year window. The bank Z-score[6] thus compares the buffer of a bank (capitalisation (Capital/Assets) and return on assets (ROA)) with the volatility (standard deviation (SD)) of those returns. Accordingly, the Z-score captures the number of standard deviations by which returns would have to fall from the mean to wipe out all the equity of the bank [14]. As noted by Liu et al. [15], it is appropriate to log the Z-score as the level is highly skewed, while the log is normally distributed. Accordingly, we use log Z-score as the dependent variable.

We suggest the Z-score is the most general measure of bank risk as it captures risk from the full range of bank activities, including for example income volatility driven by non-interest income or loss of profitability from reputational damage. In contrast, other measures such as non-performing loans, the provisions/loans ratio and loan growth, only capture a subset of bank risks limited to the loan book. The Z-score's importance is reflected in its use in most of the studies cited above, as well as other studies of bank risk such as Beck et al. [11] and IJtsma et al. [31].

We do not use systemic risk measures such as the Marginal Expected Shortfall of Acharya [1], since as noted by Meuleman and Vander Vennet [39], it requires stock market data. A similar comment applies to the well-known CoVaR measure which links to losses on market equity of the bank in question[7] [3]. Choice of such measures would have sharply limited the sample to listed banks, which are relatively uncommon in many of the East Asian countries we

[6] Note that this is quite distinct from the standard statistical definition of Z-Score which indicates how many standard deviations an element is from the mean. We measure ROA using pre-tax profits rather than net income, implying it is the operating ROA we utilise.

[7] For surveys of such measures see Silva et al. [40].

choose to study. As noted, existing work in both fields cited in the "Bank competition, capital and risk" and the "Macroprudential policy and bank risk" sections typically also uses the Z-score as a measure of bank risk, again with a gain in terms of sample size that outweighs the benefits of the market-based measures in capturing systemic risk elements.

It is essential to include comprehensive control variables to capture the effect of macroprudential policy and competition on risk and their possible interactions and to avoid omitted variables bias. Our model follows the modelling approach of the key competition-risk study by Beck et al. [11], as also employed in Davis and Karim [22] and Davis et al. [23]. The vector of independent variables characterises aspects of a banking sector's weighted average business model that contribute to risk. In particular, we include as control variables the following:

- Proxies for the funding structure linked to liquidity risk, whose importance was shown particularly during the 2008 Subprime crisis (customer deposits to total deposits, denoted CUST DEP SHARE),
- Asset structure and resultant credit risk, where inappropriate lending has been the most common source of bank insolvency (loans to assets ratio (LOAN/ASSETS) and provisions to loans ratio (PROVISIONS/LOANS))
- Revenue mix which also captures market risk exposure as well as scope for diversification (share of non-interest income in total income, NONINT RATIO).
- Bank growth and size via the differenced and lagged level of the log of bank assets (Δ LOG ASSETS and LOG ASSETS). Rapid growth often entails lending to riskier clients owing to adverse selection effects, while large size may lead the bank to consider itself "too big to fail" and entail managerial inefficiencies.

We add further bank-level variables, namely aggregate leverage ratios (LEVERAGE RATIO) and banking competition (LERNER), as these are key determinants of bank risk-taking behaviour relevant for macroprudential surveillance, as shown by the studies cited in the "Bank competition, capital and risk" section.

Banking competition is measured by the Lerner Index, derived by estimation of a translog cost function as in Anginer et al. [9], Beck et al. [11], Weill [43] and Davis and Karim [22]. The Lerner index is a measure of the price–cost margin, it is a proxy for current and future profits stemming from pricing power, and it varies at the level of the individual bank. Under perfect competition the index is zero as the output price (marginal revenue) equals marginal cost, and "normal" economic profits are zero. The Lerner index becomes positive as a firm's market power increases and price rises above marginal cost in a quantity-setting oligopoly model, with the limiting case being monopoly. The calculation of the index is set out in "Appendix 1."

Further control is provided by the addition of key macroeconomic variables which influence bank behaviour and performance. These are GDP growth (GDP GROWTH), CPI inflation (INFLATION), the presence of a banking crisis (BANK CRISIS) as shown in Laeven and Valencia [37] and both the difference and level of the central bank policy interest rate (ΔPOLICY RATE and POLICY RATE) to allow for an impact of monetary policy action and the monetary policy stance on bank risk taking.

Econometrically, we use panel OLS with a lagged dependent variable. Hausman tests showed that cross section (bank) fixed effects are appropriate and year fixed effects were also significant. The combined model thus controls, via bank dummies, for unobservable factors that differ across entities but are constant over time and it also controls via time dummies, for unobservable factors that change over time but are constant over entities. The lagged dependent variable is used to capture the AR(1) effect. We cluster errors at a country level to correct for in-country correlation and also because macroprudential policy is a country level variable (as argued by [7]). Standard errors and covariances are cluster-robust. A robustness check shows results using bank-level clustering in Appendix Table 19.

All control variables are entered as 1-year lags to avoid potential issues of endogeneity and reverse causality (as in papers such as Davis and Karim [22], Davis et al. [25] and Beck et al. [11]) and to allow for lagged response times by banks. There are three exceptions: the Lerner Index and the policy rate are both entered as a current first difference and first lagged level to enable short- and long-run effects to be distinguished, while as noted, we also include the growth and lagged level of the log of bank assets. To further limit endogeneity and reverse causality, the first difference of Lerner index is instrumented by two lags of itself prior to estimation of the risk equations, as are capital measures, shown by the suffix INST.[8] All variables except the banking crisis dummy are winsorised at 99%.

We contend that with sufficient control via instrumentation of key variables for endogeneity as well as lagged bank level variables, and also bank and time dummies and clustering, panel OLS should provide robust estimates (as used for

[8] Endogeneity is an inevitable issue in this paper, as there are always omitted or unobservable variables in the regressions which might be correlated to our dependent variable (Z-Score). We have used a simple AR process to generate fitted estimates that are used instead of the data, which we contend should minimise the risk of such endogeneity. Basically, we estimated OLS equations for each instrumented term using two lags of the term and a constant, and derived the fitted value from it that were then used in the estimation. This fitted value estimated from lag terms are less likely to correlate with the error term e_{ijt} and we contend that this should minimise the risk of endogeneity.

example in Gaganis et al. [30] and Meuleman and Vander Vennet [39] cited above). Alternative techniques such as GMM would entail considerable loss of data points.[9] An additional point, as also argued by Meuleman and Vander Vennet [39] is that since we are using individual bank data it is unlikely that there is a problem of reverse causality with macroprudential policy—it would rather respond to system-wide changes.

Hence, our baseline is as follows, for country j and bank i:

$$\begin{aligned}\text{LOG Z}-\text{SCORE}_{ijt} = {} & a_0 + a_1\text{LOG Z}-\text{SCORE}_{ijt-1} + a_2\Delta\text{POLICY RATE}_{jt} \\ & + a_3\text{POLICY RATE}_{jt-1} + a_4\Delta\text{LERNER INST}_{ijt} \\ & + a_5\text{LERNER}_{ijt-1} + a_6\text{CUST DEP SHARE}_{ijt-1} \\ & + a_7\text{NONINT RATIO}_{ijt-1} + a_8\text{LOAN/ASSETS}_{ijt-1} \\ & + a_9\text{PROVISIONS/LOANS}_{ijt-1} + a_{10}\text{LEVERAGE RATIO INST}_{ijt-1} \\ & + a_{11}\Delta\text{ LOG ASSETS}_{ijt} + a_{12}\text{LOG ASSETS}_{ijt-1} \\ & + a_{13}\text{GDP GROWTH}_{jt-1} + a_{14}\text{INFLATION}_{jt-1} \\ & + a_{15}\text{BANK CRISIS}_{jt-1} + D_i + D_t + e_{ijt}\end{aligned} \tag{1}$$

where D_t and D_i are vectors of year and bank dummies, respectively, and other variables are as set out above. Having developed baseline equations, we now turn to our main variable of interest (i.e., macroprudential policy variables) and add one variable at a time to assess their effect on bank's risk. This is in line with the standard approach in the literature on macroprudential policy such as Cerutti et al. [17], Akinci and Olmstead-Rumsey [5]), Carreras et al. [16] and Gaganis et al. [30].[10] In line with competition and the policy rate, we seek to distinguish short- and long-run effects of macroprudential policy by including the implementation or change in policy for the current year as a current-period variable (ΔMP), together with the lagged cumulative effect of such policy (MP) which feeds through the lagged dependent variable, as described in the data section below:

$$\begin{aligned}\text{LOG Z}-\text{SCORE}_{ijt} = {} & b_0 + b_1\text{LOG Z}-\text{SCORE}_{ijt-1} + b_2\Delta\text{POLICY RATE}_{jt} \\ & + b_3\text{POLICY RATE}_{jt-1} + b_4\Delta\text{LERNER INST}_{ijt} + b_5\text{LERNER}_{ijt-1} \\ & + b_6\text{CUST DEP SHARE}_{ijt-1} + b_7\text{NONINT RATIO}_{ijt-1} + b_8\text{LOAN/ASSETS}_{ijt-1} \\ & + b_9\text{PROVISIONS/LOANS}_{ijt-1} + b_{10}\text{LEVERAGE RATIO INST}_{ijt-1} \\ & + b_{11}\Delta\text{ LOG ASSETS}_{ijt} + b_{12}\text{LOG ASSETS}_{ijt-1} + b_{13}\text{GDP GROWTH}_{jt-1} \\ & + b_{14}\text{INFLATION}_{jt-1} + b_{15}\text{BANK CRISIS}_{jt-1} + b_{16}\Delta\text{MP}_{jt} + b_{17}\text{MP}_{jt-1} \\ & + D_i + D_t + e_{ijt}\end{aligned} \tag{2}$$

The macroprudential policy variables are drawn from the comprehensive list in the IMF iMaPP integrated Macroprudential Policy Dataset. In this study, we consider the effect of macroprudential policy on bank risk at both individual level (where the MP variable entails one macroprudential policy at a time) and aggregate level (where, the MP variable is constructed by adding multiple macroprudential policy variables), so as to have more insights on granular as well as overall effects. The complete list of macroprudential variables with their definitions is further discussed in the "Data and descriptive statistics" section.

Finally, we interact the macroprudential effects with the lagged level of the Lerner Index, to assess whether the response to policy in terms of risk is dependent on the market power of the bank in question. Note that in the interaction terms, we demean the Lerner Index[11] using the average across the entire sample of banks in the 13 countries before interacting, so the average bank has a Lerner Index of 1. Hence, an equal and opposite coefficient on macroprudential policy and the interacted coefficient means there is a zero effect for a bank of average market power:

$$\begin{aligned}\text{LOG Z}-\text{SCORE}_{ijt} = {} & c_0 + c_1\text{LOG Z}-\text{SCORE}_{ijt-1} + c_2\Delta\text{POLICY RATE}_{jt} \\ & + c_3\text{POLICY RATE}_{jt-1} + c_4\Delta\text{LERNER INST}_{ijt} + c_5\text{LERNER}_{ijt-1} \\ & + c_6\text{CUST DEP SHARE}_{ijt-1} + c_7\text{NONINT RATIO}_{ijt-1} + c_8\text{LOAN/ASSETS}_{ijt-1} \\ & + c_9\text{PROVISIONS/LOANS}_{ijt-1} + c_{10}\text{LEVERAGE RATIO INST}_{ijt-1} \\ & + c_{11}\Delta\text{ LOG ASSETS}_{ijt} + c_{12}\text{LOG ASSETS}_{ijt-1} + c_{13}\text{GDP GROWTH}_{jt-1} \\ & + c_{14}\text{INFLATION}_{jt-1} + c_{15}\text{BANK CRISIS}_{jt-1} + c_{16}\Delta\text{MP}_{jt} + c_{17}\text{MP}_{jt-1} \\ & + c_{18}\left(\Delta\text{MP}_{jt} * \text{LERNER}_{ijt-1}\right) + c_{19}\left(\text{MP}_{jt-1} * \text{LERNER}_{ijt-1}\right) + D_i + D_t + e_{ijt}\end{aligned} \tag{3}$$

[9] Another option to consider could be multi-level estimation, which refers to dividing the data into sub-groups according to the hierarchy of data. Using our own dataset as an example, the hierarchy is "ijt" or "countries → banks → time." A multi-level estimation for our paper will then be running the regressions country by country, and then study the variance between the country sub-groups of banks. We suggest that this additional analysis would not be very informative, as the number of observations in each subgroup would be small, leading to a risk of incorrect inferences on significance. Also, as the East Asian countries are closely connected and have similar business cycles, we suggest that it is not conceptually wrong to put them in a single group for analysis, as we do indeed do when we use a pooled dataset. Accordingly, we have not used multi-level estimation due to data limitation and interconnections.

[10] We do however include a robustness check where all the policy and interaction terms are included together, as in Davis et al. [25].

[11] Altunbas et al. [7] adopted a similar approach to size and capitalisation, demeaning each variable in interacted terms to better show the net effect of macroprudential policies.

Data and descriptive statistics

Our data, covering 1990–2018 for 13 East Asian countries are from three sources: (1) Annual data for banks' balance sheets and profit and loss statements from Fitch-Connect. (2) Macro data from International Financial Statistics and the World Development Indicators databases. (3) The IMF iMaPP dataset for macroprudential policy from IMF [32] as described by Alam et al. [6].

We choose data for the 100 largest banks for each country in 1995, 2005 and 2015 (or less if there are less in the database) as in Claessens et al. [20].[12] This avoids the sample being dominated by countries with many banks (which would have been Japan). The number of banks and the countries covered are shown in Table 1.

Meanwhile, Table 2 provides details of the statistical properties of the baseline independent and dependent variables. These are in line with those in other studies such as Davis and Karim [22]. We also calculated correlations, which are well below 0.5 with the exception of the policy rate with inflation (0.79).

As noted, having estimated the baselines, we then incorporate the macroprudential policy data from the IMF iMaPP integrated Macroprudential Policy Dataset, originally constructed by Alam et al. [6], which covers 134 countries with monthly data from January 1990 to December 2018 [32]. This dataset provides information on the tightening and loosening of policy across 17 individual instruments and 7 summary measures, as suggested in Alam et al. [6]. The policies are measured as (0,+1,−1) dummies, as well as permitting aggregation across instruments.[13]

Note that the formulation showing either tightening (+1) and loosening (−1) has only categorical (as opposed to numerical) values for the macroprudential policies (i.e. they show simply whether the policy is tightened or loosened, not the severity of application or easing). Results will accordingly reflect the average degree of policy action.

We aggregated the monthly data to annual observations to obtain an annual indicator of short-run macroprudential policy action. Separately, we also cumulated the monthly data from 1990 before annualising to obtain an indicator of the macroprudential policy stance, following the approach of Bergant et al. [12] using this dataset, as well as Meuleman and Vander Vennet [39] with the ECB MaPPED database, work by Akinci and Olmstead-Rumsey [5] and the earlier IMF database highlighted in Cerutti et al. [18].

Accordingly, our methodology, besides giving an indicator of policy tightening or loosening from the database, provides an approximate measure of the stance and stringency of macroprudential regulation at each point in time by cumulating, with a higher index showing a tighter stance. Cumulation shows the stance, while the tightening/loosening show the implementation of policy. By entering both along with a lagged dependent variable, we can estimate both long and short-run effects.

As noted by Meuleman and Vander Vennet [39], cumulation is important since macroprudential measures can have effects not just initially but also subsequently and because it cannot be shown at what point the policy becomes binding (see also Cerutti et al. [17] and Akinci and Olmstead-Rumsey [5]). Cumulative measures are also less likely to be subject to issues of endogeneity, as they are mostly predetermined [12].

Tables 3 and 4 list the individual and summary variables in the database.

Before moving on to estimation, we show in Table 5 some measures of the operation of policy, showing how widespread use of the macroprudential policies has been in East Asia, and accordingly how suitable this set of countries are for the analysis we undertake. Thus, column (1) shows that many of the policies were in operation (i.e. the cumulative measure of tightening was positive) for most or the countries in 2018, bearing in mind there are 13 countries in all. Column (2) shows a considerable number of tightening policy actions over the period 1990–2018, with particularly high

Table 1 Country and bank coverage

Country	ISO Code	IMF category	No. of banks	
			ADV	EMDE
Australia	AUS	ADV	154	
China	CHN	EMDE		129
Hong Kong	HKG	ADV	129	
India	IND	EMDE		127
Indonesia	IDN	EMDE		166
Japan	JPN	ADV	158	
Korea	KOR	ADV	142	
Malaysia	MYS	EMDE		97
Mongolia	MNG	EMDE		13
New Zealand	NZL	ADV	45	
Philippines	PHL	EMDE		98
Singapore	SGP	ADV	57	
Thailand	THA	EMDE		58
Total	13		685	688

ADV advanced country, *EMDE* emerging market and developing economy according to IMF classification

[12] We retained all the chosen banks for each base year through the full sample, which is why some countries have more than 100 banks.

[13] Note that this is a considerable advance on the earlier datasets produced by the IMF (as in [17]) which kept the dummy at 1 as long as the policies are in operation, typically had fewer instruments and were typically for a much shorter period such as 2000–2013 or 2014.

Table 2 Variable statistics (winsorised at 99% except Bank Crisis)

Variable	Mean	Median	Maximum	Minimum	Std. dev	Observations
Risk measure						
LOG Z-SCORE	3.790	3.869	6.990	−4.221	1.375	13,217
Independent variables						
POLICY RATE (%)	5.408	5.000	48.238	0.100	4.863	36,959
LERNER	0.25	0.252	0.653	−0.912	0.185	12,185
CUST DEP SHARE	0.913	0.981	1.000	0.007	0.167	15,263
NONINT RATIO	0.263	0.216	1.268	−0.542	0.256	16,351
LOAN/ASSETS	0.591	0.611	0.999	0.003	0.201	16,461
PROVISIONS/LOANS (%)	1.089	0.550	18.752	−3.150	2.160	13,123
LEVERAGE RATIO	0.121	0.078	0.900	0.002	0.142	16,810
LOG ASSETS	22.016	22.089	27.117	16.054	2.357	17,048
GDP GROWTH (%)	4.727	4.824	11.467	−8.669	3.367	39,817
INFLATION (%)	4.380	3.079	268.151	−0.923	7.256	39,778
BANK CRISIS	0.078	0.000	1.000	0.000	0.268	39,817

LOG Z-SCORE is the log of the bank Z-score as defined above, POLICY RATE is the central bank policy rate, LERNER is the Lerner Index as a measure of competition, CUST DEP SHARE is customer deposits to total deposits, NONINT RATIO is the share of non-interest income in total income. LOAN/ASSETS is the loans to assets ratio, PROVISIONS/LOANS is the provisions to loans ratio, LEVERAGE RATIO is unadjusted capital adequacy (equity/assets), LOG ASSETS is the log of total assets, NPL RATIO is a credit risk measure (non-performing loans/gross Loans), GDP GROWTH is the real economic growth rate in terms of GDP, INFLATION is the CPI inflation rate (The high maximum inflation rate refers to the transition in Mongolia in 1993, which only affects one observation) and BANK CRISIS is a dummy for an ongoing banking crisis

activity for policies such as conservation buffers (CONSERVATION), capital measures (CAPITAL), loan limits (LOANR), loan-to-value ratios (LTV), liquidity measures (LIQUIDITY) and reserve requirements (RR). The evolution of the stance of policies over time is shown in columns (3)-(6), bearing in mind that the stance is measured by the sum of policy tightening since 1990 less the policy loosenings (so it can be negative). It is shown that policy activity has expanded over time, but there was already considerable activity in 2010 and also 2000, in the wake of the Asian crisis.

Results

Baseline results

Our baseline results are shown in Table 6. Note that a lower log Z-score implies a rise in risk, while a lower Lerner Index shows a rise in competition. We see that both the instrumented difference and lagged level of competition impacts directly on the Z-score with a positive sign, where a rise in competition (smaller ΔLERNER INST) as well as a higher level of competition (lower LERNER) raise bank risk as shown by a lower Z-score, and vice versa for lower competition. Thus, the average response of East Asian banks to competition supports "competition fragility" in the short and long run. A similar result for Asia–Pacific banks was found by Fu et al. [28] but not by Soedarmono et al. [41] who, as noted above, found that in Asian emerging markets at least, higher market power entailed higher insolvency risk.

Risk for individual banks is also raised by a higher loan/asset ratio (LOAN/ASSETS) and higher provisions (PROVISIONS/LOANS). Accordingly, banks with more loans on the balance sheet and higher provisions are more vulnerable. As regards macroeconomic effects, we note that a banking crisis raises risk, as it is likely to leave surviving banks in a vulnerable position with depleted capital and low profitability.

We now go on to show the effect on the log Z-score of the introduction (DMP) and lagged stance (MP(−1)) of individual macroprudential policies (defined in Table 3) and the summary variables (defined in Table 4) without interaction with competition. These results are shown in the first two columns of Table 7 (denoted "Macroprudential variables only").

Full-sample results for Z-score

We see that in the short run, the Z-score is boosted (risk is lower) when there is tightening of loan restrictions (LOANR), foreign currency lending limits (LFC), limits to the debt-service-to-income ratio (DSTI), tax measures (TAX) and liquidity measures (LIQUIDITY). It is reduced (risk is higher) in the short run from the tightening of loan loss provision measures (LLP), limits to credit growth

Table 3 Instruments in the IMF IMAPP integrated Macroprudential Policy Dataset (2020)

Instrument	Abbreviation	Description
Survey instruments		
Countercyclical buffer	CCB	A requirement for banks to maintain a countercyclical capital buffer. Implementations at 0% are not considered as a tightening in dummy-type indicators
Conservation buffer	CONSERVATION	Requirements for banks to maintain a capital conservation buffer, including the one established under Basel III
Capital requirements	CAPITAL	Capital requirements for banks, which include risk weights, systemic risk buffers, and minimum capital requirements. Countercyclical capital buffers and capital conservation buffers are captured in the above measures, respectively, and thus not included here
Leverage requirements	LVR	A limit on leverage of banks, calculated by dividing a measure of capital by the bank's non-risk-weighted exposures (e.g. Basel III leverage ratio)
Provisioning requirements	LLP	Loan-loss provision requirements for macroprudential purposes, which include dynamic provisioning and sectoral provisions (e.g. housing loans)
Credit growth limits	LCG	Limits on growth or the volume of aggregate credit, the household-sector credit, or the corporate-sector credit by banks, and penalties for high credit growth
Loan restrictions	LOANR	Loan restrictions, that are more tailored than those captured in "LCG." They include loan limits and prohibitions, which may be conditioned on loan characteristics (e.g. the maturity, the size, the LTV ratio and the type of interest rate of loans), bank characteristics (e.g. mortgage banks), and other factors
Limits on foreign currency loans	LFC	Limits on foreign currency (FC) lending, and rules or recommendations on FC loans
Loan-to-value limits	LTV	Limits to the loan-to-value ratios, including those mostly targeted at housing loans, but also includes those targeted at automobile loans, and commercial real estate loans
Debt-to-income limits	DSTI	Limits to the debt-service-to-income ratio and the loan-to-income ratio, which restrict the size of debt services or debt relative to income. They include those targeted at housing loans, consumer loans, and commercial real estate loans
Levy/tax on financial institutions	TAX	Taxes and levies applied to specified transactions, assets, or liabilities, which include stamp duties, and capital gain taxes
Liquidity measures	LIQUIDITY	Measures taken to mitigate systemic liquidity and funding risks, including minimum requirements for liquidity coverage ratios, liquid asset ratios, net stable funding ratios, core funding ratios and external debt restrictions that do not distinguish currencies
Loan to deposit limits	LTD	Limits to the loan-to-deposit (LTD) ratio and penalties for high LTD ratios
Limits on FX operations	LFX	Limits on net or gross open foreign exchange (FX) positions, limits on FX exposures and FX funding, and currency mismatch regulations
Reserve requirements	RR	Reserve requirements (domestic or foreign currency) for macroprudential purposes. This category may currently include those for monetary policy as distinguishing those for macroprudential or monetary policy purposes is often not clear-cut
SIFI surcharges	SIFI	Measures taken to mitigate risks from global and domestic systemically important financial institutions (SIFIs), which includes capital and liquidity surcharges
Other macroprudential measures	OTHER	Macroprudential measures not captured in the above categories—e.g. stress testing, restrictions on profit distribution, and structural measures (e.g. limits on exposures between financial institutions)

Source: Alam et al. [6], IMF [32]. The database covers a sample from 1990 to 2018, with monthly data which we have (1) annualised to gain a measure of policy action (denoted DMP) and (2) cumulated over time from 1990 and annualised to gain a measure of policy stance (denoted MP)

(LCG), limits on FX positions (LFX) and other measures (OTHER). As regards effects of the long-run stance of macroprudential policy, which are arguably more relevant for financial stability, risk according to Z-score is lower with tighter countercyclical buffers (CCB), limits to the debt-service-to-income ratio (DSTI), liquidity measures (LIQUIDITY) and other measures (OTHER). But Z-scores fall and risk increases in the long-run, as banks respond to limits to credit growth (LCG), loan restrictions (LOANR) and foreign currency position limits (LFX).

Looking at the summary measures, a tightening of policies captured by "DEMAND" has a positive short run effect and "SUPPLY-CAPITAL" has a negative short-run effect on the Z-score, while summary measures "LOAN-TARGETED" and "SUPPLY-LOANS" as well as the aggregate of all policies (MAPP-INDEX) have significant positive long-run effects, implying lower risk when policy is tightened.

There are a number of relevant points for policymakers' consideration even before we allow for interacted effects

Table 4 Summary measures derived from the IMF IMAPP integrated Macroprudential Policy Dataset (2020)

Derived and summary Instruments	Abbreviation	Definition
All measures	MAPP INDEX	Sum-total of the instruments listed in Table 3
Loan-targeted measures	LOAN-TARGETED	Sum of the "Demand-targeted measures" and the "Loan-supply targeted measures"
Demand-targeted measures	DEMAND	Sum of loan-to-value limits and debt-to-income limits
Supply-targeted measures	SUPPLY-ALL	All measures except loan-to-value limits and debt-to-income limits
Loan-supply targeted measures	SUPPLY-LOANS	Sum of provisioning requirements, credit growth limits, loan restrictions, limits to the loan to deposit ratio, and limits to foreign currency loans
General supply targeted measures	SUPPLY-GENERAL	Sum of reserve requirements, liquidity requirements, and limits to FX positions
Capital related supply measures	SUPPLY-CAPITAL	Sum of leverage, countercyclical buffers, conservation buffers, and capital requirements

Sources: Alam et al. [6], IMF [32]—the summary measures are suggested in the former paper. The database covers a sample from 1990 to 2018 with monthly data, which we have (1) annualised to gain a measure of policy action (denoted DMP) and (2) cumulated over time from 1990 and annualised to gain a measure of policy stance (denoted MP)

of competition: certain macroprudential policies were not effective in reducing risk or were even damaging (lowering Z-score) to Asian banks. Furthermore, other than the debt-service-to-income ratio (DSTI) and liquidity measures (LIQUIDITY) there is no macroprudential policy which was effective in reducing risk in both the short run and long run. Typically, significant capital-based and liquidity-based policies reduce risk in the long run while certain loan-based policies tend to increase it (in line with Ely et al. 2020). Limits on lending may lead to higher risk taking in unregulated sectors to maintain profitability.

The third to sixth columns of Table 7 (denoted "Macroprudential and interacted variables") show the impact of the change and lagged stance of policy (DMP and MP(−1)) when interacted with the lagged demeaned level of competition (DMP*LERNER(−1) and MP(−1)*LERNER(−1)). The aim is to give an estimate of whether the effect of policy on risk varies depending on the level of market power that an individual bank has, as measured by the demeaned Lerner Index. As noted, such demeaning allows the reader to assess the impact of the interaction relative to the direct effect of macroprudential policy directly, since the average bank will have a Lerner index of 1.

The same macroprudential policies tend to be significant with the same sign when we add the interacted demeaned competition measures, although in some cases the policy effect is captured by the interacted terms, which are often highly significant. We can thus rule out *Hypothesis One* that all banks respond similarly in terms of risk reduction to macroprudential policy, given the control variables included, regardless of market power.

In this sample, we find a balance between policies where there is a lower or more negative effect of the macroprudential measure on risk for banks with a higher Lerner index (stronger market position) and other policies where the opposite is true, namely a lower effect on risk for banks with a lower Lerner index (weaker market position). The former case is shown by a negative sign on the interaction terms, while the latter case is shown by a positive sign. The implication is that in some cases macroprudential policy is less effective or even counter-productive for risk reduction in banks with market power. Competitive banks become more stable in response to macroprudential policies than uncompetitive ones do. In others the opposite is the case, in that competitive banks become less stable in response to macroprudential policy than uncompetitive ones do.

Since in each case the coefficients on the interacted variables are typically around half the size of the macroprudential effects themselves, it is at particularly high levels of market power that this offsetting effect becomes strong.

For example, the long-run effect of macroprudential policy on the Z-score is less positive (a negative sign on the interaction term) in the case of banks with market power for the countercyclical capital buffer (CCB), limits to credit growth (LCG), loan growth limits (LOANR), tax measures (TAX) and reserve requirements (RR). Combined with the separate levels term on MP(−1), the net effect, which is typically positive for banks with low market power, becomes zero for banks at around double the average Lerner index and negative for banks above that level (i.e. with considerable market power). And in the case of limits to credit growth (LCG), the effect is more negative for banks with more market power. As shown in Table 5, these five measures with a negative interaction effect are among the most widely and consistently used in East Asia. These results are consistent with *Hypothesis Three*.

On the other hand, there are positive and significant interaction terms for capital requirements (CAPITAL), foreign currency lending limits (LFC), liquidity measures (LIQUIDITY) and measures on systemic institutions (SIFI), as well as the aggregate measure SUPPLY-CAPITAL. The net effect is typically negative for banks with low market power (low Lerner index) becomes zero for banks at around double the average Lerner index and positive for banks above that level

Table 5 East Asian countries—measures of policy in operation

	(1) Countries with policy in operation in 2018	(2) Sum of tightening over 1990–2018	(3) Average stance in 1990	(4) Average stance in 2000	(5) Average stance in 2010	(6) Average stance in 2018
CCB	2	4	0.00	0.00	0.03	0.23
CONSERVATION	12	33	0.00	0.00	0.00	2.51
CAPITAL	10	38	0.00	0.08	0,58	2.40
LVR	8	8	0.00	0.00	0.00	0.81
LLP	6	11	0.00	0.28	0.88	1.15
LCG	2	2	0.00	0.00	0.09	0.15
LOANR	8	38	0.06	0.15	0.39	2.23
LFC	2	3	0.00	0.00	0.12	0.15
LTV	9	58	0.00	0.20	1.10	2.62
DSTI	6	20	0.00	0.08	0.69	0.99
TAX	6	29	0.00	− 0.08	0.25	1.79
LIQUIDITY	12	52	0.00	− 0.03	0.05	3.22
LTD	1	3	0.00	0.00	− 0.08	0.08
LFX	4	14	0.00	0.00	− 0.02	0.46
RR	4	89	0.34	− 0.81	1.21	1.89
SIFI	9	21	0.00	0.00	0.00	1.52
OTHER	8	17	0.00	0.11	0.31	1.20

Source: IMF iMaPP (2020) database (see Table 3); note there are 13 countries included, as shown in Table 1

(i.e. with considerable market power). And in the case of foreign currency limits (LFC) and liquidity measures (LIQUIDITY), the effect is more positive for banks with more market power. It is notable that most of these policies are affected by the Basel agreements, notably Basel III. These results are consistent with *Hypothesis Two*.

Meanwhile, the short-run beneficial effect on risk of macroprudential policy tightening is mitigated in the cases of the counter cyclical buffer (CCB) and reserve requirements (RR), which again becomes zero at around one-and-a-half times the average Lerner and deleterious for those with a demeaned Lerner of above two. For limits to credit growth (LCG), there is a negative effect, enhancing risk in the short run for all banks with a positive Lerner and this is greater in the case of banks with high levels of market power.

Accordingly we find that some of the East Asian results support *Hypothesis Three*, namely banks with low levels of market power respond less in terms of risk reduction to macroprudential policy, as shown by negative interaction terms. Others support *Hypothesis Two* that banks with high levels of market power respond less in terms of risk reduction to macroprudential policy, as shown by positive interaction terms.

As discussed above, for cases where there are negative interaction terms, market power may enable banks to adjust internally and offset the effects of policy, possibly by risk-shifting, such as by moving to corporate lending and securities holdings, operating outside regulatory parameters and cross-border. This risk-shifting effect may link in turn to moral hazard generated by the safety net of deposit insurance and lender of last resort for banks that consider themselves "too big to fail". Banks with stronger market positions may be harder to supervise, and such banks may have weaker corporate governance. Furthermore, higher lending rates offered by banks in strong market positions may lead to adverse selection, with only riskier borrowers seeking funds and inducing moral hazard by firms seeking greater risk.

On the other hand, for cases where there are positive interaction terms, lack of market power may lead banks to adjust risk less than those in stronger positions. As discussed, this is in line with our prior expectation that uncompetitive banks seek to avoid risk so will respond to macroprudential policy more than competitive banks. The latter will aim to attain high levels of balance sheet risk to maintain profitability and thus seek to circumvent effects of macroprudential policy on risk taking by appropriate risk-shifting.

To further highlight the results on the effects of macroprudential policy and competition on bank risk, and calibrate the economic significance of our results, we calculated the percentage effect on the log Z-score of the various policies using the coefficients set out in Table 7. The Z-score being the sum of the return on average assets plus capital adequacy, divided by the standard deviation of the return on average assets, a decline to zero implies the bank is insolvent. Since the dependent variable is in logs, a policy change is set to one and the Lerner is demeaned in the estimation, this can be straightforwardly calculated using the relevant

Table 6 Baseline regression results (estimated by panel OLS over 1990–2018, with bank and time fixed effects and country-clustered standard errors)

Dependent variable	LOG Z-SCORE
C	2.657**
	(2.4)
LAGGED DEPENDENT	0.425***
	(34.1)
Δ POLICY RATE	−0.00481
	(0.5)
POLICY RATE(−1)	−0.00533
	(0.4)
Δ LERNER_INST	0.822***
	(4.1)
LERNER(−1)	1.732***
	(3.8)
CUST DEP SHARE(−1)	0.0171
	(0.1)
NONINT RATIO(−1)	−0.2263
	(1.5)
LOAN/ASSETS(−1)	−0.333*
	(1.9)
PROVISIONS/LOANS(−1)	−0.0609**
	(2.8)
LEVERAGE RATIO_INST(−1)	−0.149
	(0.5)
Δ LOG ASSETS	−0.142
	(1.2)
LOG ASSETS(−1)	−0.0289
	(0.6)
GDP GROWTH(−1)	−0.0138
	(0.9)
INFLATION(−1)	0.00731
	(0.7)
BANK CRISIS(−1)	−0.45***
	(3.2)
PERIODS	26
R2	0.618
OBSERVATIONS	6897
BANKS	886

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 are winsorised at 99%. The equations are estimated by panel OLS with country-clustered standard errors and bank and time fixed effects, and using cluster-robust standard errors. POLICY RATE is the central bank policy rate, LERNER is the Lerner Index as a measure of competition, CUST DEP SHARE is customer deposits to total deposits, NONINT RATIO is the share of non-interest income in total income, LOAN/ASSETS is the loans to assets ratio, PROVISIONS/LOANS is the provisions to loans ratio, LEVERAGE RATIO is unadjusted capital adequacy (equity/assets), LOG ASSETS is the log of total assets, GDP GROWTH is the real economic growth rate in terms of GDP, INFLATION is the CPI inflation rate and BANK CRISIS is a dummy for banking crisis. "Δ" implies first difference and "INST" shows variables instrumented by two lags of themselves prior to estimation. For more details, see Table 2

coefficients.[14] Note, however, that since the macroprudential variables are categorical and the same for any degree of policy tightening and loosening, the calculations will show the average effect across the sample and it may vary for more calibrated policy actions.

As regards the results, we can see that the effects of macroprudential policy alone on the Z-score (in the first two columns of Table 8) are quite substantial for certain policies. Recall that a rise in Z-score reduces risk and a fall raises it. Short-term effects, which are mainly negative, vary between − 24.5% and + 39.6%, while long run effects, which are mainly positive, range from − 65.7% to + 29.1%.[15]

Concerning effects with the inclusion of average competition effects, we find broadly similar results in terms of size and range of the effect on risk in columns 3 and 4 to the ones without those terms. There are a small number of cases in which policies have a significant effect on risk.

The most interest in the table is in the effect of varying the level of competition. Notably, as regards the long run effects, we see that in each case where the interaction terms are significant and negative, the effect of macroprudential policy is more favourable in terms of risk in the case of high competition. For example, the long-term effect on the Z-score of credit growth limits (LCG) is -31.9% for a low level of competition (demeaned Lerner of 1.792) while for a higher level of competition (demeaned Lerner of 0.288) the Z-score falls by only -5.1%. On the other hand, where the interaction terms are significant and positive, the effect of macroprudential policy is more effective in the case of low competition. For example, for liquidity policy (LIQUIDITY) the long-term effect on the Z-score is + 15.5% for a low level of competition (demeaned Lerner of 1.792), while for a higher level of competition (demeaned Lerner of 0.288), the Z-score only rises by 2.5%.

Looking at the short term, we also find that there are a number of policies where a low level of competition implies

[14] Since a change of macroprudential policy is set to one, we can calculate the short-term effect without interaction terms from Eq. (2) as simply the difference term b16 while the long run effect allowing for the equation dynamics is the levels effect divided by one minus the lagged dependent variable b17/(1 − b1). Setting the Lerner Index to 1 (as it is demeaned in the estimation), the short run effect with interaction terms in Eq. (3) is then c16 + c18 while the long run effect with interaction terms is (c17 + c19)/(1 − c1). We can then vary the Lerner to show the effects of different levels of competition. Plus one standard deviation (less competition) gives a demeaned Lerner of 1.792 while minus one standard deviation gives 0.288. Then we have the short-term effects with low competition as c16 + (c18*1.792) and the long run effect as (c17 + (c19*1.792))/(1 − c1). Correspondingly the short-term effects with high competition are c16 + (c18*0.288) and the long run effect is (c17 + (c19*0.288))/(1 − c1).

[15] Comparing the results with the usage data in Table 5, we find that some of the more extreme estimates are related to policies that are relatively little used.

Table 7 East Asian banks—effects on log Z-score of macroprudential policies and interacted effects of competition

	Macroprudential variables only		Macroprudential and interacted variables			
	DMP	MP(−1)	DMP	MP(−1)	DMP* LERNER(−1)	MP(−1)* LERNER(−1)
CCB	−0.0363	0.234*	0.756***	0.653***	−0.579***	−0.307***
	(0.2)	(2.0)	(5.5)	(5.9)	(6.3)	(3.3)
CONSERVATION	−0.09	0.0367	−0.105	−0.0801	−0.001	0.0833
	(1.1)	(0.9)	(0.7)	(1.3)	(0.1)	(1.6)
CAPITAL	−0.099	−0.0461	−0.094	−0.101**	−0.0104	0.0534*
	(1.4)	(1.0)	(0.5)	(2.2)	(0.1)	(2.1)
LVR	−0.148	0.0081	−0.169	−0.157	0.00395	0.143
	(1.7)	(0.1)	(1.4)	(0.8)	(0.1)	(1.2)
LLP	−0.188***	−0.02	−0.295***	−0.0681	0.09	0.05
	(3.7)	(0.5)	(3.8)	(1.5)	(1.3)	(1.0)
LCG	−0.245***	−0.36*	0.118	−0.263	−0.331***	−0.103*
	(3.4)	(1.9)	(0.9)	(1.4)	(4.0)	(1.9)
LOANR	0.063*	−0.0682**	0.205**	0.117***	−0.107	−0.0361*
	(2.1)	(2.5)	(2.6)	(3.6)	(1.7)	(1.9)
LFC	0.396***	0.0104	0.154	−0.14	0.194	0.143***
	(4.2)	(0.1)	(0.3)	(1.6)	(0.6)	(4.5)
LTV	0.0322	0.0294	0.0336	0.0604	0.0005	−0.021
	(1.4)	(1.7)	(0.6)	(1.3)	(0.1)	(0.7)
DSTI	0.114***	0.128*	0.151	0.134	−0.0282	−0.0039
	(3.3)	(2.0)	(1.1)	(1.1)	(0.3)	(1.5)
TAX	0.0622*	0.0465	0.172**	0.11**	−0.0905	−0.0478**
	(1.8)	(1.6)	(2.5)	(2.7)	(1.3)	(2.2)
LIQUIDITY	0.097**	0.169**	0.0734	0.1	0.0254	0.0501**
	(2.3)	(2.3)	(1.3)	(1.5)	(0.8)	(2.9)
LTD	0.00316	−0.125	−0.008	−0.244	0.0344	0.11
	(0.5)	(1.0)	(0.1)	(1.8)	(0.4)	(0.6)
LFX	−0.114**	−0.161**	−0.103*	−0.183**	−0.0105	0.0196
	(2.7)	(2.6)	(1.8)	(2.4)	(0.1)	(0.4)
RR	0.0119	0.0109	0.0588***	0.0307**	−0.0414**	−0.0172***
	(0.5)	(1.2)	(4.2)	(2.4)	(2.8)	(3.2)
SIFI	−0.0253	−0.0833	−0.0746	−0.271**	0.0512	0.141**
	(0.2)	(1.0)	(0.6)	(2.2)	(0.5)	(2.6)
OTHER	−0.0662*	0.0878*	0.0225	0.0717	−0.0675	0.0139
	(1.9)	(1.9)	(0.2)	(1.0)	(0.8)	(0.3)
MAPP-INDEX	−0.00132	0.00947*	0.00583	0.009	−0.0059	0.00035
	(0.2)	(2.0)	(0.2)	(1.1)	(0.3)	(0.1)
LOAN-TARGETED	0.199	0.025**	0.0298	0.028	−0.0065	−0.002
	(1.1)	(2.3)	(0.7)	(1.4)	(0.3)	(0.1)
DEMAND	0.041**	0.0375	0.0413	0.0607	0.002	−0.016
	(2.7)	(2.0)	(0.8)	(1.4)	(0.1)	(0.5)
SUPPLY-ALL	−0.0078	0.00581	0.0041	0.0033	−0.01	0.00187
	(0.8)	(1.2)	(0.1)	(0.3)	(0.5)	(0.2)
SUPPLY-LOANS	0.0035	0.0332*	0.0554	0.0226	−0.044	0.0082
	(0.1)	(2.1)	(0.5)	(0.8)	(0.6)	(0.3)
SUPPLY-GENERAL	0.0091	0.0079	0.0169	0.0146	−0.0072	−0.0057
	(0.5)	(0.8)	(0.8)	(0.8)	(0.4)	(0.6)
SUPPLY-CAPITAL	−0.0808**	−0.0022	−0.036	−0.074	−0.052	0.0608***
	(2.5)	(0.1)	(0.3)	(1.7)	(0.6)	(3.1)

The macroprudential instruments' coefficient values are reported and the t-statistics are reported in parenthesis below each estimated coefficient. Each equation includes all the control variables shown in Table 6. The equations are estimated by panel OLS with country-clustered standard errors and bank and time fixed effects, and using cluster-robust standard errors., with macroprudential variables added one at a time. *** significant at 1%, ** significant at 5%, * significant at 10%. Mean of 0.25028 for East Asian banks used for demeaning LERNER. Individual measures are CCB the countercyclical capital buffer, CONSERVATION the capital conservation buffer, CAPITAL capital requirements, LVR leverage ratio limits, LLP loan-loss provision measures, LCG limits to credit growth, LOANR loan restrictions, LFC foreign currency lending limits, LTV limits to the loan-to-value ratio, DSTI limits to the debt-service-to-income ratio, TAX tax measures, LIQUIDITY liquidity measures, LTD loan to deposit limits, LFX limits on FX positions, RR reserve requirements, SIFI measures on systemic institutions, OTHER measures not captured otherwise. Summary measures, firstly, are MAPP INDEX which is the sum of dummies for all of 17 categories. The LOAN TARGETED group consists of the "Demand" and the "Supply-loans" instruments. DEMAND comprises: LTV and DSTI. SUPPLY-ALL is the sum of all

Table 7 (continued)

measures except LTV and DSTI, SUPPLY-LOANS is loan growth limits, provision measures, loan measures, limits to the loan to deposit ratio, and limits to foreign currency loans. SUPPLY-GENERAL is reserve requirements, liquidity requirements, and limits to FX positions. SUPPLY-CAPITAL is leverage, countercyclical buffers, conservation buffers, and capital requirements. For more details, see Tables 3 and 4

a more adverse change in risk than a high level, since all the significant short run interaction effects are negative. The exceptions for short and/or long run effects are cases where the interaction terms are not significant so the effects are the same regardless of the level of competition.

In sum, this section has shown that competition has a positive relation to risk in East Asia and that macroprudential policies affect risk but do not always act to reduce it. There are indications from interaction terms that for some policies, banks with low levels of market power respond more in terms of risk reduction to macroprudential policy than those with high market power, supporting our *Hypothesis Three*. But for other policies, there is support for *Hypothesis Two*, with the banks with low levels of market power responding less than the banks with high market power.

Subsample results

It may be questioned whether our results are driven by different patterns of responses in certain East Asian countries such as the emerging market and developing economies (EMDEs) as compared to those in East Asian advanced economies. The full sample, of course, aggregates both types of country, as shown in Table 1. The contrast of results for risk and competition by Fu et al. [28] with a mix of advanced and emerging countries and Soedarmono et al. [41] with emerging countries, underlines the potential importance of this issue.

To answer this, we separately examined countries in EMDE and the advanced categories, according to the IMF. Results are shown in Table 9 (East Asian EMDEs) and 10 (East Asian advanced countries). The baseline equations are shown in "Appendix 2 Table 15," where there are some differences in significant control variables, but in both country groups competition is positively related to risk (i.e. "competition-fragility" overall). This is the case for both difference and level of LERNER for the EMDE countries and the difference only for the advanced countries. We note that the long run competition effect on risk (excluding macroprudential policies) is somewhat larger in the EMDEs than the full Asian sample, highlighting their vulnerability and the importance of the correct choice and calibration of macroprudential policy to offset it. This result contrasts with Soedarmono et al. [41] who found that the Z-score and Lerner index were negatively related in Asian EMDEs, with greater market power leading to greater insolvency risk.

There are also some differences in the effects of macroprudential policies on bank risk between advanced and EMDE groups. The risk-reducing effect of macroprudential policies (excluding interacted effects) is most apparent in the EMDEs (Table 9). Risk is reduced in the short run by countercyclical buffers (CCB), foreign currency lending limits (LFC) and tax measures (TAX) and countercyclical buffers (CCB), loan restrictions (LOANR), loan-to value limits (LTV), debt-to-income limits (DSTI), tax measures (TAX), liquidity measures (LIQUIDITY) and other measures (OTHER) in the long run. There are also some risk-raising effects in the short run from capital measures (CAPITAL), provisioning measures (LLP) and credit growth limits (LCG), and in the long run from loan-loss provision measures (LLP), limits to credit growth (LCG), foreign currency lending limits (LFC), foreign currency position limits (LFX) and measures on systemic institutions (SIFI). However, the risk reducing measures dominate in the long run as shown by the summary indices, a number of which show risk reduction from macroprudential policy in the long run, namely MAPP INDEX (the sum of dummies), LOAN-TARGETED and DEMAND. DEMAND has a positive sign in the short run also.

The risk effects of types of macroprudential policy in EMDEs are less clear cut than in the main sample (Table 7). We find, unlike Ely et al. [27] that while some capital and liquidity measures to reduce risk in the long run, some loan based measures do the same.

In EMDEs, we also find a wide range of polices have a negative interacted effect with market power in both the short and long run. In virtually all cases, this implies less competitive banks take relatively more risk in response to macroprudential policies, in line with *Hypothesis Three*. This either offsets a positive direct effect or shows a significant negative effect that is larger for less competitive banks. In the long run, this is shown by negative and significant effects for interacted terms for loan restrictions (LOANR), Loan-to-value limits (LTV), tax measures (TAX), loan-to-deposit measures (LTD) and reserve requirements (RR) as well as the summary measures LOAN-TARGETED and DEMAND. Short run negative interacted effects are found for leverage measures (LVR), limits to credit growth (LCG), loan restrictions (LOANR), loan-to-deposit measures (LTD) and reserve requirements (RR). Again, as in Table 7, the interacted coefficients are typically smaller than those of the macroprudential effects, implying (given that we have demeaned the interacted Lerner) that effects on the log Z-score become negative at levels of market power that are well above average.

Table 8 East Asian banks—short and long run percentage effects on Z-score of macroprudential policies plus interacted effects of competition

Percent	No interaction terms		Average competition—interaction terms and demeaned Lerner set at mean (set to 1)		Low competition—interaction terms and demeaned Lerner at mean plus one standard deviation (set to 1.792)		High competition—interaction terms and demeaned Lerner at mean minus one standard deviation (set to 0.288)		Memo: sign of significant interacted terms	
	Short term	Long term	Short term	Long term	Short term	Long term	Short term	Long term	Short term	Long term
CCB	–	40.4	17.7	59.2	−28.2	17.6	58.9	96.7	–	–
CONSERVATION	–	–	–	–	–	–	–	–		
CAPITAL	–	–	–	−8.2	–	−0.9	–	−14.8		+
LVR	–	–	–	–	–	–	–	–		
LLP	−18.8	–	−29.5	–	−29.5	–	−29.5	–		
LCG	−24.5	−65.7	−33.1	−17.8	−59.3	−31.9	−9.5	−5.1	–	–
LOANR	6.3	−11.8	20.5	−41.9	20.5	−91.1	20.5	2.2		–
LFC	39.6	–	–	24.9	–	44.6	–	7.2		+
LTV	–	–	–	–	–	–	–	–		
DSTI	11.4	22.0	–	–	–	–	–	–		
TAX	6.2	–	17.2	10.7	17.2	4.2	17.2	16.6		–
LIQUIDITY	9.7	29.1	–	8.7	–	15.5	–	2.5		+
LTD	–	–	–	–	–	–	–	–		
LFX	−11.4	−27.6	−10.3	−31.3	−10.3	−31.3	−10.3	−31.3		
RR	–	–	1.7	2.3	−1.5	0.0	4.7	4.5	–	–
SIFI	–	–	–	19.8	–	39.2	–	2.3		+
OTHER	−6.6	15.3	–	–	–	–	–	–		
MAPP-INDEX	–	1.6	–	–	–	–	–	–		
LOAN-TARGETED	–	4.3	–	–	–	–	–	–		
DEMAND	4.1	–	–	–	–	–	–	–		
SUPPLY-ALL	–	–	–	–	–	–	–	–		
SUPPLY-LOANS	–	5.8	–	–	–	–	–	–		
SUPPLY-GENERAL	–	–	–	–	–	–	–	–		
SUPPLY-CAPITAL	−8.1	–	–	10.6	–	19.0	–	3.1		+

For details of calculation see Footnote 14 and for variable definitions and underlying coefficients see Table 7. Significant effects only are included in the table

There are three positive interactions, namely short run effects of capital measures (CAPITAL) and limits on foreign currency loans (LFC) and long run measures on systemic institutions (SIFI), where less competitive banks are shown as less risky in response to macroprudential policy than those that are more competitive.

Overall, for East Asian EMDE banks this suggests, in line with the *Hypothesis Three*, that lower levels of competition/higher levels of market power undermine the beneficial impact of macroprudential policy on risk in Asian EMDEs in both the short and long run. This is a much clearer and consistent result than for East Asia as a whole as shown in Table 7, which reflects bank performance across both EMDEs and advanced countries.

As regards the advanced Asian economies (Table 10), effects of macroprudential policies on bank risk are to reduce risk via limits on foreign currency loans (LFC) and debt-service-to-income limits (DSTI) in the short run and leverage ratio limits (LVR), loan-loss provision measures (LLP) and liquidity measures (LIQUIDITY) in the long run. There are a number of risk-raising terms, namely, countercyclical buffers (CCB), leverage measures (LVR) and other measures (OTHER) in the short run and limits on FX positions (LFX) and other measures (OTHER) in the long term. The summary measures are typically positive in the short run and zero in the long run. Again, we cannot simply categorise capital and liquidity measures as reducing risk and loan measures as risk inducing.

The pattern for interacted terms differs almost completely from the EMDEs, in that there is a balance of negative and positive short-run coefficients but all significant effects are positive in the long run. This suggests that there is a relative risk-raising effect of macroprudential policy for more competitive banks, especially in the long run, namely for countercyclical buffers (CCB), leverage ratio limits (LVR), loan-loss provision measures (LLP), foreign currency lending limits (LFC), liquidity measures (LIQUIDITY) and limits on loan-to-deposit ratios (LTD). This is also the case for MAPP-INDEX, SUPPLY-ALL, SUPPLY-LOANS SUPPLY-GENERAL and SUPPLY-CAPITAL among the summary measures. These suggest that banks with low levels of market power respond less in terms of risk reduction to macroprudential policy than those with high market power, in line with the franchise value approach of Keeley [34]. In several cases, notably the aggregate measure MAPP-INDEX, a long-run risk increasing effect of the policy reverses into risk reduction for the least competitive firms.

There are some exceptions in the case of negative short-term interactions of countercyclical buffers (CCB) and capital measures (CAPITAL) with competition, and the summary measures SUPPLY-LOANS and SUPPLY-CAPITAL.

Apart from these, this pattern of results for advanced East Asian countries is much more in line with *Hypothesis Two*, namely that that banks with high levels of market power respond less in terms of risk reduction to macroprudential policy.

The presence of significant interacted coefficients in both samples implies that the competition effect is not just a consequence of country-development (in fact, levels of competition are close—the average Lerner index for the EME banks is 0.254 and advanced countries 0.243). It also implies that *Hypothesis One* (i.e. no interaction) can be ruled out for both samples. However, the differences between EMDEs and advanced countries show that there may be differences in the response, that may link in turn to contrasts in regulation and management incentives as well as market structure.

In sum, we have found that for East Asian banks in EMDE countries, banks with low levels of market power respond less in terms of risk reduction to macroprudential policy than those with high market power (*Hypothesis Three*). On the other hand, results for the long run interaction in advanced East Asian countries suggests that banks with high levels of market power respond less in terms of risk reduction to macroprudential policy than those with low market power (*Hypothesis Two*). Results for the region as a whole (in the "Baseline results" section) reflect a balance between the two patterns as they integrate both EMDE and advanced country banks.

Robustness checks

We contend that the subsample results in Tables 9 and 10 are already a form of robustness check, as also noted by Meuleman and Vander Vennet [39]. We also undertook three additional formal robustness checks. The first was to add variables for the quality of supervision, the second was to include all of the policy and policy-interaction effects simultaneously, and the third uses bank-level clustering instead of country-level clustering.

The additional supervision variables in the first robustness check are summary measures for activity restrictions, capital regulation and supervisory power derived from the series of World Bank publications on supervision around the world [10], updated using the latest survey for 2016 [8]. These data were also used in papers such as Karolyi and Tabaoda [33], Gaganis et al. [30], Danisman and Demirel [21] and Davis et al. [25]. We note that the studies themselves are dated 1999, 2003, 2007, 2011 and 2016. To cover the sample, we have interpolated between the values given in the samples and fixed the values of 1999 for 1990–8 and

Table 9 East Asian EMDE banks—effects on log Z-score of macroprudential policies and interacted effects of competition

	Macroprudential variables only		Macroprudential and interacted variables			
	DMP	MP(−1)	DMP	MP(−1)	DMP* LERNER(−1)	MP(−1)* LERNER(−1)
CCB	0.235*	0.449***	0.611**	0.697***	−0.375	−0.22
	(2.4)	(6.2)	(2.7)	(3.9)	(1.6)	(1.5)
CONSERVATION	−0.138	0.0523	−0.0617	−0.0887	−0.0635	0.114
	(1.4)	(1.0)	(0.3)	(1.2)	(0.8)	(1.4)
CAPITAL	−0.145**	−0.053	−0.307**	−0.0872**	0.157**	0.0361
	(3.0)	(1.1)	(3.5)	(2.7)	(2.7)	(1.2)
LVR	−0.0113	−0.0179	0.106	−0.0531	−0.182**	−0.0287
	(1.5)	(0.1)	(0.9)	(0.2)	(3.5)	(0.4)
LLP	−0.262***	−0.103**	−0.257**	−0.0536	−0.00595	−0.0546
	(4.9)	(3.3)	(2.5)	(1.0)	(0.1)	(1.7)
LCG	−0.308**	−0.374*	0.0616	−0.273	−0.334**	−0.105
	(3.1)	(2.0)	(0.4)	(1.4)	(3.3)	(1.1)
LOANR	0.0413	0.0736**	0.281***	0.136***	−0.184**	−0.0467***
	(1.5)	(3.0)	(3.9)	(4.3)	(2.9)	(3.6)
LFC	0.241**	−0.432**	−0.419*	−0.517*	0.476***	0.0717
	(2.7)	(2.5)	(2.3)	(2.2)	(5.9)	(1.2)
LTV	0.0295	0.0533**	0.0522	0.145***	−0.0183	−0.0645***
	(1.0)	(2.6)	(0.5)	(7.6)	(0.3)	(4.1)
DSTI	0.0342	0.34***	0.0508	0.362*	−0.0128	−0.0186
	(0.3)	(5.2)	(0.2)	(2.3)	(0.1)	(0.2)
TAX	0.146***	0.0651**	0.143**	0.168***	0.0052	−0.08***
	(3.9)	(2.8)	(3.2)	(6.8)	(0.2)	(3.7)
LIQUIDITY	0.082	0.206*	0.0453	0.147	0.0324	0.0452
	(1.0)	(2.0)	(0.5)	(1.6)	(1.1)	(0.9)
LTD	−0.0132	−0.131	0.0723	−0.053	−0.0727**	−0.0688***
	(0.3)	(1.6)	(1.1)	(0.6)	(3.5)	(4.9)
LFX	−0.0837	−0.156**	−0.0881	−0.199**	0.0047	0.0389
	(1.2)	(2.7)	(0.9)	(2.5)	(0.1)	(0.7)
RR	0.0144	−0.0119	0.0651**	0.0343**	−0.0444***	−0.0188**
	(0.4)	(1.8)	(3.1)	(3.0)	(4.6)	(3.4)
SIFI	−0.123	−0.212*	−0.0606	−0.423***	−0.0419	0.189**
	(1.4)	(2.4)	(0.5)	(4.1)	(0.4)	(3.2)
OTHER	−0.0756	0.111**	−0.008	0.151*	−0.0493	−0.0347
	(1.7)	(2.6)	(0.1)	(2.2)	(0.5)	(1.2)
MAPP-INDEX	−0.0106	0.00986**	−0.0085	0.0167**	−0.0015	−0.00537
	(0.9)	(3.1)	(0.8)	(3.3)	().1)	(1.6)
LOAN-TARGETED	0.00165	0.0327**	0.0387	0.0631***	−0.0283	−0.0229**
	(0.1)	(2.9)	(0.7)	(4.4)	(0.8)	(2.7)
DEMAND	0.0455*	0.0937*	−0.0571	0.175***	−0.0075	−0.0572**
	(2.2)	(2.3)	(0.6)	(4.2)	(0.1)	(2.8)
SUPPLY-ALL	−0.01	0.006	0.00364	0.0119	−0.0111	−0.0051
	(0.7)	(1.6)	(0.3)	(1.2)	(0.7)	(1.1)
SUPPLY-LOANS	−0.0253	0.0267	0.0889	0.0588*	−0.092	−0.0259
	(0.8)	(1.8)	(1.0)	(2.1)	(1.3)	(1.5)
SUPPLY-GENERAL	0.0131	0.00872	0.0325	0.0229	−0.0172	−0.0116
	(0.5)	(1.2)	(1.8)	(1.6)	(1.7)	(1.9)
SUPPLY-CAPITAL	−0.129	−0.013	−0.168	−0.0489	0.0295	0.0328
	(3.7)	(0.3)	(1.1)	(1.0)	(0.3)	(1.9)

See Table 7 for details of variables and estimation, and Appendix Table 15 column 2 for baseline estimation results

Table 10 East Asian advanced country banks—effects on log Z-score of macroprudential policies and interacted effects of competition

	Macroprudential variables only		Macroprudential and interacted variables			
	DMP	MP(−1)	DMP	MP(−1)	DMP* LERNER(−1)	MP(−1)* LERNER(−1)
CCB	−0.368***	−0.0144	1.13***	−0.45***	−0.943***	0.283***
	(5.0)	(0.2)	(4.7)	&.0)	(7,6)	(21.1)
CONSERVATION	0.15	−0.179	0.0539	−0.263*	0.0737	0.362
	(0.9)	(1.5)	(0.3)	(2.2)	(0.5)	(1.0)
CAPITAL	−0.0113	−0.101	0.373	−0.212**	−0.378***	0.131
	(0.1)	(1.5)	(1.9)	(2.5)	(4.2)	(2.0)
LVR	−0.209*	0.479**	−0.478**	−0.0651	0.19***	0.424***
	(2.1)	(3.3)	(3.8)	(0.4)	(4.3)	(4.3)
LLP	0.0206	0.166***	−0.0931	−0.0267	0.0437	0.179***
	(0.2)	(8.8)	(1.6)	(0.6)	(0.8)	(5.3)
LCG						
LOANR	0.111	−0.018	0.0895	−0.0758	0.0143	0.0364
	(1.0)	(0.2)	(0.7)	(0.6)	(0.3)	(0.5)
LFC	0.738***	0.0631	0.544***	−0.189**	0.231	0.249***
	(5.5)	(1.2)	(9.3)	(3.2)	(1.9)	(5.9)
LTV	0.0659	−0.0283	0.0124	−0.0794	0.037*	0.0363
	(1.4)	(0.8)	(0.2)	(1.9)	(2.2)	(1.1)
DSTI	0.109**	−0.0019	0.0435	−0.056	0.0454	0.0409
	(3.9)	(0.1)	(0.4)	(0.7)	(0.5)	(0.5)
TAX	0.00183	−0.051	0.127	0.00652	−0.115	−0.0378
	(0.1)	(0.9)	(1.3)	(0.1)	(1.4)	(1.0)
LIQUIDITY	0.0844	0.199**	0.106	0.0593	−0.0715	0.0902**
	(1.2)	(3.3)	(0.8)	(0.7)	(0.4)	(2.6)
LTD	0.0489	0.0939	−0.808**	−0.669***	0.785***	0.736**
	(0.3)	(0.7)	(3.7)	(4.0)	(5.8)	(5.7)
LFX	−0.0895	−0.272***	−0.0268	−0.222***	−0.0598	−0.05
	(1.5)	(6.5)	(0.3)	(12.3)	(1.3)	(1.7)
RR	−0.0326	0.0856	0.333	0.301	−0.452	−0.245
	(0.1)	(0.4)	(1.8)	(1.1)	(1.0)	(0.9)
SIFI	0.268	0.055	0.163	0.0178	0.0783	0.0219
	(1.9)	(1.0)	(1.8)	(0.1)	(0.5)	(0.4)
OTHER	−0.216**	−0.191*	−0.258	−0.348***	0.0142	0.13
	(2.9)	(2.3)	(1.2)	(4.4)	(0.1)	(1.5)
MAPP-INDEX	0.015	−0.0106	0.0413	−0.0308*	−0.0291	0.0161**
	(1.8)7	(0.9)	(1.2)	(2.1)	(1.1)	(3.3)
LOAN-TARGETED	0.0625*	−0.0012	0.0417	−0.0267	0.0106	0.0197
	(2.5)	(0.1)	(1.3)	(1.4)	(0.8)	(1.9)
DEMAND	0.0603*	−0.0128	0.0118	−0.0411	0.0353	0.0204
	(2.3)	(0.5)	(0.2)	(1.3)	(1.1)	(0.9)
SUPPLY-ALL	−0.0023	−0.00457	0.0999	−0.0488*	−0.111	0.047***
	(0.1)	(0.3)	(1.2)	(2.4)	(1.7)	(5.6)
SUPPLY-LOANS	0.113*	0.0271	0.203**	−0.0434	−0.083*	0.0649***
	(2.2)	(0.9)	(3.4)	(1.2)	(2.1)	(5.6)
SUPPLY-GENERAL	−0.00202	−0.0282	0.0157	−0.134*	−0.0447	0.101***
	(0.1)	(0.5)	(0.1)	(2.3)	(0.4)	(7.5)
SUPPLY-CAPITAL	−0.0291	−0.0334	0.152	−0.172***	−0.204**	0.128***
	(0.4)	(0.6)	(1.0)	(4.4)	(2.7)	(5.7)

See Table 7 for details of variables and estimation, and Appendix Table 15 column 1 for baseline estimation results. There were no cases of credit growth limits (LCG) as defined by the database

2016 for 2017–18. Karolyi and Tabaoda [33] similarly fixed their values for 2012–2015 at the 2011 level.

"Appendix Table 16" shows the results for the quality of supervision check without macroprudential variables (column 1), and the baseline variables from the all-policy variants (columns 2 and 3), along with bank clustering equation (column 4) and the original baseline as shown in Table 6. It can be seen that the lagged dependent remains significant in each case, as do the competition variables (showing overall "competition-fragility"), provisions/loans and the banking crisis dummy. GDP growth enters the quality of supervision and bank clustering variants with a negative sign, while bank clustering also includes the noninterest ratio and the loan/asset ratio with a negative sign.

Concerning the quality of supervision variables (column 1 of Table 16), we note that the number of observations is lower than in Table 6, given the supervision variables do not cover all countries and time periods. We see that it is the stringency in application of capital adequacy that is significant in reducing risk and not activity restrictions or overall quality of supervision. This contrasts with Gaganis et al. [30] who found activity restrictions to be significant for reducing risk, while capital requirements were not. We retain the three variables for the checks for macroprudential effects.

"Appendix Table 17" shows results for the equation including quality of supervision (column (1) of Table 11), where as in the rest of the estimates, each macroprudential variable is added one by one. Comparing the table with Table 7, it can be seen that the results are closely comparable, in terms of significant variables and their signs and magnitude, both with and without the interacted terms. The key result of a balance between positive and negative long run interaction terms remains, with seven terms similarly significant and with the same sign (two long run interaction terms are now insignificant, namely capital measures (CAPITAL) and loan limits (LOANR)). A similar congruency applies to the short run interaction terms with the exception of provision limits (LLP) which is now insignificant.

Looking at the results in "Appendix Table 18" for equations with all policies entered together (columns 1 and 2) and all policies plus interaction terms (columns 3–6), it should be noted that the summary variables are not included to avoid double counting. We again find a balance between positive and negative interaction terms, with the sign and significance being similar in the long run to Table 7 for foreign currency lending restrictions (LFC), tax measures (TAX) and measures on systemic institutions (SIFI). This is also the case for countercyclical buffers (CCB) in the short run. Some other interactions differ, namely the long run effects of competition interacted with conservation measures (CONSERVATION), leverage ratio measures (LVR) and loan-loss provision measures (LLP) as well as leverage ratio measures (LVR) and loan-to-deposit limits (LTD) in the short run.

Finally the bank level clustering ("Appendix Table 19")—based on column (3) of Table 11—mostly leads to greater significance (the coefficients are of course the same as in the country-clustering). In estimates with macroprudential measures only, there remains a slight predominance of risk-reduction effects in the long run, while there are more cases of risk raising in the short term. In the estimates interacted with competition, all the existing long run effects remain significant except credit growth limits (LCG), while there are two additional ones, both with a positive sign, namely conservation buffers (CONSERVATION) and leverage ratio limits (LVR). In the short run, we retain the existing significant effects, with the additional of loan restrictions (LOANR) and tax measures (TAX). All of the significant interacted terms have a negative sign in the short run. Note that each macroprudential variable is added one by one in this equation.

We contend that each of the robustness checks support the pattern in Table 7 of a balance between *Hypothesis Three* that banks with low levels of market power respond less in terms of risk reduction to macroprudential policy than those with high market power and *Hypothesis Two* that the opposite is the case. On balance, we contend that the robustness checks underpin the principal results of the paper.

Broader samples

Before concluding, we show estimates of results using broader samples, namely a global and a European sample, to judge the extent to which our results are specific to East Asia. These data are collected similarly to the East Asian sample with the 100 largest banks for each country in 1995, 2005 and 2015 (or less if there are less in the database). There are 43,348 observations for the global sample across 4601 banks in 92 countries[16] and 22,840 observations for 2193 banks in 36 European countries. As shown in "Appendix 2, Table 15," the determination of log Z-score is similar to the baseline in the global and European samples, as well as for subsamples of the East Asia group. Notably we find in each case both short- and long-run positive effects of competition on risk, consistent with "competition-fragility".

Table 11 shows that for a global sample, the effects of macroprudential policy on risk is generally to reduce it. In the short run, this is the case for foreign currency lending limits (LFC), loan-to-value limits (LTV), debt-service to income limits (DSTI), tax measures (TAX) and loan-to-deposit measures (LTD). The only policy shown to give a

[16] For more detail on the global dataset see Davis et al. [25].

Table 11 Global sample—effects on log Z-score of macroprudential policies and interacted effects of competition

	Macroprudential variables only		Macroprudential and interacted variables			
	DMP	MP(−1)	DMP	MP(−1)	DMP* LERNER(−1)	MP(−1)* LERNER(−1)
CCB	0.0256	0.149***	0.0838	0.182*	−0.0466	−0.0181
	(0.4)	(5.4)	(1.6)	(1.9)	(0.7)	(0.4)
CONSERVATION	0.0216	0.0583*	−0.0044	0.00185	0.0255	0.0462*
	(0.6)	(1.8)	(0.1)	(0.1)	(0.7)	(1.8)
CAPITAL	−0.0209	−0.0091	−0.0305	−0.0417***	0.0103	0.0297**
	(0.8)	(0.7)	(1.1)	(2.9)	(0.5)	(2.5)
LVR	−0.0254	0.0482	−0.759	0.0165	0.0376	0.0244
	(0.5)	(0.9)	(1.2)	(0.2)	(0.8)	(0.6)
LLP	−0.01	0.0516	−00702	0.0219	0.0476	0.0279
	(0.2)	(1.5)	(0.8)	(0.6)	(0.9)	(1.2)
LCG	−0.141*	0.0595	−0.228**	0.0295	0.0841	0.0221
	(1.7)	(0.6)	(2.3)	(0.2)	(1.4)	(0.5)
LOANR	0.0597	0.0429	0.0277	00166	0.0247	0.0196
	(1.3)	(1.6)	(0.6)	(0.3)	(0.9)	(0.8)
LFC	0.139***	−0.00946	0.0873**	−0.0217	0.0515*	0.012
	(3.3)	(0.4)	(2.4)	(1.4)	(1.8)	(0.5)
LTV	0.059***	0.0409**	0.0547*	0.00523	0.00217	0.0269
	(3.3)	(2.3)	(1.8)	(0.2)	(0.1)	(1.4)
DSTI	0.0687**	0.0567	0.0504	0.00314	0.00916	0.0444*
	(2.4)	(1.3)	(1.0)	(0.1)	(0.2)	(1.9)
TAX	0.0578*	0.0452**	0.0022	0.0313	0.0488	0.01
	(1.8)	(2.2)	(0.1)	(1.0)	(1.3)	(0.6)
LIQUIDITY	0.00388	0.0122	−0.0325	−0.00766	0.0312	0.0161*
	(0.1)	(0.6)	(0.8)	(0.5)	(1.6)	(1.7)
LTD	0.12*	−0.0718	0.0383	−0.11**	0.0547	0.027
	(1.8)	(0.8)	(0.5)	(2.2)	(1.3)	(0.5)
LFX	−0.035	−0.0349	−0.0357	−0.0453	0.000167	0.00843
	(0.8)	(0.8)	(0.5)	(0.9)	(0.1)	(0.6)
RR	0.0161	0.0154	0.0237	0.0119	−0.00783	0.00284
	(1.6)	(1.4)	(1.6)	(0.9)	(0.7)	(0.7)
SIFI	−0.0143	0.0119	−0.0414	−0.0741	0.0264	0.0602**
	(0.3)	(0.2)	(0.8)	(1.4)	(0.7)	(2.1)
OTHER	−0.0258	0.0137	−0.0297	−0.0132	0.00288	0.0243
	(0.8)	(0.4)	(0.7)	(0.3)	(0.1)	(1.3)
MAPP-INDEX	0.00838	0.00934	0.00263	0.002	0.00467	0.00584**
	(1.1)	(1.6)	(0.2)	(0.3)	(0.8)	(2.0)
LOAN-TARGETED	0.0293**	0.0207**	0.0125	0.00744	0.0128	0.0101
	(2.2)	(2.0)	(0.7)	(0.6)	(1.2)	(1.5)
DEMAND	0.0433***	0.0304	0.039*	0.00372	0.00209	0.0205*
	(3.4)	(2.0)	(1.7)	(0.2)	(0.1)	(1.8)
SUPPLY-ALL	0.00527	0.00788	0.00021	−0.00021	0.00447	0.00691**
	(0.6)	(1.0)	(0.1)	(0.1)	(0.7)	(2.3)
SUPPLY-LOANS	0.0323	0.0242	−0.00203	0.00906	0.0288*	0.0123
	(1.1)	(1.2)	(0.1)	(0.4)	(1.8)	(1.2)
SUPPLY-GENERAL	0.0109	0.0128	0.0104	0.00536	0.000425	0.00611
	(1.2)	(1.3)	(0.7)	(0.5)	(0.1)	(1.5)
SUPPLY-CAPITAL	−0.00923	0.00732	−0.0114	−0.0217	0.00419	0.0245***
	(0.4)	(0.6)	(0.4)	(1.4)	(0.3)	(3.1)

See Table 7 for details of variables and estimation, and Appendix Table 15 column 3 for baseline estimation results. Mean of 0.225478 for global banks used for demeaning LERNER

short run increase in risk is credit growth limits (LCG). In the long run, the significant effects arise from countercyclical buffers (CCB), conservation buffers (CONSERVATION), loan-to-value limits (LTV) and tax measures (TAX) which again reduce risk. Summary measures for DEMAND and LOAN TARGETED are significant and risk-reducing in the short run and LOAN-TARGETED also in the long run. This overall risk-reducing effect is in line with studies such as Gonzalez (2022).

There are less significant interacted effects of competition than in the Asian samples, but they are consistently positive, showing that on average globally, less competitive banks become less risky in response to macroprudential measures. This is the case in the long term for conservation buffers (CONSERVATION), capital measures (CAPITAL), debt-service to income (DSTI), liquidity measures (LIQUIDITY) and measures on systemic institutions (SIFI). It is notable that apart from DSTI, all these measures are covered by the Basel III agreement, suggesting regulators need to be vigilant for risk increases by institutions facing intense competition as Basel III is introduced. The summary measures MAPP-INDEX, DEMAND, SUPPLY-ALL and SUPPLY-CAPITAL also have positive long run interaction terms. There is also a positive short-term interaction term for limits on foreign currency lending (LFC).

The global sample results may, as in Asia, overlay regional variations in the effect of competition on risk responses to macroprudential policies. To assess this, we chose to finally estimate across a European sample of banks (Table 12), while bearing in mind that most European countries adopted macroprudential policies later than East Asian countries did. Looking first at the effects of macroprudential policy without interacted effects, we find that they again mostly accompany a reduction in risk. This is the case in the long run for the countercyclical buffer (CCB), provisioning requirements (LLP), credit growth limits (LCG) and reserve requirements (RR) and for leverage measures (LVR) and foreign currency lending limits (LFC) in the short term. There is one exception to this as tax measures (TAX) raise risk in the long term. As in the global sample, summary measures DEMAND and LOAN TARGETED are significant and risk-reducing in the short run.

The interacted effects are somewhat akin to the Advanced Asian sample in Table 10. The long-run interacted effects are consistently positive across a number of variables, namely capital measures (CAPITAL), leverage measures (LVR), loan restrictions (LOANR), loan-to-value limits (LTV), debt-to-income limits (DSTI), levy/Tax on Financial Institutions (TAX) and liquidity measures (LIQUIDITY). Also, among the summary measures, in the long run, this is the case for MAPP-INDEX, LOAN-TARGETED, DEMAND, SUPPLY-ALL and SUPPLY-CAPITAL. In the short run, a positive interaction effect is also found for provisioning requirements (LLP), restrictions on foreign currency lending (LFC) and tax (TAX), although there are negative signs for countercyclical buffers (CCB) and limits on FX positions (LFX).

In sum, both the global results and the European results suggest that less competitive banks take less risk in response to macroprudential policies, in line with the *Hypothesis Two*. Accordingly, in such cases more supervisory attention should be given to the more competitive firms which are shown to take relatively more risk in response to macroprudential policies.

Conclusions

We have assessed the relation of macroprudential policy and competition to bank risk jointly for a sample of banks from 13 East Asian countries over 1990–2018. To our knowledge, this is the first paper to include both macroprudential policy and individual bank market power, as well as their interaction, as determinants of bank risk. On the one hand, we find direct effects of both macroprudential policy and competition on risk, in line with the existing literature. Table 13 summarises the macroprudential effects. On the other hand, we also detect important interaction effects as summarised in Table 14.

We have found that macroprudential policies, controlling for competition, had an effect on bank risk in East Asian countries over 1990–2018. Whereas there is commonly a beneficial effect on risk, there are a number of cases where policies were deleterious (increasing risk). Short and long run effects on risk often differ also. Notably in our full East Asian sample, significant capital-based and liquidity based policies reduce risk in the long run while certain loan-based policies tend to increase it, as also found by Ely et al. [27]. This may link in turn to greater scope to adjust balance sheets under loan-based policies, so as to raise risk on uncontrolled lending. The implication is that the introduction of loan-based policies necessitates heightened microprudential oversight and macroprudential surveillance. However, we note that this result does not hold for the global sample, suggesting a need for separate estimation at a regional level.

Meanwhile, heightened competition leads to increased risk taking in the short and long run, again implying grounds for caution among regulators in such cases. Besides macroprudential policies, microprudential policies in conjunction with competition policy would be important in maintaining

Table 12 European sample—effects on log Z-score of macroprudential policies and interacted effects of competition

	Macroprudential variables only		Macroprudential and interacted variables			
	DMP	MP(−1)	DMP	MP(−1)	DMP* LERNER(−1)	MP(−1)* LERNER(−1)
CCB	−0.00346	0.124**	0.0935***	0.151	−0.0826***	−0.0111
	(0.1)	(2.5)	(3.0)	(1.3)	(5.2)	(0.2)
CONSERVATION	0.0546	0.0344	0.00795	0.00151	0.0426	0.0268
	(1.1)	(0.9)	(0.1)	(0.1)	(1.3)	(1.0)
CAPITAL	0.0327	−0.0025	0.00832	−0.0678**	0.0221	0.0488***
	(0.9)	(0.1)	(0.2)	(2.2)	(1.1)	(3.2)
LVR	0.0869*	0.0952	0.141	−0.044	−0.0457	0.116***
	(1.9)	(1.7)	(1.3)	(0.8)	(0.7)	(6.0)
LLP	0.0993	0.148***	−0.0788	0.123	0.132**	0.0162
	(1.2)	(3.6)	(0.7)	(1.6)	(2.1)	(0.3)
LCG	−0.0491	0.219*	−0.149	0.161	0.0892	0.0447
	(0.5)	(2.0)	(1.2)	(1.2)	(1.2)	(0.6)
LOANR	0.0636	0.0522	0.0277	−0.0156	0.0256	0.0516**
	(1.1)	(0.9)	(0.5)	(0.3)	(0.9)	(2.7)
LFC	0.133**	0.01	0.0967**	0.00559	0.0369**	0.00402
	(2.6)	(0.4)	(2.4)	(0.3)	(2.4)	(0.3)
LTV	0.0674	0.0273	0.0525	−0.0722	0.00868	0.0266*
	(1.5)	(0.9)	(1.2)	(0.3)	(0.3)	(1.8)
DSTI	0.0534	0.0255	0.0556	−0.0412	−0.00912	0.0589*
	(1.0)	(0.3)	(0.7)	(0.5)	(0.2)	(2.0)
TAX	−0.0815	−0.132*	−0.18	−0.181**	0.1*	0.043***
	(0.9)	(1.8)	(1.6)	(2.7)	(1.8)	(4.1)
LIQUIDITY	−0.05	−0.0146	−0.0805	−0.024*	0.0233	0.0138**
	(1.1)	(0.7)	(1.6)	(1.9)	(1.3)	(2.1)
LTD						
LFX	0.76	0.0686	0.192	0.0524	−0.0374*	0.0145
	(1.6)	(0.8)	(1.7)	(0.7)	(1.9)	(1.1)
RR	0.0351	0.0443*	0.0276	0.0432*	0.00886	0.001
	(1.4)	(1.9)	(1.5)	(1.9)	(0.6)	(0.2)
SIFI	−0.001	0.0317	−0.00289	−0.0313	0.0103	0.0511
	(0.1)	(0.4)	(0.1)	(0.4)	(0.2)	(1.6)
OTHER	−0.00731	0.00144	−0.0142	−0.0131	0.00582	0.0133
	(0.2)	(0.1)	(0.5)	(0.3)	(0.2)	(0.7)
MAPP-INDEX	0.0204	0.014	0.0107	0.00396	0.00745	0.00736*
	(1.6)	(1.4)	(0.6)	(0.4)	(1.0)	(2.0)
LOAN-TARGETED	0.0327*	0.0236	0.0112	0.00243	0.0151	0.0158*
	(1.8)	(1.3)	(0.4)	(0.1)	(1.1)	(2.1)
DEMAND	0.0456*	0.0168	0.0449	−0.0118	−0.0032	0.0231*
	(1.8)	(0.7)	(1.2)	(0.5)	(0.1)	(1.9)
SUPPLY-ALL	0.0232	0.0157	0.00896	0.0046	0.0121*	0.00814*
	(1.6)	(1.5)	(0.5)	(0.5)	(1.7)	(2.0)
SUPPLY-LOANS	0.0489	0.0378	0.0125	0.0182	0.0323***	0.0154
	(1.5)	(1.2)	(0.4)	(0.7)	(3.0)	(1.2)
SUPPLY-GENERAL	0.00308	0.0226	−0.0122	0.0131	0.0147	0.00764
	(0.1)	(1.3)	(0.5)	(0.7)	(1.3)	(1.2)
SUPPLY-CAPITAL	0.0393	0.0096	0.0418	−0.0311*	0.00103	0.03***
	(1.4)	(0.7)	(1.0)	(2.0)	(0.1)	(3.9)

See Table 7 for details of variables and estimation, and Appendix Table 15 column 4 for baseline estimation results. There were no cases of loan to deposit limits (LTD) as defined by the database. Mean of 0.207217 for European banks used for demeaning LERNER

Table 13 Summary table of macroprudential policy effects on log Z-score (columns 1 and 2)

	Table 7: East Asia		Table 9: East Asia EMDEs		Table 10: East Asia advanced		Table 11: Global		Table 12: European	
	DMP	MP(−1)	DMP	MP(−1)	DMP	MP(−1)	DMP	MP(−1)	DMP	MP(−1)
CCB		+*	+*	+***	−***			+***		+**
CONSERVATION								+*		
CAPITAL			−**							
LVR					−*	+**			+*	
LLP	−***		−***	−**		+***				+***
LCG	−***	−*	−**	−*			−*			+*
LOANR	+*	−**		+**						
LFC	+***		+**	−**	+***		+***		+**	
LTV				+**			+***	+**		
DSTI	+***	+*		+***	+**		+**			
TAX	+*		+***	+**			+*	+*		−*
LIQUIDITY	+**	+**		+*		+**				
LTD							+*			
LFX	−**	−**		−**		−***				
RR										+*
SIFI				−*						
OTHER	−*	+*		−**	−**	−*				
MAPP-INDEX		+*		+**						
LOAN-TARGETED		+*		+**	+*		+**	+**	+*	
DEMAND	+**		+*	+*	+*		+***		+*	
SUPPLY-ALL										
SUPPLY-LOANS		+*			+*					
SUPPLY-GENERAL										
SUPPLY-CAPITAL	−**									

See Table 7 for details of variables and estimation

a set of resilient (individual) banks and hence lowering systemic risk in the longer run.

There are a number of significant interactions between competition and macroprudential measures, showing a different response depending on banks' market power. In East Asian EMDEs, the policies tend to be less effective where there is market power (in line with our *Hypothesis Three*), which is an issue relevant to policy makers. Market power may enable banks to adjust internally to offset the effects of policy, possibly by risk-shifting as suggested inter alia by Meuleman and Vander Vennet [39], owing to weak corporate governance [30], adverse selection of borrowers from high interest rates, the difficulty of supervision if uncompetitive banks are large and the perception in that case of being "too big to fail".

On the other hand, in East Asian advanced countries as well as in the global sample and in Europe there is a long-run tendency for the more competitive banks to take relatively more risk in response to macroprudential policies (in line with our *Hypothesis Two*), consistent with the franchise value hypothesis of Keeley [34]. This suggests that the East Asian EMDEs may be an outlier, although further work on other region EMDEs would be needed to prove this. Our overall East Asian sample reflects a balance of *Hypothesis Two* (from advanced country bank behaviour) and *Hypothesis Three* (from EMDE banks).

We suggest that a key result of our work is the widespread significance of the interacted terms. These results imply that market power is a relevant consideration when applying macroprudential policy and it should be monitored closely when enforcing such policy. This is quite apart from its direct effect on risk-taking which is found in this and other papers. It could be considered what further regulation is needed so that risk-shifting/risk taking can be minimised in the wake of macroprudential policy measures. Policymakers should take into account the

Table 14 Summary table of interaction effects on log Z-score (columns 5 and 6)

	Table 7: East Asia		Table 9: East Asia EMDEs		Table 10: East Asia advanced		Table 11: Global		Table 12: European	
	DMP* LERNER(−1)	MP(−1)* LERNER(−1)	DMP* LERNER(−1)	MP(−1)* LERNER(−1)	DMP* LERNER(−1)	MP(−1)* LERNER(−1)	DMP* LERNER(−1)	MP(−1)* LERNER(−1)	DMP* LERNER(−1)	MP(−1)* LERNER(−1)
CCB	−***	−***			−***	+***			−***	
CONSERVATION								+*		
CAPITAL		+*	+**		−***			+**		+***
LVR			−**		+***	+***				+***
LLP						+***			+**	
LCG	−***	−*	−**							
LOANR		−*	−**	−***						+**
LFC		+***	+***			+***	+*		+**	
LTV				−***	+*					+*
DSTI								+*		+*
TAX		−**		−***					+*	+**
LIQUIDITY		+**				+**		+*		+**
LTD			−**	−***	+***	+**				
LFX									−*	
RR	−**	−***	−***	−**						
SIFI		+**		+**				+**		
OTHER										
MAPP-INDEX						+**		+**		+*
LOAN-TARGETED				−**						+*
DEMAND				−**				+*		+*
SUPPLY-ALL						+***		+**	+*	+*
SUPPLY-LOANS					−*	+***	+*		+***	
SUPPLY-GENERAL						+***				
SUPPLY-CAPITAL		+***			−**	+***		+***		+***

See Table 7 for details of variables and estimation

competitiveness of their domestic banking system not only in setting the level but also choosing among various macroprudential policies. Some macroprudential policies' lack of effectiveness is reinforced by an uncompetitive banking system and in other cases it is offset. We note that in some samples Basel III regulations (such as the countercyclical buffer and liquidity policies) are effective against risk but also subject to higher risk taking by competitive banks, implying special care is needed as such policies are introduced.

We suggest that further research could undertake similar analyses for other regions such as Latin America and Africa. Given the approach is based on individual bank data, it can also be readily undertaken for individual countries wishing to assess the effectiveness of their macroprudential policies. Furthermore, consideration could be given in future work to cross-country spillovers since global banks restricted in one country may raise lending—and risk—in their subsidiaries elsewhere, or banks restricted in domestic borrowing may seek cross-border sources of funds.

Appendix 1: Lerner index calculation

To calculate the Lerner Index, we first estimate the following log cost function:

$$\begin{aligned}\log\left(C_{it}\right) = {} & \alpha + \beta_1 \times \log\left(Q_{it}\right) + \beta_2 \times \left(\log\left(Q_{it}\right)\right)^2 \\ & + \beta_3 \times \log\left(W_{1,it}\right) + \beta_4 \times \log\left(W_{2,it}\right) \\ & + \beta_5 \times \log\left(W_{3,it}\right) + \beta_6 \times \log\left(Q_{it}\right) \times \log\left(W_{1,it}\right) \\ & + \beta_7 \times \log\left(Qit\right) \times \log\left(W_{2,it}\right) + \beta_8 \times \log\left(Q_{it}\right) \times \log\left(W_{3,it}\right) \\ & + \beta_9 \times \left(\log\left(W_{1,it}\right)\right)^2 + \beta_{10} \times \left(\log\left(W_{2,it}\right)\right)^2 \\ & + \beta_{11} \times \left(\log\left(W_{3,it}\right)\right)^2 + \beta_{12} \times \log\left(W_{1,it}\right) \times \log\left(W_{2,it}\right) \\ & + \beta_{13} \times \log\left(W_{1,it}\right) \times \log\left(W_{3,it}\right) + \beta_{14} \times \log\left(W_{2,it}\right) \times \log\left(W_{3,it}\right) \\ & + \Theta \times \textit{Year Dummies} + \varepsilon_{it}\end{aligned} \tag{4}$$

where C_{it} is total costs; Q_{it} is the quantity of output and is measured as total assets; $W_{1,\,it}$ is the ratio of interest expenses to the sum of total deposits and money market funding. $W_{2,\,it}$ is measured as personnel expenses divided by total assets. $W_{3,\,it}$ is the ratio of administrative and other operating expenses to total assets. Having estimated this equation, we impose the following restrictions again in line with the earlier authors, to ensure homogeneity of degree one in input prices:

$$\begin{aligned}&\beta_3 + \beta_4 + \beta_5 = 1; \beta_6 + \beta_7 + \beta_8 = 0; \beta_9 + \beta_{12} + \beta_{13} = 0; \\ &\beta_{10} + \beta_{12} + \beta_{14} = 0; \beta_{11} + \beta_{13} + \beta_{14} = 0\end{aligned} \tag{5}$$

We then use the coefficient estimates from the previous regression to estimate marginal cost for bank *i* in calendar year *t*:

$$\begin{aligned}MC_{it} = \delta C_{it}/\delta Q_{it} = {} & C_{it}/Q_{it} \times [\beta_1 + 2 \times \beta_2 \times \log\left(Q_{it}\right) \\ & + \beta_6 \times \log\left(W_{1,it}\right) + \beta_7 \times \log\left(W_{2,it}\right) + \beta_8 \times \log(W_{3,it})]\end{aligned} \tag{6}$$

And the Lerner index for each bank-year is:

$$Lerner_{it} = \left(P_{it} - MC_{it}\right)/P_{it} \tag{7}$$

where P_{it} is the price of assets and is equal to the ratio of total revenue to total assets.

Appendix 2: Alternative Z-score baselines

See Table 15.

Table 15 Log Z-score estimates for subsamples and wider samples (estimated by panel OLS over 1990–2018, with bank and time fixed effects and country- or bank-clustered standard errors)

Dependent variable	(1) Asian Advanced countries	(2) Asian EMDEs	(3) Global sample	(4) European sample	(5) Memo: Baseline equation
C	2.5** (2.7)	4.44** (2.9)	2.75*** (7.5)	2.026*** (3.8)	2.657** (2.4)
LAGGED DEPENDENT	0.391*** (20.3)	0.429*** (38.7)	0.472*** (41.8)	0.489*** (33.1)	0.425*** (34.1)
Δ POLICY RATE	0.105 (1.4)	−0.003 (0.7)	−0.00427 (1.4)	0.0103 (0.6)	−0.00481 (0.5)
POLICY RATE(−1)	0.0236 (0.8)	−0.00734 (0.3)	−0.0073* (1.8)	0.0069 (0.4)	−0.00533 (0.4)
Δ LERNER_INST	0.572* (2.3)	1.043*** (3.6)	0.588*** (14.7)	0.558*** (9.1)	0.822*** (4.1)
LERNER(−1)	1.025 (1.7)	2.0*** (3.7)	0.934*** (9.8)	0.817*** (9.0)	1.732*** (3.8)
CUST DEP SHARE(−1)	0.0966 (1.2)	−0.0427 (0.1)	0.0495 (0.7)	0.138 (1.5)	0.0171 (0.1)
NONINT RATIO(−1)	0.0404 (0.1)	−0.337* (2.2)	−0.0871 (1.5)	−0.08556 (1.2)	−0.2263 (1.5)
LOAN/ASSETS(−1)	−0.109 (0.3)	−0.38* (2.1)	−0.0985 (1.3)	−0.0231 (0.2)	−0.333* (1.9)
PROVISIONS/LOANS(−1)	−0.0903** (2.7)	−0.0535* (2.4)	−0.0297*** (5.4)	−0.0271*** (3.1)	−0.0609** (2.8)
LEVERAGE RATIO_INST(−1)	−0.0192 (0.1)	−0.138 (0.5)	−0.27** (2.7)	−0.455** (2.5)	−0.149 (0.5)
Δ LOG ASSETS	−0.093 (1.3)	−0.266 (1.5)	−0.188*** (3.2)	−0.333*** (5.6)	−0.142 (1.2)
LOG ASSETS(−1)	−0.025 (0.5)	−0.0299 (0.4)	−0.0034 (0.1)	−0.0412 (1.6)	−0.0289 (0.60
GDP GROWTH(−1)	−0.00989 (0.4)	−0.0247 (1.3)	0.012** (2.3)	0.0327*** (2.9)	−0.0138 (0.9)
INFLATION(−1)	−0.0277 (1.4)	0.0105 (0.7)	0.00241 (1.6)	−0.00665 (0.5)	0.00731 (0.7)
BANK CRISIS(−1)	−0.116 (0.3)	−0.532** (3.2)	−0.18977*** (3.6)	−0.096* (1.7)	−0.45*** (3.2)
PERIODS	26	26	26	26	26
R2	0.66	0.609	0.556	0.644	0.618
OBSERVATIONS	2527	4370	43,348	22,840	6897
BANKS	352	464	4601	2193	886

See Table 6 for details of variables and estimation

Appendix 3: Robustness checks

See Tables 16, 17, 18, 19.

Table 16 Robustness checks regression results (estimated by panel OLS over 1990–2018, with bank and time fixed effects and country-clustered standard errors)

Variant	(1) With quality of supervision	(2) With all policies together	(3) With all policies and leveraged terms	(4) With bank clustering instead of country clustering	(5) Memo: baseline equation
C	1.676 (1.1)	1.873 (1.6)	2.025 (1.6)	2.658*** (2.8)	2.657** (2.4)
LAGGED DEPENDENT	0.397*** (24.1)	0.403*** (30.2)	0.4*** (27.4)	0.425*** (29.1)	0.425*** (34.1)
Δ POLICY RATE	0.0255 (0.6)	−0.00834 (0.9)	−0.00883 (0.9)	−0.00481 (0.5)	−0.00481 (0.5)
POLICY RATE(−1)	−0.0251 (1.0)	0.00989 (1.0)	0.00922 (0.9)	−0.00533 (0.5)	−0.00533 (0.4)
Δ LERNER_INST	0.885*** (3.6)	0.824*** (4.4)	0.886*** (4.9)	0.822*** (6.8)	0.822*** (4.1)
LERNER(−1)	1.694*** (3.2)	1.719*** (4.5)	1.823*** (4.5)	1.732*** (7.8)	1.732*** (3.8)
CUST DEP SHARE(−1)	−0.0853 (0.2)	0.0851 (0.3)	0.09 (0.3)	0.0171 (0.1)	0.0171 (0.1)
NONINT RATIO(−1)	−0.126 (0.8)	−0.249 (1.7)	−0.26 (1.7)	−0.226* (1.8)	−0.2263 (1.5)
LOAN/ASSETS(−1)	−0.0664 (0.3)	−0.163 (1.1)	−0.165 (1.1)	−0.333** (2.2)	−0.333* (1.9)
PROVISIONS/LOANS(−1)	−0.0825*** (4.3)	−0.054*** (3.6)	−0.0532*** (3.7)	−0.0609*** (6.0)	−0.0609** (2.8)
LEVERAGE RATIO_INST(−1)	−0.0414 (0.2)	−0.035 (0.1)	−0.0122 (0.1)	−0.15 (0.6)	−0.149 (0.5)
Δ LOG ASSETS	−0.115 (0.7)	−0.135 (1.1)	−0.126 (1.0)	−0.142 (1.5)	−0.142 (1.2)
LOG ASSETS(−1)	−0.0104 (0.2)	−0.0018 (0.1)	−0.0074 (0.1)	−0.0286 (0.7)	−0.0289 (0.60
GDP GROWTH(−1)	−0.0234* (2.0)	0.00712 (0.5)	0.0083 (0.6)	−0.0138* (1.8)	−0.0138 (0.9)
INFLATION(−1)	0.0115 (1.1)	−0.00231 (0.3)	−0.0029 (0.3)	0.00731 (1.0)	0.00731 (0.7)
BANK CRISIS(−1)	−0.691*** (3.5)	−0.38** (2.7)	−0.37** (2.7)	−0.45*** (5.0)	−0.45*** (3.2)
ACTREST	0.0222 (0.7)				
CAPREQ	0.0609** (2.7)				
SUPERV	−0.00453 (0.1)				
PERIODS	26	26	26	26	26
R2	0.619	0.631	0.635	0.618	0.618
OBSERVATIONS	6011	6897	6897	6897	6897
BANKS	816	886	886	886	886

See Table 6 for details of variables. ACTREST is the summary variable for activity restrictions, CAPREQ is the summary variable for stringency of capital requirements and SUPERV is the summary variable for supervisory power, source Barth et al. [10], Anginer et al. [8] and authors' calculations. All equations have country-clustered standard errors except for the estimate in column 4 which has bank clustering. Estimates in columns 2 and 3 show the baseline variables for regressions including also all policies (column 2) and all policies plus interaction terms (column 3). The policy and interaction variables are shown in Appendix Table 18

Table 17 Quality of supervision variant—effects on log Z-score of macroprudential policies and interacted effects of competition

	Macroprudential variables only		Macroprudential and interacted variables			
	DMP	MP(−1)	DMP	MP(−1)	DMP* LERNER(−1)	MP(−1)* LERNER(−1)
CCB	−0.013	0.265*	0.816***	0.69***	−0.603***	−0.293**
	(0.1)	(2.0)	(7.6)	(4.1)	(8.7)	(3.0)
CONSERVATION	−0.132	0.0176	−0.107	−0.117	−0.0357	0.0986
	(1.3)	(0.3)	(0.8)	(1.2)	(0.4)	(1.7)
CAPITAL	−0.111*	−0.0491	−0.174	−0.118**	0.0508	0.0617
	(2.1)	(1.1)	(1.0)	(2.7)	(0.4)	(1.7)
LVR	−0.147	−0.0016	−0.184	−0.173	0.0168	0.15
	(1.7)	(0.1)	(1.4)	(0.9)	(0.2)	(1.4)
LLP	−0.222**	−0.012	−0.376***	−0.08	0.129*	0.0696
	(2.9)	(0.3)	(3.7)	(1.7)	(2.0)	(1.4)
LCG	−0.334**	−0.44***	0.058	−0.317*	−0.362***	−0.132*
	(2.5)	(3.1)	(0.4)	(2.1)	(3.6)	(2.1)
LOANR	0.08**	0.0909**	0.202**	0.132***	−0.0918	−0.031
	(2.2)	(2.6)	(2.3)	(3.6)	(1.4)	(1.4)
LFC	0.397***	−0.0178	0.187	−0.196**	0.172	0.167***
	(3.5)	(0.2)	(0.4)	(2.3)	(0.6)	(5.3)
LTV	0.0319	0.0245	0.027	0.0485	0.00496	−0.0159
	(1.3)	(0.9)	(0.5)	(1.1)	(0.1)	(0.5)
DSTI	0.0978**	0.157**	0.0519	0.105	0.0309	0.0405
	(2.6)	(2.4)	(0.5)	(0.9)	(0.5)	(0.5)
TAX	0.0802***	0.0374	0.158*	0.0946**	−0.0633	−0.0437*
	(2.7)	(1.2)	(2.1)	(2.2)	(0.8)	(1.8)
LIQUIDITY	0.082*	0.155**	0.0545	0.0888	0.0285	0.0497**
	(1.9)	(2.2)	(0.9)	(1.5)	(0.9)	(2.2)
LTD	0.0459	−0.147	−0.0686	−0.324*	0.102	0.161
	(0.6)	(1.5)	(0.6)	(2.1)	(0.9)	(0.8)
LFX	−0.116**	−0.22**	−0.0885	−0.234***	−0.0263	0.0126
	(2.9)	(2.9)	(1.3)	(3.5)	(0.3)	(0.3)
RR	0.0121	0.0077	0.0556**	0.0262	−0.0416*	−0.0189***
	(0.5)	(0.5)	(2.6)	(1.5)	(2.1)	(3.2)
SIFI	−0.0113	−0.0614	−0.0549	−0.257*	0.0417	0.146**
	(0.1)	(0.7)	(0.5)	(2.0)	(0.4)	(2.8)
OTHER	−0.071*	0.119**8	−0.0602	0.106	−0.00813	0.0112
	(2.0)	(3.4)	(0.5)	(1.4)	(0.1)	(0.2)
MAPP-INDEX	−0.0012	0.0109	0.00029	0.00984	−0.0013	0.00078
	(0.1)	(1.5)	(0.1)	(1.1)	(0.1)	(0.1)
LOAN-TARGETED	0.0156	0.0298*	0.0123	0.0273	0.00233	0.00178
	(0.7)	(1.8)	(0.2)	(1.4)	(0.1)	(0.1)
DEMAND	0.0351**	0.0374	0.0203	0.0488	0.0126	−0.00766
	(2.3)	(1.7)	(0.4)	(1.2)	(0.3)	(0.3)
SUPPLY-ALL	−0.013	0.00187	−0.00425	−0.00035	−0.00734	0.00166
	(1.1)	(0.3)	(0.1)	(0.1)	(0.3)	(0.2)
SUPPLY-LOANS	−0.00762	0.0274	0.0141	0.0115	−0.0194	0.0131
	(0.1)	(1.1)	(0.1)	(0.4)	(0.2)	(0.5)
SUPPLY-GENERAL	0.00868	0.00398	0.0189	0.0112	−0.0102	−0.00708
	(0.5)	(0.3)	(0.7)	(0.5)	(0.5)	(0.9)
SUPPLY-CAPITAL	−0.0962**	0.00121	−0.0586	−0.0738	−0.0455	0.0626**
	(3.0)	(0.1)	(0.5)	(1.7)	(0.5)	(2.5)

See Table 7 for details of variables, and Appendix Table 16 column 1 for baseline estimation results

Table 18 All policies together variant—effects on log Z-score of macroprudential policies and interacted effects of competition

	Macroprudential variables only		Macroprudential and interacted variables			
	DMP	MP(−1)	DMP	MP(−1)	DMP* LERNER(−1)	MP(−1)* LERNER(−1)
CCB	−0.266	0.163	0.644**	0.649*	−0.759***	−0.332
	(1.5)	(1.5)	(2.6)	(2.0)	(3.6)	(1.6)
CONSERVATION	−0.178*	−0.103	0.0312	−0.283**	−0.179	0.189***
	(1.9)	(1.1)	(0.1)	(2.2)	(1.3)	(3.5)
CAPITAL	−0.0546	0.0267	−0.0359	0.0398	0.0134	−0.00139
	(0.8)	(1.0)	(0.3)	(0.5)	(0.2)	(0.1)
LVR	0.0185	0.0369	0.236*	0.401**	−0.207**	−0.334*
	(0.3)	(0.3)	(1.8)	(3.0)	(2.3)	(2.1)
LLP	−0.215**	0.0612	−0.358*	0.125	−0.102	−0.0766**
	(2.4)	(2.1)	(1.9)	(1.6)	(1.0)	(2.3)
LCG	0.0119	−0.519***	−0.0694	−0.304	0.0913	−0.158
	(0.1)	(3.1)	(0.1)	(0.9)	(0.2)	(0.6)
LOANR	0.117*	0.099	0.228**	0.0589	−0.0829	0.0223
	(1.8)	(1.5)	(2.9)	(0.7)	(1.2)	(0.6)
LFC	0.124	0.0334	0.0834	−0.305*	0.00942	0.318***
	(0.5)	(0.3)	(0.2)	(2.2)	(0.1)	(3.2)
LTV	0.0202	−0.00573	0.035	0.00569	−0.0112	−0.003
	(0.6)	(1.2)	(0.7)	(0.1)	(0.2)	(0.1)
DSTI	0.0939	0.0769	0.242	0.057	−0.108	0.0264
	(1.3)	(0.9)	(1.2)	(0.5)	(0.9)	(0.4)
TAX	−0.0654	−00812*	−0.0058	0.0381	−0.047	−0.0819**
	(1.2)	(2.2)	(0.1)	(0.6)	(0.8)	(2.5)
LIQUIDITY	0.0656	0.0733	0.0333	0.0982*	0.0416	−0.0327
	(1.4)	(1.4)	(0.4)	(1.9)	(0.7)	(0.7)
LTD	−0.086	−0.329**	0.0552	−0.334**	−0.107***	0.0312
	(1.4)	(2.5)	(0.8)	(3.0)	(3.5)	(0.6)
LFX	−0.0117**	−0.132**	−0.072	−0.078	−00443	−0.0182
	(3.0)	(2.4)	(0.9)	(1.1)	(0.6)	(0.4)
RR	−0.0135	0.001	0.0137	−0.0184	−0.0222	0.0148
	(0.6)	(0.1)	(0.5)	(1.1)	(1.7)	(1.4)
SIFI	0.0845	0.0515	−0.116	−0.0877	0.178	0.106*
	(0.8)	(1.0)	(1.3)	(0.8)	(1.7)	(1.9)
OTHER	−0.945	−0.0378	0.00973	−0.083	−0.0763	0.0471
	(1.6)	(0.9)	(0.1)	(1.3)	(1.1)	(0.8)

See Table 7 for details of variables. This table shows the policy and interaction terms for regressions including also all policies and all policies plus interaction terms. The baseline estimation results are shown in Appendix Table 16 columns 2 and 3

Table 19 Bank level clustering variant—effects on log Z-score of macroprudential policies and interacted effects of competition

	Macroprudential variables only		Macroprudential and interacted variables			
	DMP	MP(−1)	DMP	MP(−1)	DMP* LERNER(−1)	MP(−1)* LERNER(−1)
CCB	−0.0363	0.234***	0.756***	0.653***	−0.579***	−0.307***
	(0.4)	(3.5)	(3.4)	(4.6)	(3.2)	(3.3)
CONSERVATION	−0.09*	0.0367	−0.105	−0.0801	−0.001	0.0833**
	(1.8)	(0.9)	(1.0)	(1.2)	(0.1)	(2.0)
CAPITAL	−0.099***	−0.0461**	−0.094	−0.101***	−0.0104	0.0534**
	(2.9)	(2.1)	(1.1)	(2.8)	(0.1)	(2.0)
LVR	−0.148***	0.0081	−0.169*	−0.157	0.00395	0.143**
	(3.1)	(0.2)	(1.8)	(1.6)	(0.1)	(2.2)
LLP	−0.188***	−0.02	−0.295***	−0.0681*	0.09	0.05*
	(4.7)	(0.7)	(3.6)	(1.9)	(1.5)	(1.9)
LCG	−0.245**	−0.36***	0.118	−0.263*	−0.331**	−0.103
	(2.1)	(4.0)	(0.5)	(1.8)	(2.2)	(0.9)
LOANR	0.063**	−0.0682***	0.205***	0.117***	−0.107**	−0.0361**
	(2.0)	(4.8)	(2.6)	(4.8)	(2.1)	(2.6)
LFC	0.396***	0.0104	0.154	−0.14**	0.194	0.143***
	(3.9)	(0.2)	(0.4)	(2.1)	(0.7)	(5.0)
LTV	0.0322	0.0294**	0.0336	0.0604**	0.0005	−0.021
	(1.5)	(2.1)	(0.6)	(2.3)	(0.1)	(1.3)
DSTI	0.114***	0.128***	0.151	0.134**	−0.0282	−0.0039
	(3.0)	(3.9)	(1.6)	(2.4)	(0.4)	(0.1)
TAX	0.0622**	0.0465***	0.172***	0.11***	−0.0905*	−0.0478*
	(2.2)	(3.1)	(2.6)	(3.2)	(1.8)	(1.9)
LIQUIDITY	0.097***	0.169***	0.0734	0.1**	0.0254	0.0501***
	(3.1)	(4.9)	(1.3)	(2.5)	(0.6)	(3.0)
LTD	0.00316	−0.125*	−0.008	−0.244**	0.0344	0.11
	(0.4)	(1.9)	(0.1)	(2.1)	(0.3)	(1.3)
LFX	−0.114***	−0.161***	−0.103	−0.183***	−0.0105	0.0196
	(3.2)	(4.3)	(1.2)	(3.2)	(0.2)	(0.5)
RR	0.0119	0.0109*	0.0588**	0.0307***	−0.0414**	−0.0172***
	(0.9)	(1.8)	(2.2)	(3.6)	(2.1)	(3.6)
SIFI	−0.0253	−0.0833**	−0.0746	−0.271***	0.0512	0.141***
	(0.6)	(2.3)	(0.9)	(3.2)	(0.8)	(2.7)
OTHER	−0.0662**	0.0878***	0.0225	0.0717	−0.0675	0.0139
	(2.4)	(3.0)	(0.2)	(1.3)	(1.0)	(0.3)
MAPP-INDEX	−0.00132	0.00947***	0.00583	0.009**	−0.0059	0.00035
	(0.2)	(3.0)	(0.4)	(2.0)	(0.6)	(0.1)
LOAN-TARGETED	0.199*	0.025***	0.0298	0.028**	−0.0065	−0.002
	(1.7)	(3.5)	(1.1)	(2.6)	(0.4)	(0.3)
DEMAND	0.041**	0.0375***	0.0413	0.0607***	0.002	−0.016
	(2.4)	(3.2)	(0.9)	(2.8)	(0.1)	(1.1)
SUPPLY-ALL	−0.0078	0.00581	0.0041	0.0033	−0.01	0.00187
	(0.9)	(1.5)	(0.2)	(0.6)	(0.7)	(0.5)
SUPPLY-LOANS	0.0035	0.0332***	0.0554	0.0226	−0.044	0.0082
	(0.2)	(2.8)	(1.0)	(1.3)	(1.2)	(0.8)
SUPPLY-GENERAL	0.0091	0.0079	0.0169	0.0146*	−0.0072	−0.0057
	(0.7)	(1.3)	(0.7)	(1.7)	(0.4)	(1.1)
SUPPLY-CAPITAL	−0.0808***	−0.0022	−0.036	−0.074***	−0.052	0.0608***
	(3.4)	(0.1)	(0.6)	(2.8)	(1.1)	(3.5)

See Table 7 for details of variables and Appendix Table 16 column 4 for baseline estimation results

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