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# THE BANK CAPITAL-COMPETITION-RISK NEXUS – A GLOBAL PERSPECTIVE

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# The Bank Capital-Competition-Risk Nexus – A Global Perspective

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## *Abstract*

The Global Financial Crisis (GFC) highlighted the importance of a number of unresolved empirical issues in the field of financial stability. First, there is the sign of the relationship between bank competition and financial stability. Second, there is the relation of capital adequacy of banks to risk. Third, the introduction of a leverage ratio in Basel III following the crisis leaves open the question of its effectiveness relative to the risk adjusted capital ratio (RAR). Fourth, there is the issue of the relative stability of advanced versus emerging market financial systems, and whether similar factors lead to risk, which may have implications for appropriate regulation. Finally, there is the nature of the relation between bank competition and bank capital. In this context, we address these five issues via estimates for the relation between capital adequacy, bank competition and other control variables and aggregate bank risk. We undertake this for different country groups and time periods, using macro data from the World Bank's Global Financial Development Database over 1999-2015 for up to 120 countries globally, using single equation logit and GMM estimation techniques and panel VAR. This is an overall approach that to our knowledge is new to the literature.

The results cast light on each of the issues outlined above, with important implications for regulation: (1) The results for the Lerner Index largely underpin the "competition-fragility" hypothesis of a positive relation of competition to risk rather than "competition stability" (a negative relation) and show a widespread impact of competition on risk generally. (2) There is a tendency for both the leverage ratio and the RAR to be significant predictors of risk, and for crises and Z score they are supportive of the "skin in the game" hypothesis of a negative relation between capital ratios and risk, whereas for provisions and NPLs they are consistent with the "regulatory hypothesis" of a positive relation of capital adequacy to risk. (3) The leverage ratio is much more widely relevant than the RAR, underlining its importance as a regulatory tool. The relative ineffectiveness of risk adjusted measures may relate to untruthful or inaccurate assessments of bank real risk exposure. (4) There are marked differences between advanced countries and EMEs in the capital-risk-competition nexus, with for example a wider impact of competition in EMEs (although both types of country need to pay careful attention to the evolution of competition in macroprudential surveillance). Similar pattern to EMEs are apparent in many cases for the global sample pre crisis, which arguably are more consistent with normal market functioning than post crisis. (5) Competition reduces leverage ratios significantly in a Panel VAR, with impulse responses showing that more competition leads to lower leverage ratios and vice versa. This result is consistent over a range of subsamples and risk variables. In the variance decomposition, we find that competition is autonomous, while the variance of both risk and capital ratios are strongly affected by competition. The Panel VAR results give some indication of the transmission mechanism from competition to risk and financial instability.

**Keywords:** Macroprudential policy, capital adequacy, leverage ratio, bank competition, bank risks, emerging market economies, logit, GMM, Panel VAR

**JEL Classifications:** E58, G28

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## 1 Introduction

The Global Financial Crisis highlighted the importance of a number of unresolved empirical issues in the field of financial stability. First, there is the relationship between bank competition[1] and financial stability, where the opposing points of view are that competition prompts risk taking (competition-fragility) and that it rather leads to stability (competition-stability). Second, there is the relation of capital adequacy of banks to risk, where again two opposing points of view can be discerned, that capital and risk are inversely related (skin in the game) or that there is a positive relation of capital to risk (regulatory hypothesis). Then, there is the observation that bank leverage ratios often predicted risk in the crisis better than the risk adjusted capital ratio (RAR), prompting the introduction of a leverage ratio in Basel III, but whose effectiveness is still not fully tested. Fourth, there is the issue of the relative stability of advanced versus emerging market financial systems, and whether similar factors lead to risk. Finally there is the nature of the relation between bank competition and bank capital.

We contend that a weakness of existing work is that such issues are rarely considered together, when in fact omission of relevant variables may bias results. Furthermore, in many cases empirical work is focused on micro data, when for macroprudential assessment macro data may be as or more appropriate. This is the case not least in that macro data provides weighted average data, thus giving implicitly greater importance to large systemic institutions, while micro work typically gives equal weight to each institution.

In this context, we undertake empirical research which assesses the effectiveness of a leverage ratio[2] relative to a measure of the RAR in affecting bank risk given competition. To our knowledge, such work has not been undertaken before in this manner. In doing so we cast light on all five of the issues highlighted above. We undertake estimation for different country groups before and after the global financial crisis (GFC), using country-level macro data for up to 120 countries from the World Bank's Global Financial Development Database over 1999-2015. We utilise both appropriate single equation methods (logit and GMM) and Panel VAR approaches. The paper is structured as follows: in Section 2 we provide an overview of the existing literature, Section 3 introduces the data and methodology, Section 4 provides the main results which are summarised in Section 5. Section 6 provides robustness checks, Section 7 gives complementary Panel VAR estimates which address the competition/capital relation and Section 8 concludes.

Further work in Davis et al (2019) investigates the capital-competition-risk nexus using micro data for large numbers of individual banks in the Europe and the US from the Fitch-Connect database from 1998-2016.

## 2 Existing literature

The starting point of our work is the introduction of the leverage ratio in Basel III, which followed experience in the GFC that leverage was often a better predictor of bank risk than the risk adjusted capital ratio (RAR). In policy terms, it is widely considered to complement the RAR (Basel Committee 2014, revisions proposed 2016). It can prevent excessive leverage building up both for individual institutions and for the system as a whole (D'Hulster 2009). It acts against procyclicality and against

[1] Competition also plays a critical role in the efficient operation of the financial system and is therefore important for economic growth. As such, its regulation should be one of the key challenges of financial policy.
[2] The variable we employ is distinct from the leverage ratio as defined in Basel III as we include all regulatory capital in the numerator and on-balance-sheet assets only in the denominator, in contrast to the Basel III definition of Tier 1 capital divided by the bank's average total consolidated assets (sum of the exposures of all assets and non-balance sheet items).

regulatory arbitrage and has the benefit of simplicity. However, it also has limitations – it may have difficulty capturing "embedded leverage"[3] and may give wrong incentives, encouraging banks to take risks, given the lack of risk weighting (Kellermann and Schlag 2013), implying the RAR is also vital. Questions arise as to whether and when it should be a binding constraint on bank lending as opposed to RAR, or whether it could lead to a "race to the bottom" if it is set lower than average bank ratios. Should the leverage ratio be varied over the cycle as a macroprudential tool?

Whereas the interest of economists in bank leverage ratios dates back at least to Minsky (1982) and also theoretical work such as Holmstrom and Tirole (1997) and Diamond and Rajan (2000), these contributions did not focus on incorporating leverage into regulation. Theoretical and empirical work on leverage ratios as a regulatory instrument in the Basel context is quite recent and rather sparse. It has been mostly undertaken since the 2007-2008 global financial crisis, as excess leverage was identified as one of the causes of the crisis.

Recent theoretical work has highlighted, inter alia, the appropriate level and variability of leverage. For example, Kiema and Jokivuolle (2014) suggest the leverage ratio should induce banks to hold similar diversified portfolios, which may increase the overall balance of risk in the banking sector, because of the greater effect of model risk. Accordingly, they suggest the actual leverage ratio should be higher than current proposals. Bruno et al (2014) propose a model in which an optimal level of leverage exists which minimises financial fragility and which varies with the business cycle, (consistent with empirical observation by Adrian and Shin (2010)), leading them to recommend an adjustable leverage ratio. Dermine (2015) contends that leverage ratios are helpful in preventing bank runs when there is imperfect information on the value of a bank's assets, as it gives a floor under the RAR. Grill et al (2015), using a theoretical micro model backed by empirical work, show a leverage ratio requirement incentivises banks bound by the constraint to slightly increase risk-taking, but this is more than outweighed by the increase in loss-absorbing capacity from higher capital, thus increasing bank stability. Pfeifer et al (2015) show the constraining effect of the leverage ratio on exposures is diminished unless it rises in line with the RAR when the latter is increased for macroprudential purposes.

We note that none of these theoretical contributions focus on bank competition alongside capital. An exception is Freixas and Ma (2015) who look at the relation of bank competition to financial stability with a theoretical model and find the effect depends crucially on a bank's type of funding (retail versus wholesale) and whether leverage is exogenous or endogenous. They suggest that "this opens the road for new empirical analysis on the competition-stability link that should depend upon the type of banks and the state of the economy", a path we also follow.

Empirical work on leverage versus the RAR includes Yang (2016) who looked at leverage and risk weighted capital as predictors in 417 US bank failures between 2008 and 2012 using logit, finding leverage was important for both large and small banks but that risk adjusted capital was not significant for large banks. This is in line with Haldane and Madouros (2012) who also found the leverage ratio a superior failure predictor to the RAR, see also Aikman et al (2018).[4] Bitar et al (2018) found risk-based capital measures are unrelated to bank risk, whereas unadjusted measures such as

[3] This term relates to the use of options contracts or exchange-traded funds where leverage is built into the product thus altering leverage without having to increase borrowing and actual balance sheet leverage. See paper by Frazzini and Pederson (2012). Note however that Basel Committee (2014) states that for regulatory reporting purposes in measuring bank leverage, "in order to adequately capture embedded leverage, the framework incorporates both on- and off-balance sheet exposures".

[4] Hambusch and Shaffer (2012) sought to forecast bank leverage as an alternative tool for assessing the likelihood of failure. Results support the use of leverage as an indicator for such likelihood. They did not test the RAR as an alternative, however.

the leverage ratio are significantly positively related to risk as shown by loan loss reserves. They suggest that the ineffectiveness of risk adjusted measures may relate to untruthful assessment of bank real risk exposure. Brei and Gambacorta (2014) tested for procyclicality of capital ratios and found the leverage ratio is significantly more countercyclical than the RAR; it is a tighter constraint for banks in booms and a looser constraint in recessions.

The literature on the relation of bank competition to risk is summarised in Davis and Karim (2018) and Zigraiova and Havranek (2016). The competition/risk literature is, as noted, 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 "competition-fragility" (Keeley, 1990), institutions in an uncompetitive 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 by new entrants (from abroad as well, 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). Some analyses of the GFC (such as Financial Crisis Inquiry Commission (FCIC) 2011) do give a key role to competition as a causal factor.

On the other hand, according to "competition-stability", (Boyd and De Nicolo 2005), whereas lower lending rates in competitive banking markets increase borrowers' scope for repayment, 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. Large banks may be harder to supervise. The surveys cited above show that empirical results are evenly divided between the two hypotheses.

The third issue to be addressed is between positive and negative effects of capital on risk. According to "skin in the game", it would be expected that a higher capital ratio would be consistent with lower risk as bank managers become prudent and wiser in their investment choices (Bitar et al 2018). Banks hold higher capital to resist earnings shocks and to be able to repay deposits as requested, so obliging banks to hold more capital via regulation improves screening and monitoring and reduces the risk of bailouts (Demirguc Kunt et al 2013). For results supporting this view see, for example, Lee and Hseih (2013), Tan and Floros (2013) and Anginer and Demirguc Kunt (2014). The alternative is the "regulatory hypothesis" which would suggest that regulators require higher capital in response to higher risk, and so a positive relation of capital to risk would be expected. This is, for example, found by Iannotta et al (2007) and Bitar et al (2018).

Concerning the advanced versus EME issue, most studies of financial stability cited in Davis and Karim (2018) and Zigraiova and Havranek (2016) cover individual countries or only one subgroup (advanced or EME). The number of studies assessing the differences and similarities between the two groups is relatively small; however, we note recent work by Fratzscher et al (2016) that does look at post crisis supervisory changes' effects on risk, comparing advanced and emerging market economies. Meanwhile, Meng and Gonzalez (2017) looks at differences in credit booms between advanced countries, emerging markets and developing countries.

Finally concerning the competition-capital link, Schaeck and Čihák (2012) look at the effect of competition on capital for 2,600 banks from 10 European countries and find higher competition gives rise to higher capital ratios. This may offer an offset to higher risks taken in highly competitive banking systems. On the other hand, de-Ramon et al (2018) find that higher competition in the UK leads to lower leverage ratios, although the effect on stability measured by the Z-Score may be

offset by higher profitability. These (along with Berger et al 2009[5]) are some of the few analyses of capital ratios that takes into account competition, which is a paradox give the sizeable literature on bank competition and risk cited above.

We seek to cast light on all five of these issues by analysing the capital-competition-risk nexus globally using single equation panels and panel VARs, an approach that to our knowledge has not been undertaken in the literature to date.

## 3 Methodology

We commence with a single-equation panel econometric investigation of the relationship of the leverage ratio to risk relative to a risk-adjusted measure, with competition as an independent variable as well as standard control variables. We estimate generally from 1999-2015, using macro data from the World Bank's Global Financial Development Database (GFDD). We test a global sample and also test for high income countries and emerging market and developing economies separately, as well as before and after the financial crisis. We offer robustness checks, inter alia adding further macroeconomic variables. Thereafter in Section 7, we present results of Panel VARs for the interrelation of competition, risk and capital that cast further light on the interrelationship of these key variables in financial stability analysis.

Four dependent variables of macroprudential relevance were drawn from the World Bank Global Financial Development Database (GFDD) (Čihák et al (2012), World Bank (2017)), following Davis (2017).

First, there is the incidence of financial crises per se, as drawn from Laeven and Valencia (2012). It is 1 for each period a crisis lasted, and 0 otherwise.

Second, we use the NPL/loans ratio[6] which may show problems with asset quality in the loan portfolio across the banking sector as a whole. It is defined as the ratio of defaulting loans (payments of interest and principal past due by 90 days or more) to total gross loans (total value of loan portfolio). The loan amount recorded as nonperforming includes the gross value of the loan as recorded on the balance sheet, not just the amount that is overdue.[7]

Third, the Z-Score[8] captures the probability of default of a country's commercial banking system. Z-score compares the buffer of a country's commercial banking system (capitalization and return on assets (ROA)) with the volatility (standard deviation (SD)) of those returns. Hence Z-Score = (ROA+(Capital/Assets))/SD(ROA)).[9] As noted by Lui et al (2013), it is appropriate to log the Z score as the level is highly skewed, while the log is normally distributed, so we enter the variable as log (Z-Score).

Fourth, the Provisions/Loans ratio[10] is an indicator of how well protected a banking sector is against future losses. It is a measure of loan quality, being an indicator of a precautionary reserves policy

[5] Their finding, in line with de-Ramon et al (2018) is that banks with market power tend to have higher capitalisation, although the relation with the level of the Lerner index is not significant.
[6] This is GFDD series GFDD.SI.02.
[7] What NPL data typically do not record is whether the loans are recoverable and have been collateralized. Hence the impact on banks' balance sheet may vary. This implies write offs and uncollateralized NPL may be measures to look at as well.
[8] This is GFDD series GFDD.SI.01.
[9] Note that this is quite distinct from standard statistical definition of Z-Score which indicates how many standard deviations an element is from the mean.
[10] This is GFDD series GFDD.SI.07 divided by GFDD.SI.02.

and also an anticipation of high non performing revenue, where accounting rules such as IFRS allow. It takes the past and future performance of the loan portfolio into account (Lee and Hseih 2013).

Then, we use the leverage ratio[11] and the regulatory capital/risk adjusted assets[12] measures to test for the link of capital ratios to risk.

Our key additional variable is banking sector competition, namely LERNER (Lerner index for bank competition)[13]. The Lerner Index is a measure of market power in the banking market. It compares output pricing and marginal costs (that is, mark-up). An increase in the Lerner index indicates a decline in the competitive conduct of financial intermediaries, as reflected in wider margins. For recent work assessing the link for individual banks of competition as measured by the Lerner index to risk as measured by the Z-Score, see inter alia Beck et al (2013) and Davis and Karim (2018) as well as Davis et al (2019). Note that we do not employ the H statistic unlike Davis and Karim (2018) and others, owing to the short data on the GFDD, and also some technical issues arising with this measure (Davis et al 2019). We use the Boone index as an alternative robustness check for competition as shown in Section 6.

We note that the aggregate Lerner index in the GFDD that we use will give a greater weight to large than small institutions, and accordingly a small number of large firms may tend to drive the outcomes for the competition risk, as was found in de-Ramon et al (2018).

Other control variables (lagged) were similar to Beck et al (2013) and Davis and Karim (2018) as applied to the banking sector, namely NONINTSH (share of noninterest income)[14], showing income diversification; CREDASSET (ratio of bank loans of deposit money banks to assets for deposit money banks), which may link to credit risk[15]; and DEPASSET (ratio of deposits of deposit money banks to assets of deposit money banks) [16], which shows the dependence of banks on deposits for their funding.

For the crisis estimation, we use the traditional logit as in Barrell et al (2010) and Karim et al (2013). For the other variables, we use panel difference GMM as in Arellano and Bond (1991), with lagged dependent variable and cross section difference fixed effects and using White's method to reduce

[11] This is GFDD series GFDD.SI.03 Note that the definition is "Ratio of bank capital and reserves to total assets. Capital and reserves include funds contributed by owners, retained earnings, general and special reserves, provisions, and valuation adjustments. Capital includes regulatory capital (paid-up shares and common stock), which is a common feature in all countries' banking systems, and total regulatory capital, which includes several specified types of subordinated debt instruments that need not be repaid if the funds are required to maintain minimum capital levels (these comprise tier 2 and tier 3 capital). Total assets include all nonfinancial and financial assets". Hence it differs from the Basel leverage ratio of Tier 1 capital/total consolidated assets.

[12] This is GFDD series GFDD SI.05. Note that the definition is "The capital adequacy of deposit takers. It is a ratio of total regulatory capital to its assets held, weighted according to risk of those assets. Reported by IMF staff. Note that due to differences in national accounting, taxation, and supervisory regimes, these data are not strictly comparable across countries."

[13] This is GFDD series GFDD.OI.04.

[14] The noninterest income share is bank's income that has been generated by noninterest related activities as a percentage of total income (net-interest income plus noninterest income). Noninterest related income includes net gains on trading and derivatives, net gains on other securities, net fees and commissions and other operating income. This is GFDD series GFDD.EI.03.

[15] Loans are seen as the financial resources provided to the private sector by domestic money banks, while assets held by deposit money banks include claims on the domestic real nonfinancial sector which includes central, state and local governments, nonfinancial public enterprises and private sector enterprises. Deposit money banks comprise commercial banks and other financial institutions that accept transferable deposits, such as demand deposits. This is calculated as the ratio of GFDD series GFDD.DI.01 to GFDD.DI.02

[16] This is the ratio of GFDD series GFDD OI.02 to GFDD DI.02.

the impact of heteroskedasticity. All variables are entered as 1-year lags to assess indicator properties and reduce the risk of simultaneity.

**Table 1: Statistical measures for dependent variables**

| | Crisis | NPL/loans (%) | Log Zscore | Provisions/Loans (%) |
|---|---|---|---|---|
| Mean | 0.043 | 7.23 | 2.3 | 4.43 |
| Median | 0.00 | 4.42 | 2.36 | 2.96 |
| Maximum | 1.00 | 74.1 | 4.54 | 36.00 |
| Minimum | 0.00 | 0.01 | -4.1 | 0.00 |
| Std. Dev. | 0.2 | 7.52 | 0.74 | 4.39 |
| Skewness | 4.51 | 2.26 | -1.25 | 2.21 |
| Kurtosis | 21.38 | 10.92 | 8.54 | 10.32 |
| | | | | |
| Jarque-Bera | 187212.1 | 6513.33 | 5381.13 | 5178.33 |
| Probability | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | | |
| Sum | 459.00 | 13591.11 | 8046.9 | 7542.88 |
| Sum Sq. Dev. | 439.33 | 106330.3 | 1933.12 | 32750.26 |
| | | | | |
| Observations | 10712 | 1880 | 3493 | 1701 |

We show above in Table 1 the statistical properties of the dependent variables. On balance, we suggest these are reasonable and not afflicted by outliers. Crises are shown to occur on average once every 23 years, but this reflects the fact that the sample includes quiescent years prior to the 1970s. In the regression sample, crises are much more frequent, accounting for 118/1074 observations, implying a crisis occurring or ongoing every 10 years or so. The mean ratio of NPL to loans is 7.2% while that of provisions is 4.43%, implying an average provisions/NPL ratio of just over 60%. The log Z-Score averages 2.3.[17] Note that in a typical regression with Lerner and leverage, such as that for the NPL ratio, we have around 108 countries and 1206 observations, of which 45/538 are advanced countries and 63/668 are emerging market or developing countries.

Table 2 shows the statistical measures for the independent variables, with the mean leverage ratio being 9.7% and regulatory capital ratio 16.4%. We note that the mean deposit/asset ratio is close to one, [18] while the noninterest share is a mean 36.8%. Credit is generally 79% of assets while the mean of the Boone index is -0.09 and the Lerner index is 0.23, in line with micro data calculations for the US and Europe shown in Davis et al (2019).

[17] This is closely comparable with results for European and US banks using micro data in Davis et al (2019). The results in that paper were 0.239 for the US banks and 0.211 for European banks.

[18] This series is the ratio of domestic money banks' deposits to GDP GFDD OI.02 to domestic money banks' assets to GDP GFDD DI.02. Deposit money banks comprise commercial banks and other financial institutions that accept transferable deposits, such as demand deposits. Deposits are the total value of demand, time and saving deposits at domestic deposit money banks. Total assets held by deposit money banks include claims on the domestic real nonfinancial sector which includes central, state and local governments, nonfinancial public enterprises and private sector. The sectoral definitions accordingly vary in the numerator and the denominator (assets exclude claims to the domestic financial sector and foreign sector) and this explains why the ratio may at times exceed one. However, we consider it a viable proxy for the deposits/assets ratio and it is the closest that can be obtained using the GFDD.

**Table 2: Statistical measures for independent variables**

| | Lerner index | Bank leverage (%) | Regulatory capital/risk adjusted assets (%) | Deposit/asset ratio | Noninterest income/ total income | Credit/asset ratio |
|---|---|---|---|---|---|---|
| Mean | 0.23 | 9.72 | 16.4 | 1.00 | 36.85 | 0.79 |
| Median | 0.26 | 9.1 | 15.4 | 0.92 | 35.4 | 0.83 |
| Maximum | 1.08 | 30.60 | 48.6 | 18.45 | 93.18 | 1.00 |
| Minimum | -44.63 | 1.49 | 1.75 | 0.035 | 1.43 | 0.047 |
| Std. Dev. | 0.95 | 4.00 | 5.35 | 0.58 | 16.43 | 0.18 |
| Skewness | -43.06 | 0.996 | 1.59 | 7.98 | 0.43 | -1.39 |
| Kurtosis | 2009.61 | 4.53 | 7.00 | 167.75 | 3.28 | 5.06 |
| | | | | | | |
| Jarque-Bera | 4.15E+08 | 480.71 | 2065.30 | 7416473. | 119.2665 | 3257.832 |
| Probability | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | | | | |
| Sum | 574.54 | 17851.03 | 31103.00 | 6497.24 | 127708.2 | 5176.6 |
| Sum Sq. Dev. | 2233.59 | 29373.05 | 54215.23 | 2148.49 | 935327.8 | 211.66 |
| | | | | | | |
| Observations | 2468 | 1836 | 1896 | 6497 | 3466 | 6558 |

Table 3 shows that all variables are stationary according to the Im-Pesaran-Shin (2003) test (which allows for individual unit root processes between countries), and hence can be entered in our equations as levels.

**Table 3: Unit root tests for variables**

| Variable | Im-Pesaran-Shin panel unit root test (probability) |
|---|---|
| NPL/loans | -42.1 (0.0) |
| Log Zscore | -15.4 (0.0) |
| Provisions/Loans | -2.9 (0.0) |
| Lerner Index | -8.5 (0.0) |
| Bank leverage | -2.0 (0.02) |
| Regulatory capital/risk adjusted assets | -2.3 (0.0) |
| Deposit/asset ratio | -8.9 (0.0) |
| Noninterest income/total income | -4.8 (0.0) |
| Credit/asset ratio | -8.3 (0.0) |

## 4 Results

Baseline regression results using Lerner for competition and the leverage ratio for capital adequacy on the global sample are shown in Table 4, with the outcome for regulatory capital as a memo item. The shorter data period for the crisis regressions is a consequence of the shorter length of the crisis variable given the source in the GFDD is Laeven and Valencia (2012). The GMM regressions start in 2000 owing to a lag being taken by the methodology.

**Table 4: Baseline regression results for leverage and Lerner (1999-2015)**

| | Crisis | NPL/loans | Log (Zscore) | Provisions/Loans |
|---|---|---|---|---|
| Constant | -4.28***<br>(4.6) | - | - | - |
| Dependent (-1) | - | 0.77***<br>(45.1) | 0.223***<br>(8.2) | 0.579***<br>(26.3) |
| Lerner (-1) | -3.07***<br>(3.8) | 3.86**<br>(2.3) | -0.001<br>(0.5) | -2.83***<br>(3.2) |
| Leverage (-1) | -0.108***<br>(3.5) | 0.752***<br>(9.8) | 0.0017***<br>(2.9) | 0.276***<br>(5.2) |
| Deposits/Assets (-1) | -0.325<br>(1.5) | -16.6***<br>(6.4) | -0.053***<br>(4.7) | -12.7***<br>(8.2) |
| Noninterest income/total income (-1) | 0.024***<br>(3.2) | -0.005<br>(0.4) | 0.00001<br>(0.2) | 0.02**<br>(2.6) |
| Credit/assets (-1) | 3.68***<br>(4.0) | 26.5***<br>(6.2) | -0.04*<br>(1.8) | 0.486<br>(0.2) |
| Regression type | ML - Binary logit | Panel GMM difference regression | Panel GMM difference regression | Panel GMM difference regression |
| Effects | | Cross section fixed (first difference) | Cross section fixed (first difference) | Cross section fixed (first difference) |
| Sample (adjusted): | 1999-2011 | 2000-2015 | 2000-2015 | 2000-2015 |
| Periods included: | 13 | 16 | 16 | 16 |
| Countries included: | 112 | 108 | 108 | 107 |
| Observations: | 1074 (o/w 118=1) | 1206 | 1269 | 1063 |
| R-squared | 0.1139 | - | - | - |
| S.E. of regression | 0.3 | 4.05 | 0.024 | 2.31 |
| Sum of squared residuals | 96.19 | 19670 | 0.7 | 5648 |
| Sargan's J (probability) | - | 48.9 (0.28) | 43.6 (0.61) | 42.6 (0.53) |
| Memo: regulatory capital ratio (-1) instead of leverage (-1) | -0.104***<br>(3.6) | 0.15***<br>(2.7) | -0.0001<br>(0.3) | -0.04<br>(1.3) |

Note: T-values in parentheses (Z-statistics for logit) *** implies significance at 99%, ** at 95% and * at 90%. Regression (1) estimated by binary logit. Regressions (2-4) estimated by difference-GMM with lagged dependent variables and cross section difference fixed effects, the instruments are the second, third and fourth lag difference of the dependent variable and second lag levels of the independent variables, which include control variables shown in Table 4. White period instrument weighting matrix and White period standard errors and covariance are used.

As noted, the crisis regressions are Logit estimates. It can be seen that all of the variables for crisis are significant except for the deposit/assets ratio. Hence, banking crises are more likely if there is a high level of competition (low Lerner and hence narrow margins); low leverage (hence capital buffers are thin); a higher non-interest ratio (possibly as margins on loans are low) and a higher ratio of credit to assets (where credit is potentially riskier). Competition may be a particular issue where recent financial liberalisation – and low levels of bank efficiency - may enhance vulnerability to banking crises. Finally, regulatory capital is also significant in the crisis equation if it is substituted for the leverage ratio.

Concerning the GMM estimates for the other risk variables, the J-Statistics results indicate that the null hypothesis of over-identifying restrictions is not rejected. In each case the lagged dependent variable is highly significant and positive, especially for the NPL/loans ratio and the provisions/loans ratio.

As regards the NPL/loans regressions, there is a significant positive effect of Lerner (implying a negative effect of competition and hence "competition stability"). The NPL ratio is higher when the leverage ratio is high (consistent with the "regulatory hypothesis"), when deposits/assets are low (a higher cost of funding), and a higher credit/assets ratio (more risk), while the noninterest income ratio is not significant. Regulatory capital is also significant and positive when substituted for the leverage ratio.

Note that the lower the log Z-Score, the higher the risk to the banking sector. The Z-Score results have no significant effect of the noninterest income ratio or the Lerner measure of competition. Higher leverage gives rise to a higher Z-Score (note above that capital/assets is part of the Z-Score, however); lower deposit/assets ratios and credit/asset ratios also indicate a higher Z-Score and thus lower risk. Regulatory capital is not significant in the Z-Score equation if it is substituted for leverage.

Finally in respect of the provisions/loans ratio, the negative sign on the Lerner indicates higher competition entails higher provisions and hence risk ("competition-fragility"). The leverage ratio is significant and positive as for the NPL/loans ratio *indicating support for the "regulatory hypothesis". A lower deposits/assets ratio as well as a higher noninterest share indicate a higher rate of provisioning, an indicator of risk. Regulatory capital in place of the leverage ratio was insignificant across the whole sample.

Tables 5-8 all repeat the same form of regressions as in Table 4 for various measures of capital adequacy and competition, as well as across country groups and time periods. We run the regressions for the full period 1999-2015 as in Table 4, for the higher-income countries, for the emerging market economies and developing countries (including middle- and lower-income countries), and for the pre-crisis period up to 2007 and the post-crisis period from 2008 separately. For the crisis regression we also run the regression for the crisis onset only, given that the later years of a prolonged crisis may be affected by government measures and banks' risk aversion.

We see in Table 5 below, following the results from Table 4, that in the full sample both competition and both measures of capital adequacy are significant predictors of a crisis year. In advanced countries, however, the risk adjusted capital measure is not significant while the leverage measure is only significant at 90%. However, Lerner is again significant at 95% in each regression. This is reminiscent of the fact that leverage seemed to signal the subprime crisis better than risk adjusted measures, since the latter were distorted by inaccurate credit ratings etc. It also underlines the importance of banking competition as a crisis predictor. For emerging markets, the difference is that it is risk adjusted capital rather than leverage that is significant as a predictor, while the Lerner remains significant. A similar result is obtained for the pre-crisis years up to 2007 for the global sample. In the post-crisis period from 2008, all of the variables are significant, note however that this is giving the state of affairs after the onset of the GFC rather than predicting it.

Competition is rarely tested as a predictor of crises, this suggests a need for further work in this area. That said, as regards the regression for the onset of the crises, it is the two capital adequacy measures that are significant and not the competition measure. This is in line with the results of Barrell et al (2010) and Karim et al (2013), who found banking sector leverage to be a strong predictor of banking crises, although they did not test for an effect of competition.

**Table 5: Regression results for crisis using alternative measures of capital adequacy**

| Logit Regressions | Variable | Equation with leverage ratio | Equation with regulatory capital/risk adjusted assets |
|---|---|---|---|
| Full sample | Lerner (-1) | -3.07***<br>(3.8) | -2.87***<br>(3.6) |
| | Capital ratio (-1) | -0.108***<br>(3.5) | -0.104***<br>(3.6) |
| Higher-income countries | Lerner (-1) | -2.21**<br>(2.4) | -2.27**<br>(2.5) |
| | Capital ratio (-1) | -0.088*<br>(1.8) | -0.031<br>(0.7) |
| Emerging market economies | Lerner (-1) | -4.43***<br>(3.0) | -3.76**<br>(2.6) |
| | Capital ratio (-1) | -0.052<br>(1.0) | -0.12**<br>(2.6) |
| Pre-crisis (up to 2007) | Lerner (-1) | -3.43***<br>(3.0) | -2.88***<br>(3.0) |
| | Capital ratio (-1) | 0.0093<br>(0.2) | -0.09*<br>(1.8) |
| Post-crisis (2008 onwards) | Lerner (-1) | -4.93***<br>(3.3) | -5.92***<br>(4.0) |
| | Capital ratio (-1) | -0.23***<br>(4.8) | -0.25***<br>(4.7) |
| Crisis onset only | Lerner (-1) | -1.129<br>(1.0) | -0.176<br>(0.1) |
| | Capital ratio (-1) | -0.109*<br>(1.7) | -0.245***<br>(3.4) |

Note: Logit regressions which also include control variables shown in Table 4. Z-statistics in parentheses. *** implies significance at 99%, ** at 95% and * at 90%.

Looking at the results for the NPL/loans ratio in Table 6, we find in the full sample, as already seen in Table 4, both leverage and regulatory capital are significant (a higher level of capital adequacy implies higher NPLs) as is the Lerner index with a positive sign (high NPLs correspond to periods when competition is subdued). The higher-income countries have a similar result except that Lerner is only significant in the leverage ratio estimate. The emerging markets are distinct in that the Lerner measure of competition is highly significant and negative for the leverage ratio equation, although capital ratios are again both significant and positive. This indicates that higher competition (narrower margins[19]) leads to more NPLs; a positive link from competition to risk in lending is clearly indicated, which may reflect relatively recent financial deregulation. A similar result obtains for the pre-crisis sample where both equations have a negative sign for Lerner (a positive relation of competition to risk, so called "competition-fragility"). Only the leverage ratio is significant with a positive sign pre crisis, while the risk adjusted measures is not. Finally, for the post-crisis period all of the variables are significant with capital and the Lerner index positive.

Overall, the results show a consistent positive relation of capital adequacy to risk in line with the "regulatory hypothesis" (although regulatory capital is less often significant than the leverage ratio). Meanwhile the competition/risk relation varies between EMEs and advanced countries, as well as pre and post crisis. In the latter period, low competition may have coincided with high NPLs as the effects of the crisis were slowly absorbed whereas the pre-crisis pattern of "competition-fragility" may reflect the competition/NPL relation in more normal times.

**Table 6: Regression results for NPL/loans using alternative measures of capital adequacy**

| Panel GMM-Difference Regressions (cross section fixed effects) | Variable | Equation with leverage ratio | Equation with regulatory capital/risk adjusted assets |
|---|---|---|---|
| Full sample | Lerner (-1) | 3.86**<br>(2.3) | 2.93**<br>(2.0) |
| | Capital ratio (-1) | 0.752***<br>(9.8) | 0.15***<br>(2.7) |
| Higher-income countries | Lerner (-1) | 1.58***<br>(6.7) | 0.118<br>(0.9) |
| | Capital ratio (-1) | 0.233***<br>(15.8) | 0.149***<br>(44.3) |
| Emerging market economies | Lerner (-1) | -3.25***<br>(3.6) | 0.36<br>(0.6) |
| | Capital ratio (-1) | 0.48***<br>(17.7) | 0.061***<br>(3.3) |
| Pre-crisis (up to 2007) | Lerner (-1) | -6.96**<br>(2.0) | -6.08***<br>(2.7) |
| | Capital ratio (-1) | 0.672***<br>(3.2) | 0.05<br>(0.4) |
| Post-crisis (2008 onwards) | Lerner (-1) | 4.68*<br>(1.9) | 3.81*<br>(1.9) |
| | Capital ratio (-1) | 0.68***<br>(4.7) | 0.287***<br>(4.3) |

Note: T-values in parentheses. *** implies significance at 99%, ** at 95% and * at 90%. Regression estimated by difference-GMM with lagged dependent variables and cross section difference fixed effects, the instruments are the second third and fourth lag difference of the dependent variable and second lag levels of the independent variables, which include control variables shown in Table 4. White period instrument weighting matrix and White period standard errors and covariance are used.

[19] The narrower margins could also be related to the lesser efficiency of banking in emerging markets.

The results for log Z score (Table 7) can be compared to those in Davis and Karim (2018), Davis (2017) and de-Ramon et al (2018), where it is again the main independent variable. Unlike the other variables, note that a higher Z-Score implies lower risk and hence a positive sign for capital (or a negative sign on Lerner) shows a negative relation to risk. The most consistent result across subsamples is the leverage ratio with a significant positive sign in each regression. This is consistent with a negative relation of capital to risk ("skin in the game"). Regulatory capital is only significant with a positive sign for the advanced countries. A note of caution is that the leverage ratio enters the Z-Score as one of its components and hence there may be bias, although the lag may partly offset this. The regressions in Tables 5, 7 and 8 avoid this potential problem.

As regards the Lerner index, significant positive effects emerge for the EMEs and for the pre-crisis period 2000-2007 only. These are both consistent with "competition-fragility" and are comparable with the results shown above for NPLs, where again it was the EMEs and the pre-crisis period that showed "competition-fragility".

**Table 7: Regression results for log (Z Score) using alternative measures of capital adequacy**

| Panel GMM-Difference Regressions (cross section fixed effects) | Variable | Equation with leverage ratio | Equation with regulatory capital/risk adjusted assets |
|---|---|---|---|
| Full sample | Lerner (-1) | -0.001<br>(0.5) | 0.0004<br>(0.3) |
| | Capital ratio (-1) | 0.0017***<br>(2.9) | -0.0001<br>(0.3) |
| Higher-income countries | Lerner (-1) | -0.0037<br>(0.7) | -0.004<br>(1.0) |
| | Capital ratio (-1) | 0.0018***<br>(3.9) | 0.00066***<br>(3.9) |
| Emerging market economies | Lerner (-1) | 0.0012***<br>(5.1) | 0.0009*<br>(2.0) |
| | Capital ratio (-1) | 0.0027***<br>(20.0) | -0.00017<br>(0.5) |
| Pre-crisis (up to 2007) | Lerner (-1) | 0.076***<br>(3.2) | 0.044**<br>(2.2) |
| | Capital ratio (-1) | 0.0036**<br>(2.0) | -0.00019<br>(0.3) |
| Post-crisis (2008 onwards) | Lerner (-1) | 0.009<br>(1.0) | 0.009<br>(1.1) |
| | Capital ratio (-1) | 0.0026**<br>(2.3) | 0.00078<br>(1.6) |

Note: T-values in parentheses *** implies significance at 99%, ** at 95% and * at 90%. Regressions estimated by difference-GMM with lagged dependent variables and cross section difference fixed effects, the instruments are the second third and fourth lag difference of the dependent variable and second lag levels of the independent variables, which include control variables shown in Table 4. White period instrument weighting matrix and White period standard errors and covariance are used8

Looking at the results for provisions/loans (Table 8), this is related negatively to competition in the full sample and in both the advanced countries and the emerging market economies as well as pre crisis (a higher Lerner implies less competition and wider margins). High competition may thus imply that banks need to provision as loans are riskier, consistent with "competition-fragility". The contrast with results for NPLs in the full sample and for advanced countries may reflect differences in timing between provisioning and NPL recognition. The leverage ratio is more often significant than regulatory capital, as was the case for the other regressions, and has a significant positive sign for all of the subsamples except pre crisis. The regulatory capital ratio is significant with a positive sign for advanced countries only. Accordingly, results for capital adequacy support the "regulatory hypothesis".

**Table 8: Regression results for Provisions/Loans using alternative measures of capital adequacy**

| Panel GMM-Difference Regressions (cross section fixed effects) | Variable | Equation with leverage ratio | Equation with regulatory capital/risk adjusted assets |
|---|---|---|---|
| Full sample | Lerner (-1) | -2.83***<br>(3.2) | -1.67***<br>(2.7) |
| | Capital ratio (-1) | 0.28***<br>(5.2) | -0.04<br>(1.3) |
| Higher-income countries | Lerner (-1) | -1.7***<br>(8.1) | -1.197***<br>(5.6) |
| | Capital ratio (-1) | 0.112***<br>(14.6) | 0.019***<br>(3.4) |
| Emerging market economies | Lerner (-1) | -1.73***<br>(3.8) | -3.18***<br>(5.1) |
| | Capital ratio (-1) | 0.23***<br>(5.6) | -0.018<br>(1.0) |
| Pre-crisis (up to 2007) | Lerner (-1) | -7.27***<br>(4.4) | -6.33***<br>(2.3) |
| | Capital ratio (-1) | 0.018<br>(0.1) | -0.18<br>(1.6) |
| Post-crisis (2008 onwards) | Lerner (-1) | 0.91<br>(0.6) | 1.22<br>(0.9) |
| | Capital ratio (-1) | 0.214***<br>(3.1) | 0.051<br>(1.5) |

Note: T-values in parentheses *** implies significance at 99%, ** at 95% and * at 90%. Regression estimated by difference-GMM with lagged dependent variables and cross section difference fixed effects, the instruments are the second third and fourth lag difference of the dependent variable and second lag levels of the independent variables, which include control variables shown in Table 4. White period instrument weighting matrix and White period standard errors and covariance are used.

## 5 Summary of single equation results for issues in financial stability

Summarising the results and their implications for the various identified issues in financial stability analysis, Table 9 provides a reference.

**Table 9: Summary of significance and signs**

| Country group/time period | Risk indicator | Competition (Lerner) | Leverage ratio | RAR |
|---|---|---|---|---|
| Global | Crisis | -*** | -*** | -*** |
| | NPL/loans | +** | +*** | +*** |
| | Log Z Score | | +*** | |
| | Provisions/loans | -*** | +*** | |
| Advanced | Crisis | -** | -* | |
| | NPL/loans | +*** | +*** | +*** |
| | Log Z Score | | +*** | +*** |
| | Provisions/loans | -*** | +*** | +*** |
| EME | Crisis | -*** | | -** |
| | NPL/loans | -*** | +*** | +*** |
| | Log Z Score | +*** | +*** | |
| | Provisions/loans | -*** | +*** | |
| Pre-crisis (up to 2007) | Crisis | -*** | | -* |
| | NPL/loans | -** | +*** | |
| | Log Z Score | +*** | +** | |
| | Provisions/loans | -*** | | |
| Post-crisis (2008 onwards) | Crisis | -*** | -*** | -*** |
| | NPL/loans | +* | +*** | +*** |
| | Log Z Score | | +** | |
| | Provisions/loans | | +*** | |

Note: *** implies significance at 99%, ** at 95% and * at 90%. Cells for competition shown in white show a negative relation of competition to risk ("competition-stability"), cells for competition shown in light grey show a positive relation of competition to risk ("competition-fragility"). Cells for capital shown in dark grey show a negative relation of capital ratios to risk ("skin in the game"), cells for capital shown in white show a positive relation of capital ratios to risk ("regulatory hypothesis").

From the standpoint of *competition and risk*, the evidence strongly favours the competition-fragility hypothesis. This is evident for financial crises in all cases (except for the crisis onset), for the provisions/loans ratio except post-crisis, for the NPL/loan ratio in EMEs and before the crisis, and also for the Z score in EMEs and pre crisis. In all these cases, a narrowing of margins as indicated by a lower Lerner Index implies greater risk of financial instability for the economy in question. There is less evidence favouring the competition-stability hypothesis, with the only cases being NPL/loans in the full sample, advanced countries and post crisis.[20] The implication is clearly that regulators need to take more note of competitive conditions in banking markets when assessing the stance of macroprudential policy and the risk of financial instability.

Regarding the relation of *capital to risk*, we have mixed results. For crises and the Z score there is a negative relation, so that less capital accompanies greater risk – or conversely more capital leads to lower risk. This is most apparent for crises, especially in the full sample and post-crisis, but also in respect of at least one capital measure for advanced countries, emerging markets and prior to the

[20] A possible explanation for results in micro work favouring competition-stability is that it is most relevant for small banks, which are given equal weight in micro estimates with large and systemic institutions.

crisis. It is also the case for the log Z score in all cases for the leverage ratio, and for advanced countries with regulatory capital. These results are consistent with the "skin in the game" hypothesis, whereby it would be expected that a higher capital ratio would be consistent with lower risk as bank managers become prudent and wiser in their investment choices. The corollary is that a low capital ratio may give incentives to take risks and "gamble for resurrection" especially when there is generous and mispriced deposit insurance, and for "too big to fail" banks.

Results for provisioning rates and NPLs tend on the other hand to show a positive relation of capital to risk. This is the case for NPLs using both capital measures in all cases except for EMEs where the regulatory capital ratio is not significant. For provisioning it holds it holds for the leverage ratio in all cases except pre crisis, and it is also found for the RAR in advanced countries.[21] These results are consistent with the "regulatory hypothesis" which would suggest that regulators require higher capital in response to higher risk, and so a positive relation of capital to risk would be expected. And it is notable that NPLs and provisions are direct targets of supervisory oversight in the way that crises and Z scores are not.

*The leverage ratio* is clearly relevant for many cases that we have estimated, as is the regulatory capital ratio, thus justifying the regulatory focus on both measures. In some cases both measures are relevant, as for example in the case of financial crises and NPLs in the global sample, for NPLs, Z score and provisions for advanced countries, for NPL/loans for EMEs and for crises and NPLs in the post crisis period. In all cases the significant effect has the same sign. On the other hand, the leverage ratio is significant in many more samples than is the regulatory capital ratio, being present for 17 cases as opposed to 10 for regulatory capital. Only for crises in EMEs and over 1999-2007 is the regulatory capital ratio significant, while the leverage ratio is not. This pattern of superior indicator properties for the leverage ratio may link to the suggestion by Bitar et al (2018) that the ineffectiveness of risk adjusted measures may relate to untruthful (or at least inaccurate) assessment of bank real risk exposure.

Finally, we see numerous contrasts between the *experience of advanced countries as opposed to EMEs and developing countries* in the sample. In respect of competition, in EMEs it is relevant for all four risk indicators – in each case showing that higher competition entails higher risk, while for advanced countries it is not significant for the Z score and has a positive effect for the NPL ratio. Concerning capital measures, it is the leverage ratio that predicts crises in advanced countries but the RAR in EMEs. The regulatory capital ratio is significant in all cases except crises for advanced countries but only for crises and NPLs in the case of EMEs. Accordingly, EME regulators should pay particularly close attention to competition, while both groups are justified in a focus on leverage as well as the RAR. The lesser effect of regulatory capital for EMEs in respect of Z score and provisions may reflect more recent introduction of the Basel accords.

[21] This is consistent with the result in Davis et al (2019) for micro data who found that US banks tend to behave in a manner consistent with "skin in the game" while European banks tend to follow the "regulatory hypothesis"; and the latter constitute a significant proportion of advanced countries.

## 6 Robustness checks

In order to further check robustness we first included the macroeconomic variables GDP growth, CPI inflation and the rate of unemployment (ILO definition) in each regression. These data came from the World Bank's World Development Indicators database. We then went on to include crises as an independent variable in our regressions, and tried with the Boone index instead of Lerner as the competition measure. The statistical properties of the extra variables are shown in Table 10 below, where it can also be seen that all are stationary according to the Im-Pesaran-Shin (2003) test. It is notable that the mean rate of inflation is much higher than the median, which is likely to reflect the effect of hyperinflations.

**Table 10: Statistical properties of macro variables and Boone Indicator**

| | GDP growth | Inflation | Rate of unemployment | Boone index |
|---|---|---|---|---|
| Mean | 3.95 | 21.4 | 8.62 | -0.09 |
| Median | 3.95 | 5.31 | 6.95 | -0.04 |
| Maximum | 149.9 | 11749.6 | 44.1 | 9.45 |
| Minimum | -64.0 | -18.1 | 0.16 | -59.82 |
| Std. Dev. | 6.63 | 211.9 | 6.32 | 1.55 |
| Skewness | 2.64 | 35.1 | 1.5 | -35.43 |
| Kurtosis | 67.4 | 1613.1 | 5.81 | 1313.91 |
| | | | | |
| Jarque-Bera | 1458180. | 7.75E+08 | 3222.98 | 2.02E+08 |
| Probability | 0.000000 | 0.000000 | 0.000000 | 0.00 |
| | | | | |
| Sum | 33127.24 | 153294.3 | 39413.04 | -258.39 |
| Sum Sq. Dev. | 369183.7 | 3.22E+08 | 182432.5 | 6757.16 |
| | | | | |
| Observations | 8393 | 7164 | 4574 | 2811 |
| Unit root test (Im-Pesaran-Shin) | -50.8 (0.00) | -133.8 (0.00) | -3.7 (0.00) | 20.3 (0.00) |

The macro variables test should show whether the favourable results obtained are due to omission of such macroeconomic effects. We ran the tests for the full sample. As can be seen from Table 11 in comparison to Table 4, virtually all of the results previously obtained for the leverage ratio continue to hold, as well as the effects of competition for the crisis regressions. The regulatory capital ratio becomes significant with e negative sign in the case of provisions, but is otherwise only significant for crises. The significant competition effects found for NPLs and provisions drop out when macro variables are included. However, further investigation showed that the competition variables in the GMM equations are significant for the pre crisis period and consistent with "competition fragility" as in the equations shown in Tables 6-8 (positive for Z score and negative for NPL and provisions[22]). The results for insignificance may thus result from the post-2008 period where regulatory intervention may have blurred the relation of competition to risk.

[22] The coefficients and t values are respectively -8.33*** (2.8) for NPL ratio, -6.39*** (3.5) for the provisions ratio and 0.076*** (3.3) for the Z score.

**Table 11: Robustness check with macro variables**

| Dependent variable | Independent variables | Equation with leverage ratio | Equation with regulatory capital/risk adjusted assets |
|---|---|---|---|
| Crisis (1) | Lerner (-1) | -3.05***<br>(3.4) | -2.62***<br>(3.0) |
| | Capital ratio (-1) | -0.089**<br>(2.6) | -0.135***<br>(3.9) |
| Crisis onset (2) | Lerner (-1) | -0.73<br>(0.4) | -1.4<br>(1.3) |
| | Capital ratio (-1) | -0.222***<br>(3.0) | -0.11<br>(1.6) |
| NPL/loans (3) | Lerner (-1) | 0.83<br>(0.8) | 0.015<br>(0.1) |
| | Capital ratio (-1) | 0.367***<br>(5.7) | 0.03<br>(0.7) |
| Log Z Score (4) | Lerner (-1) | -0.0005<br>(0.3) | 0.001<br>(0.6) |
| | Capital ratio (-1) | 0.0025***<br>(4.2) | -0.0003<br>(0.9) |
| Provisions/loans (5) | Lerner (-1) | -0.25<br>(0.3) | 0.032<br>(0.1) |
| | Capital ratio (-1) | 0.15***<br>(3.0) | -0.043*<br>(1.7) |

Note: Regressions (1) and (2) estimated by binary logit. Regressions (3-5) estimated by difference-GMM with lagged dependent variables and cross section difference fixed effects, the instruments are the second, third and fourth lag difference of the dependent variable and second lag levels of the independent variables, which include control variables shown in Table 4. White period instrument weighting matrix and White period standard errors and covariance are used. Regressions also include lagged GDP growth, CPI inflation and unemployment rate (ILO definition). T-values in parentheses (Z statistics for logit) *** implies significance at 99%, ** at 95% and * at 90%.

As a second check of robustness (Table 12) we included the crisis dummy as used as a dependent variable in Tables 4 and 5 as an independent variable in the equations for NPL/loans, log Z score and provisions/loans. This seeks to ensure that the main results are not proxying for the effects of ongoing crises. In fact, the outcome is very close to the original results shown in Table 4, as shown below. The main difference is the competition effect for NPLs is no longer present. Indeed, it is close to significant negative, as for EMEs and pre crisis in Table 5, suggesting that the positive effect in the global sample is partly a post crisis phenomenon. Meanwhile the Lerner for Z score has a positive sign ("competition-fragility") again as consistent with the subsamples for EMEs and pre crisis.

**Table 12: Robustness check with crisis as independent variable**

| Dependent variable | Independent variables | Equation with leverage ratio | Equation with regulatory capital/risk adjusted assets |
|---|---|---|---|
| NPL/loans | Lerner (-1) | -4.2<br>(1.6) | -1.11<br>(0.5) |
| | Capital ratio (-1) | 0.89***<br>(7.2) | 0.18**<br>(2.0) |
| Log Z Score | Lerner (-1) | 0.038**<br>(2.3) | 0.022<br>(1.3) |
| | Capital ratio (-1) | 0.0016*<br>(1.8) | -0.00017<br>(0.4) |
| Provisions/loans | Lerner (-1) | -3.31**<br>(2.5) | -3.66***<br>(3.2) |
| | Capital ratio (-1) | 0.421***<br>(4.4) | -0.0006<br>(0.1) |

Note: T-values in parentheses (Z statistics for logit) *** implies significance at 99%, ** at 95% and * at 90%.Estimated by difference-GMM with lagged dependent variables and cross section difference fixed effects, the instruments are the second, third and fourth lag difference of the dependent variable and second lag levels of the independent variables, which include control variables shown in Table 4. White period instrument weighting matrix and White period standard errors and covariance are used. Regressions also include the lagged crisis variable.

As a third robustness check, we used the Boone Index (BOONE) as a competition measure. The Boone Index is a measure of the degree of competition as reflected in the reallocation of profits from inefficient banks to efficient ones, calculated as the elasticity of profits to marginal costs. To obtain the elasticity, the log of profits (measured by return on assets) is regressed on the log of marginal costs. The estimated coefficient (computed from the first derivative of a translog cost function) is the elasticity. The rationale behind the indicator is that higher profits are achieved by more-efficient banks. Hence, the more negative the Boone indicator, the higher the degree of competition is because the effect of reallocation is stronger.[23] It has been employed recently in bank competition and risk studies inter alia by Schaeck and Čihák (2014) and de-Ramon et al (2018).

We find in Table 13 that the Boone indicator is not significant for crises or crisis onset, but has a positive sign for NPL/loans, and a negative one for the Z score. There is also a positive sign for provisions/loans in the case of regulatory capital. These results tend to suggest that there is a negative relation of competition to risk in the full sample, which is a different result for Z score (where Lerner was insignificant in the full sample) and for provisions (where the effect in the full sample was for a positive link of competition to risk). However, further investigation showed that the Boone indicator is insignificant for the Z score and provisions prior to the crisis, although the coefficient for the NPL ratio remains positive. The results for a negative relation of competition to risk with the Boone indicator for Z score and provisions come in the post-2008 period where regulatory intervention may have blurred the relation of competition to risk. Nevertheless, these results suggest a need for care in interpreting competitive conditions, and a need for further research on the consistency of the Lerner and Boone measures. We note that in Davis and Karim (2018) the Lerner and the H statistic suggested different long run effects of competition on risk, with Lerner giving most consistent support for competition-fragility.

[23] This is GFDD series GFDD.OI.05. Estimations of the Boone indicator in the GFDD database follow the methodology used by Schaeck and Čihák (2010) with a modification to use marginal costs instead of average costs. Regional estimates of the Boone indicator pool the bank data by regions.

**Table 13: Robustness check with Boone indicator as measure of competition**

| Dependent variable | Independent variables | Equation with leverage ratio | Equation with regulatory capital/risk adjusted assets |
|---|---|---|---|
| Crisis (1) | Lerner (-1) | -0.071<br>(0.2) | 0.099<br>(0.2) |
| | Capital ratio (-1) | -0.162***<br>(5.0) | -0.128***<br>(4.5) |
| Crisis onset (2) | Lerner (-1) | -0.34<br>(0.5) | -0.24<br>(0.4) |
| | Capital ratio (-1) | -0.12*<br>(1.9) | -0.25***<br>(3.6) |
| NPL/loans (3) | Lerner (-1) | 1.49***<br>(5.6) | 3.0***<br>(3.6) |
| | Capital ratio (-1) | 0.021<br>(0.3) | 0.137***<br>(3.3) |
| Log Z Score (4) | Lerner (-1) | -0.0098***<br>(3.7) | -0.0095***<br>(3.4) |
| | Capital ratio (-1) | 0.00017***<br>(2.8) | 0.0003<br>(1.2) |
| Provisions/loans (5) | Lerner (-1) | 0.2<br>(1.5) | 0.656***<br>(4.1) |
| | Capital ratio (-1) | 0.067*<br>(1.7) | 0.025<br>(1.1) |

Note: T-values in parentheses (Z statistics for logit) *** implies significance at 99%, ** at 95% and * at 90%.Regressions (1) and (2) estimated by binary logit. Regressions (3-5) estimated by difference-GMM with lagged dependent variables and cross section difference fixed effects, the instruments are the second third and fourth lag difference of the dependent variable and second lag levels of the independent variables, which include control variables shown in Table 4. White period instrument weighting matrix and White period standard errors and covariance are used.

Overall, we contend that these checks underpin the validity of the results summarised in Table 9.

## 7 Panel VAR estimation

To complement our single equation work and investigate further the capital-competition-risk nexus, and in particular the relation of capital to competition, we ran a simple Panel VAR to assess the interrelations of these variables where risk is measured by the NPL ratio. Other control variables used in the principal regressions above (DEPASS, CREDASS and NONINT) are also included but not detailed below. We took two lags of each variable in the VAR. The results of the impulse responses and variance decompositions are shown below. Impulse responses were run using Pesaran's generalised impulses, the variance decompositions with Cholesky ordering competition, capital, DEPASS, CREDASS, NONINT then risk but also tested with the reverse ordering giving similar results.

The most striking feature of the impulse responses in Figure 1 is that competition drives leverage ratios significantly, with more competition leading to lower capital ratios and vice versa, a similar result to de-Ramon et al (2018) albeit contrary to Schaeck and Čihák (2012). Meanwhile, there is also a significant two-way relation between leverage and the NPL ratio, while a shock to Lerner itself does not have a significant direct effect on the NPL ratio. In Figure 2, where the RAR is substituted for the leverage ratio in the VAR, there is not a significant impact of competition at 95% on regulatory capital, although there is again an interrelation of regulatory capital and risk.

**Figure 1: Impulse responses for VAR of NPL, leverage and competition (Lerner), including also the other control variables**

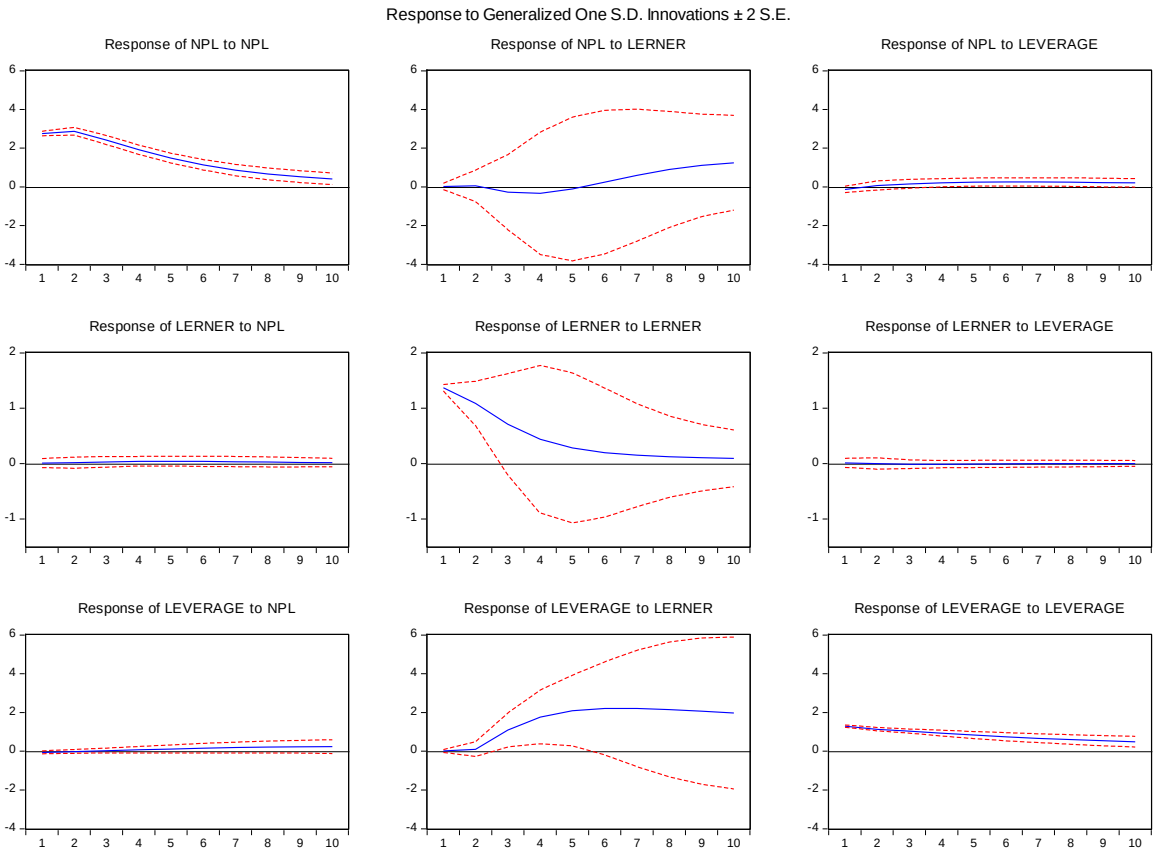


**Figure 2: Impulse responses for VAR of NPL, regulatory capital and competition (Lerner), including also the other control variables**

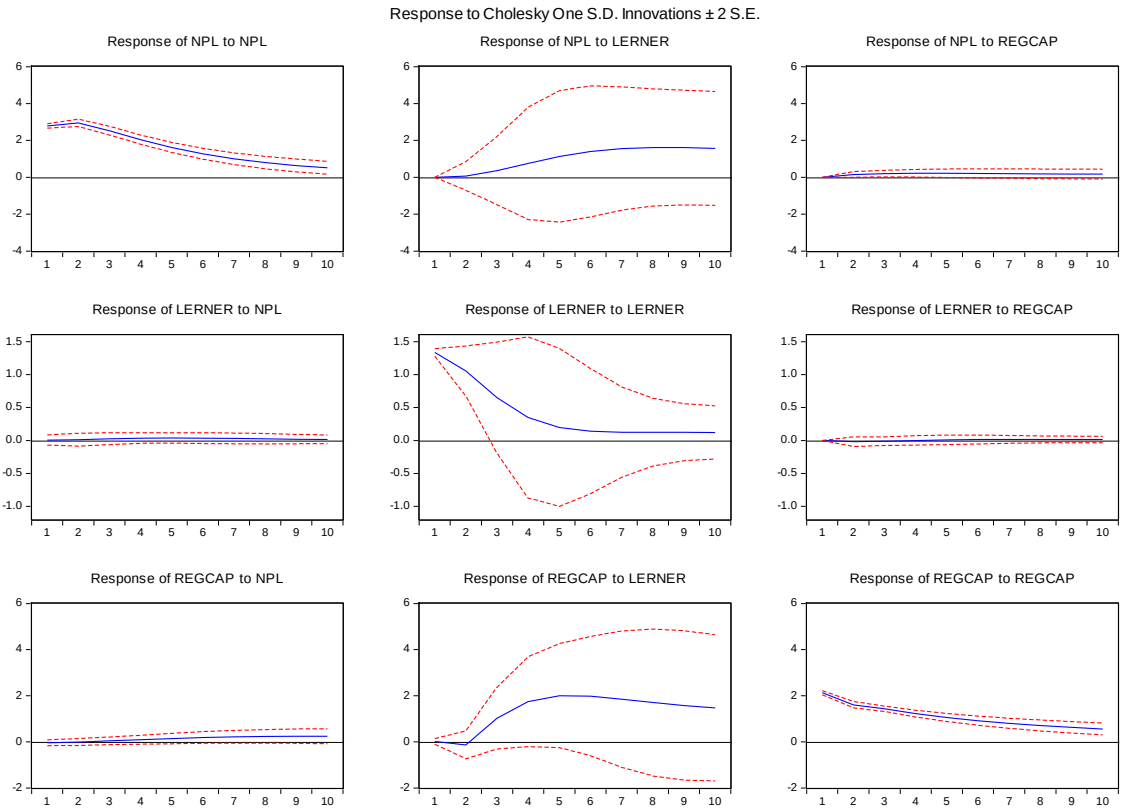



**Table 14: Variance decomposition for VAR of NPL ratio, leverage and competition (Lerner)**

NPL:

| Period | S.E. | NPL | LERNER | LEVERAGE | DEPASS | NONINT | CREDASS |
|---|---|---|---|---|---|---|---|
| 1 | 2.75 | 99.16 | 0.0035 | 0.24 | 0.47 | 0.11 | 0.0051 |
| | | (0.6) | (0.15) | (0.26) | (0.42) | (0.25) | (0.12) |
| 5 | 5.33 | 96.61 | 0.73 | 0.53 | 1.45 | 0.68 | 0.0014 |
| | | (16.3) | (16.8) | (0.45) | (0.8) | (0.59) | (0.21) |
| 10 | 6.03 | 83.76 | 11.53 | 1.13 | 1.54 | 1.99 | 0.047 |
| | | (24.7) | (26.0) | (1.0) | (0.9) | (1.63) | (0.31) |

LERNER:

| Period | S.E. | NPL | LERNER | LEVERAGE | DEPASS | NONINT | CREDASS |
|---|---|---|---|---|---|---|---|
| 1 | 1.37 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| 5 | 1.96 | 0.091 | 99.51 | 0.019 | 0.015 | 0.031 | 0.33 |
| | | (0.34) | (0.57) | (0.15) | (0.17) | (0.22) | (0.37) |
| 10 | 1.99 | 0.18 | 99.28 | 0.021 | 0.079 | 0.04 | 0.4 |
| | | (0.59) | (0.99) | (0.27) | (0.23) | (0.44) | (0.52) |

LEVERAGE:

| Period | S.E. | NPL | LERNER | LEVERAGE | DEPASS | NONINT | CREDASS |
|---|---|---|---|---|---|---|---|
| 1 | 1.293667 | 0.00 | 0.0068 | 99.99 | 0.00 | 0.00 | 0.00 |
| | | (0.00) | (0.17) | (0.17) | (0.00) | (0.00) | (0.00) |
| 5 | 3.778735 | 0.28 | 61.11 | 38.52 | 0.026 | 0.046 | 0.023 |
| | | (0.34) | (19.16) | (18.8) | (0.15) | (0.47) | (0.11) |
| 10 | 6.232241 | 0.74 | 80.26 | 18.73 | 0.02 | 0.086 | 0.16 |
| | | (0.88) | (21.27) | (20.17) | (0.24) | (1.4) | (0.44) |

Note; standard errors in parentheses

In the variance decompositions (Tables 14 and 15), it is notable that competition is autonomous in both VARs, with over 99% of the variance self-determined even after 10 years. NPLs variance is significantly related to competition (when leverage is included, it accounts for 12% after 10 years and 29% with regulatory capital). In contrast, the variance of capital (on both measures) is influenced by competition quite significantly (it accounts for 80% with leverage after 10 years and 60% for regulatory capital). Variance of regulatory capital and leverage do not majorly influence the NPL ratio. Overall, this would appear to indicate weak exogeneity of competition in the system.

**Table 15: Variance decomposition for VAR of NPL ratio, regulatory capital and competition (Lerner)**

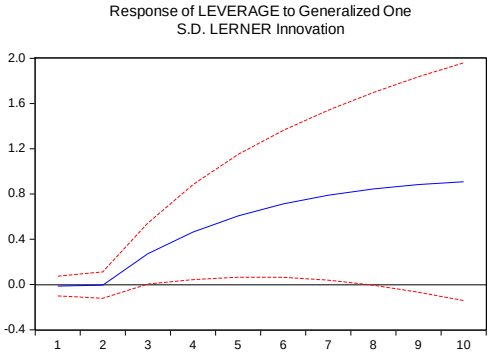
| NPL: | | | | | | | |
|---|---|---|---|---|---|---|---|
| Period | S.E. | NPL | LERNER | REGCAP | DEPASS | NONINT | CREDASS |
| 1 | 2.78 | 99.39 | 0.0019 | 0.044 | 0.42 | 0.063 | 0.08 |
| | | (0.47) | (0.13) | (0.16) | (0.36) | (0.16) | (0.17) |
| 5 | 5.65 | 91.62 | 6.33 | 0.3 | 1.34 | 0.27 | 0.14 |
| | | (15.45) | (16.1) | (0.48) | (0.91) | (0.48) | (0.31) |
| 10 | 6.97 | 68.12 | 29.0 | 0.5 | 1.28 | 0.69 | 0.36 |
| | | (26.13) | (27.57) | (0.86) | (1.1) | (1.24) | (0.48) |
| LERNER: | | | | | | | |
| Period | S.E. | NPL | LERNER | REGCAP | DEPASS | NONINT | CREDASS |
| 1 | 1.34 | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| 5 | 1.87 | 0.081 | 99.52 | 0.017 | 0.017 | 0.028 | 0.34 |
| | | (0.26) | (0.54) | (0.14) | (0.1) | (0.22) | (0.34) |
| 10 | 1.89 | 0.16 | 99.26 | 0.044 | 0.088 | 0.043 | 0.4 |
| | | (0.5) | (0.98) | (0.23) | (0.17) | (0.41) | (0.55) |
| REGCAP: | | | | | | | |
| Period | S.E. | NPL | LERNER | REGCAP | DEPASS | NONINT | CREDASS |
| 1 | 2.13 | 0.00 | 0.009 | 99.99 | 0.00 | 0.00 | 0.00 |
| | | (0.00) | (0.14) | (0.14) | (0.00) | (0.00) | (0.00) |
| 5 | 4.47 | 0.22 | 40.65 | 58.97 | 0.021 | 0.11 | 0.033 |
| | | (0.29) | (22.65) | (22.42) | (0.081) | (0.35) | (0.12) |
| 10 | 6.15 | 0.81 | 60.82 | 38.09 | 0.025 | 0.058 | 0.2 |
| | | (0.86) | (28.33) | (27.89) | (0.16) | (0.72) | (0.28) |

Note; standard errors in parentheses

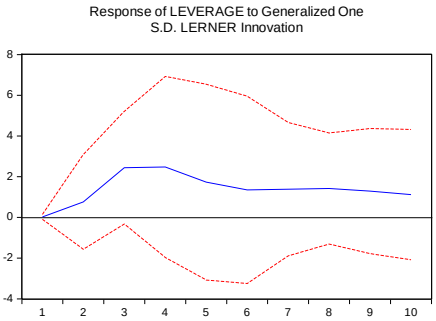
In Figure 3 we show impulse responses for competition on the leverage ratio for a variety of subsamples and for different risk variables. We find that the effect of competition on capital is quite general, although it is not significant at 95% for emerging market economies. It applies in the cases of advanced countries, pre and post crisis, with the provisions/loans and log Z score measures of risk, and also with the additional macro variables for NPL/loans and for provisions/loans.

## Figure 3: Response of Leverage to Lerner for subgroups

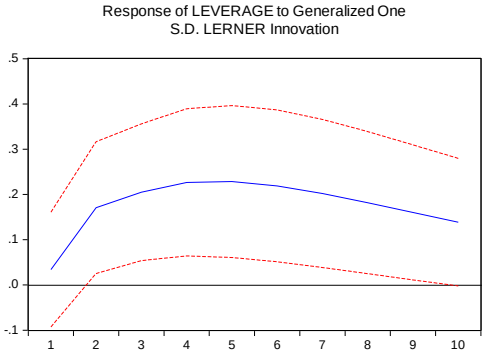
### Advanced countries



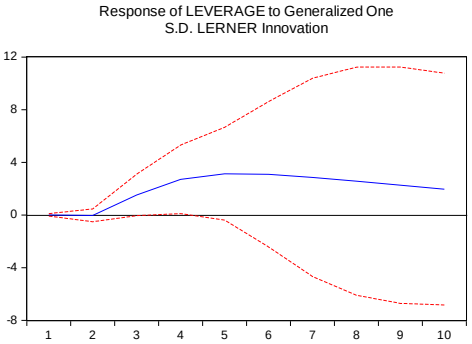

### Emerging market economies



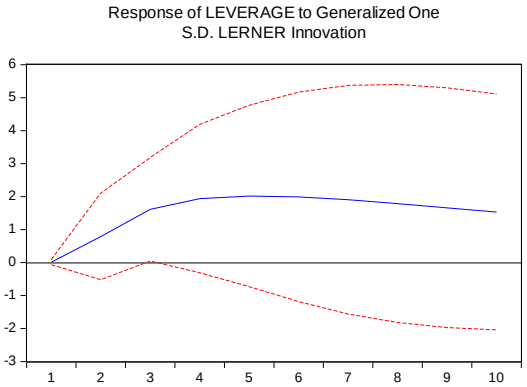

### 1998-2006



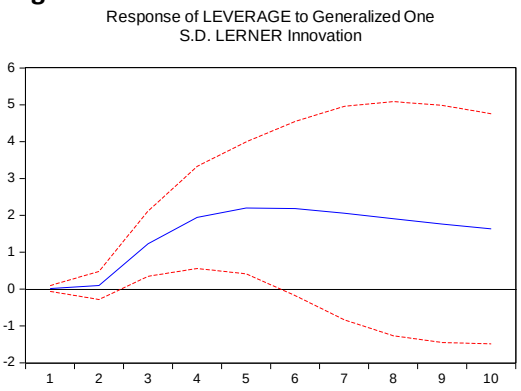

### 2007-2015



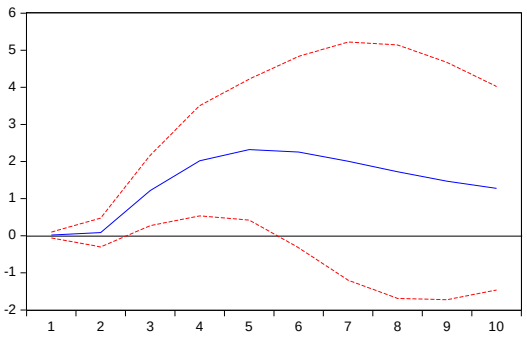

### Provisions/loans



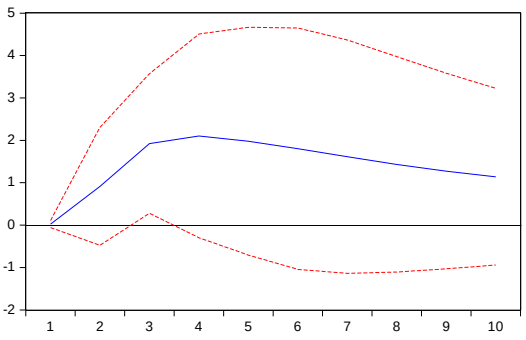

### Log Z Score




### With macro variables: NPL




### With macro variables: Provisions/Loans



**Conclusions**

Using annual data for a range of countries using the Global Financial Development Database and with five unresolved issues in financial stability analysis in mind, we have obtained a number of relevant results from regression of competition and capital on risk.

- The results for the Lerner Index largely underpin the "competition-fragility" hypothesis rather than "competition stability" and show a widespread impact of competition on risk generally.
- There is a tendency for both the leverage ratio and the RAR to be significant predictors of risk, and for crises and Z score they are supportive of the "skin in the game" hypothesis of a negative relation between capital ratios and risk, whereas for provisions and NPLs they are consistent with the "regulatory hypothesis" of a positive relation of capital adequacy to risk.
- The leverage ratio is much more widely relevant than the RAR, underlining its importance as a regulatory tool. The relative ineffectiveness of risk adjusted measures may relate to untruthful or inaccurate assessments of bank real risk exposure.
- There are marked differences between advanced countries and EMEs in the capital-risk-competition nexus, with for example a wider impact of competition in EMEs (although both types of country need to pay careful attention to the evolution of competition in macroprudential surveillance). Similar pattern to EMEs are apparent in many cases for the global sample pre crisis, which arguably are more consistent with normal market functioning than post crisis.
- Competition reduces leverage ratios significantly in a Panel VAR, with impulse responses showing that more competition leads to lower leverage ratios and vice versa. This result is consistent over a range of subsamples and risk variables. In the variance decomposition, we find that competition is autonomous, while the variance of both risk and capital ratios are strongly affected by competition. The Panel VAR results give some indication of the transmission mechanism from competition to risk and financial instability.

We contend that such results using macroeconomic data may in some ways be superior to those with individual bank data. This is the case not least in that the underlying macro data is a weighted average of individual institutions thus giving implicitly greater importance to large systemic institutions, while micro work typically gives equal weight to each institution. Furthermore, we overcome a weakness of existing work is that such issues are rarely considered together, when in fact omission of relevant variables may bias results. Robustness checks show that the inclusion of key macroeconomic variables and crises do not amend the main results, while the outturn for Boone measures of competition show a need for care in interpreting competitive conditions, and a need for further research on the consistency of the Lerner and Boone measures.

As regards regulatory implications, perhaps the most important is the positive relation of bank competition to risk for most risk measures and subsamples, that has often been disregarded by regulators in the past. The fact that competition policy in the economy in general is often under separate anti-trust authorities makes control of banking competition at a macroprudential level more complex, but the results stress the importance of regulators monitoring such competition. Then there is the widespread importance of the leverage ratio, that underlines the appropriateness of its inclusion in Basel III as a complement to risk-adjusted regulatory capital ratios. The fact that capital's relation to risk is negative ("skin in the game") for crises and Z score underlines the importance of overall capital regulation. The contrasts in some of the results between advanced countries and emerging markets/developing countries underlines that there is no "one size fits all"

for regulation. Finally the effect of competition on capital indicates that there are indirect as well as direct effects of competition on risk, again emphasising the importance of its monitoring for macroprudential purposes.

As regards further research, this could look inter alia at the further breakdown of results between Emerging Market Economies against developing countries. It could also use coefficients that vary over different horizons for example using the functional coefficients approach as in Herwartz and Xu (2010). Further work could assess interrelations of the Boone and Lerner measures. Since the GFDD and the crisis data are regularly updated, there will in due course be scope to assess robustness including the latest observations. Further work could also look at the interaction of the RAR and the leverage ratio to see if this enhances stability (as it is expected to). This could be undertaken in future once Basel III is properly in place.

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