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Abstract

Policy makers need to know if the structure of competition and the degree of banking market concentration change the incidence of financial crises. Previous studies have not always come to clear conclusions. We use a new dataset of 19 countries where we include capital adequacy and house price growth as factors affecting crisis incidence, and we find a positive role for bank concentration in reducing incidence. In addition, we look at New Industrial Economics indicators of market structure and find that increased market power also reduces crisis incidence. We conclude that attempts to increase competition in banking, although welcome for welfare reasons, should be accompanied by increases in capital standards.

Keywords: Financial Stability; Bank Competition; Banking Crises; Macroprudential Policy.

JEL Classifications: E44; G01; G18;

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1. Introduction

The financial crises in 2007 and 2008 have left a long and depressing shadow over the North Atlantic economies, and it is important to understand the forces that drove them. We look at the role of bank concentration and banking market competition in influencing the frequency of crises using standard concentration indices as well as indicators derived from the New Industrial Economics literature. Although there has been much research in this area, the relationship between stability and competition/concentration is not clear and theory and empirical evidence seem to be inconclusive.

We review the literature on banking market structure and its impact on financial stress and banking crises, concluding that the previous results on links between these indicators and crises are at best mixed. We discuss both structural concentration indices and types of behavioural market indicators of competition. It is important when undertaking an evaluation of links between market structure and crises to take account of the causes of and defences against crises. Estimates that exclude either of them will be biased unless structural indicators and the causes and defences are orthogonal. We follow Barrell et al (2010) in our experimental design, using indicators of market structures in aggregate models of crisis incidence.

We also discuss the data set covering 19 countries over the period 1996 to 2017. We use published data on all variables, with capital adequacy as measured without risk weighting (inverted leverage) along with banking concentration and competition indicators. The growth of house prices has been commonly linked to crises as well, and we include them in our empirical work. We stress the Laeven and Valencia (2018) crisis definition, which is tighter than the one used in Barrell et al (2010). We examine data on bank concentration and competitiveness indicators. These have not been widely used in aggregate studies of financial crises. The objective of this paper is to redress this imbalance in the literature and include market structure indicators in our analysis.

Our core results suggest that rising house prices in the recent past increase crisis probabilities, whilst increased capital adequacy reduces them. In addition we find a role for indicators of banking concentration. We look at New Industrial Economics indicators, and find a role for the Lerner indicator of mark-ups which tell us about both monopoly power and efficiency, but we do not find a role for the competition based Boone indicator.

In our analysis of robustness, we investigate whether credit growth and on balance sheet liquidity have a role as causes or defences in crisis situations. We show that the BIS derived credit gap is not a significant determinant of crisis incidence in our sample of 19 OECD countries over the 20 years from the late 1990s. In addition, we look at the relationship between house price growth and consumer credit growth and suggest that the link is not strong, and we also show that house price declines are not particularly important as a factor driving crises. We also evaluate the relative importance of competition and concentration indices in Europe and show that market contestability is more important than banking market concentration in the determination of European crises.

We discuss the design of macroprudential policy in the light of our results and suggest that it should be based mainly on adequate levels of capital. Policy would perhaps benefit from taking account of recent house price growth indicators, and from adjusting capital standards in the light of changes in the competitive environment within which banks work. Our second section discusses banking competition and financial crises, whilst our third section looks at our data. The fourth section contains our core results with robustness tests in the fifth section. Section six looks at macroprudential policy issues and we then conclude.

2. Financial Crises and the Structure of Banking Markets

There has been an extensive technical and historical literature on the causes and consequences of crises, and it has expanded rapidly since 2007. Bordo and Meissner (2016) bring out several strands, from narrative accounts such as Reinhart and Rogoff (2009) and Bordo (2018) through simple univariate early warning indicators used by Reinhart and Kaminsky (1999) and Borio and Drehmann (2009), to more sophisticated logit based models as in Barrell et al (2010) and Schularick and Taylor (2012). However, this macroeconomic literature has taken little notice of the indicators of banking market structure and the implications of these for crisis incidence, even though stress levels are clearly affected by market structure.

Financial crises happen when it becomes clear that a reasonable proportion of the banking system cannot meet their obligations, either because they are short on liquidity, or because they do not have enough capital (essentially the difference between their loans, or assets, and their liabilities or deposits) to cover their short-term losses, and hence they are potentially insolvent. Definitions of crisis vary over a number of dimensions including what proportion of loans are non-performing. The most widely used have been those from the IMF in Laeven and Valencia (2018) who use a much more restrictive set of criteria than that utilised in Barrell et al (2010)[1], whilst Romer and Romer (2017) investigate wider measures of financial market stress. We use the IMF definition in this paper, as it focuses on the scale of losses made by a banking system. Losses come from bad lending decisions and may either be as a result of bank actions, taking on more risk when lending, or from borrowers' actions in hiding risks from their lenders.

Banking market structure has previously been addressed in the literature on financial stability with Beck et al. (2006) finding that increased market concentration reduces

[1] Laeven and Valencia define a financial crisis as a situation where the proportion of non-performing loans to total banking system assets was greater than 10%, or the public bailout cost exceeded 3 percent of GDP, or systemic crisis caused large scale bank nationalisation, and if not, emergency government intervention was sustained. They stress the role of public sector interventions in defining crises.

crisis incidence across a group of 49 countries in the 1980s and 1990s, whilst Schaeck et al. (2009) found competition rather than concentration raised stability. However, neither study includes system wide bank capitalisation ratios or property price growth, as we do. The impact of regulation and competition may vary over time as well, as Anginer et al. (2014) show in their study of deposit insurance around the 2008 crisis. They also point out the importance of good supervision in ensuring market stability.

Greater competition might compromise the solvency of some institutions, thus hampering the stability of the banking system at an aggregate level. Banks under competitive pressure could take more risks in order to raise potential profits and bonuses for senior staff, whilst increasing the likelihood of failure. A negative relationship between the number of banks in the market and the average banks' credit quality could also be explained by the fact that when banks compete for deposits, the net margin between deposit and lending rates may fall and, due to the contraction of banks' franchise values, banks have less to lose, and hence might take more risks. However, as Boyd and De Nicolò, (2005) argue, competition in the loan market might also lower bank risk by reducing interest rates and hence the risk-taking incentives of borrowers. Hence, we could see differences in outcomes for financial market stress depending on which of the deposit and lending markets become more competitive. This is particularly important as cross border lending expands, as Barrell and Nahhas (2019) discuss.

Banks in more competitive markets are more exposed to contagion as they are price-takers under perfect competition and there are limited incentives to provide liquidity to a troubled bank, helping the contagion to spread, as Allen and Gale (2004) discuss. Both they and Beck et al (2006) argue that in more concentrated systems banks tend to be larger, and consequently better diversified and therefore less fragile than in banking system with many small banks. Fewer banks may also mean more effective supervision which in turn will make the risk of contagion and systematic crisis less pronounced in concentrated banking systems. However, a more collusive banking market may increase financial fragility as market power in deposit taking induces banks to increase the cost of borrowing for entrepreneurs and their default risk will increase as a consequence, in part because their profits decline, but also because of moral

hazard involved in policing borrowers who are willing to take on high interest rates. The higher borrower default risk weakens bank financial security as is discussed by Boyd and De Nicolò (2005). Tabak et al (2012) in a study of Latin American Banks around the financial crisis show that high and low levels of competition can enhance stability. They also note the positive role of the level of bank capitalisation on stability. Uhde and Heimeshoff (2009) also demonstrate the importance of capital adequacy in European banks when discussing the negative impact of high levels of concentration.

To summarise, in more concentrated markets, banks will charge higher interest rates, boosting the risk-taking behaviour of borrowers, leading therefore to an increase in the probability of default. However, banks will have a higher net interest margin and hence may be able to more easily absorb the defaults because probabilities of losses can be built into decision making. More competition leads to lower loan rates and to lower firm default probabilities, but also lower net interest margins with less ability to absorb losses in the income account. However, evidence suggests that although more concentrated markets are associated with higher capital ratios, they also display higher income volatility and higher bank insolvencies, supporting the idea that even though banks retain more capital in less competitive markets, this is not enough to counterbalance the impact of default risk of higher risk-taking institutions.

The literature on the measurement of market concentration considers both structural and non-structural approaches. Structural approaches use concentration measures as proxies for competition and market power, assuming that banks operating in concentrated markets have higher profits due to monopoly rents. This assumption means that they cannot take in to account the contestability of the market and the impact of contestability on profits and financial stability. There are two are the main measures of concentration, large bank market share ratios and the Herfindhal-Hirschman Index, which requires information on the entire distribution and incorporates each firm individually. The non-structural measures derived from the New Industrial Economics approach (see Barrell and Nahhas 2019) assume that the conduct of firms in the market is directly observed. Among the main indicators are the Lerner index (it measures the market power by the divergence between the firm's price and its marginal cost), the Panzer-Rosse index making use of the transmission of input

prices on firms' revenues and lastly the Boone indicator based on the idea that efficient firms are more highly rewarded in more competitive markets. We discuss these measures below, along with their background assumptions such as cost estimates based on a translog cost function. The World Bank publishes these measures for banking systems (see Appendix). The Three Bank and Five Bank concentration ratios are widely available but the Herfindahl index has much greater data requirements and is not commonly available. The same is true for the Panzer Rosse H statistic whilst the Lerner index is widely available, and the Boone index is available for many countries from the late 1990s.

The New Industrial Economics (NIE) literature does not infer competition from indirect indices such as concentration ratios, but rather focuses on the conduct of the firm in response to changes in supply and demand conditions. We focus here on one measure of competition and one of market power, in part because of the data restrictions we face, but also because of their strong relationship to other similarly focussed indicators. Both the Boone competition measure and the Lerner market power indicator require some knowledge of the cost structure in the banking system, and in our data set both rely on bank based estimates of costs using a quadratic cost function. These estimates proxy banking production by total assets in a translog cost function as specified below:

$$Ln(C_{it}) = a_{0i} + b_0 \ln(Q_{it}) + b_1(0.5 \ln[(Q_{it})^2] + a_1 \ln(W_{1it}) + a_2 \ln(W_{2it}) + b_2(0.5[\ln(Q_{it}) * \ln(W_{1it})]) + b_3(0.5[\ln(Q_{it}) * \ln(W_{2it})]) + a_3[ln(W_{1it}) * (W_{2it})] + a_4[\ln(W_{1it})^2] + a_5[\ln(W_{2it})^2] + \textit{technical progress trends} + u_{it} \quad (1)$$

where i denotes banks and t denotes years. C is total operating plus financial costs, Q is total assets, W_1 is the ratio of interest expenses to total deposits and money market funding which is a proxy for input price of deposits and W_2 is the ratio of other expenses to total assets which we use as a proxy for input price of labour and capital[2]. Marginal cost is calculated by taking the derivative of C_{it} with respect to Q_{it}, and this is then used for calculating the Boone and Lerner indicators which vary over time as the

[2] Separate estimates of these two costs are used, but we suppress the difference for expositional purposes.

derivative contains time dated variables. Our estimates use the published data on the Boone and Lerner indicators for each of our countries based on the individual bank data in the underlying World Bank studies.

In the NIE, competition is measured directly in many studies, with an indicator developed by Hay and Liu (1997) and by Boone (2008) being perhaps the most common. These studies demonstrate that in more competitive markets individual firms profits are more affected by increases in their costs than they are in less competitive markets where prices can be increased to cover increases in costs. The log of profits (measured by return on assets) is regressed on the log of marginal costs in the bank based regression (2), and the coefficient 'b_t' can be seen as an indicator of competition in year t.

$$Ln(Profits_{it}) = a - b_t(\ln(C_{it})) \quad (2)$$

Where i denotes a bank, and C_i is a measure of marginal cost from the quadratic cost function (1). This measure is the elasticity of profits to marginal costs. In contestable markets it can also be useful to substitute market share for profits, as prices are given but efficient firms gain share. The more negative the Boone indicator, the higher the degree of competition is because the effect of reallocation of profits or market share is stronger.

The NIE also looks at the behaviour of firms that take in to account the response of other firms to their actions. In oligopoly, other firms respond to changes in the output of an initiating firm, and this feeds back on the initiating firm's decision making. The conjectural variation of industry output Q to firm Q_i's output can be written as:

$$\frac{\partial Q/\partial Q_i}{Q/Q_i} = \eta\,(P)[(P - MC)/P] \quad (3)$$

where P is the market price calculated as total bank revenue over assets, η(P) is the price elasticity of demand, and MC is a measure of marginal cost from (1), equivalent to C_i above. In perfect competition P = MC and hence the conjectural variation is zero, whilst the greater the ability to mark price up over cost the higher the conjectural variation and the less competition is present. The term [(P-MC)/P] is the Lerner Index of market power, and the World Bank estimates follows the methodology described in Demirgüç-Kunt and Martínez Pería (2010).

3. Data issues in models of crisis incidence

Our data set is more constrained than some cross-country studies as we wish to use published data on capital adequacy and house price growth indicators over a reasonably long period. We could increase the time domain back to 1980, as in Barrell et al (2010) but only at the cost of losing 5 countries (and 3 crises). In addition, the market structure indicators based on the New Industrial Economics literature are only widely available from the 1990s. The data covers 19 countries from 1996 to 2017 and is sourced from the BIS, IMF and the OECD along with the World Bank GFDI database, supplemented by the New Zealand Reserve Bank, Bank of Canada and Statistics Norway for occasional years[3]. The dependent variable is taken from Laeven and Valencia's (2018) crisis database.

[3] See statistical appendix.

Table 1 Country data on capital, house prices growth banking structure

		House price growth	Bank Capital	5 Bank	Boone	Lerner	Correlation (house/capital)
Australia	2000	0.037	8.095	83.480	-0.063	0.070	-0.091
	2015	0.074	5.970	93.506	0.276	0.173	
Belgium	2000	0.028	3.646	89.395	-0.026	0.105	-0.465
	2015	0.011	6.780	85.021	-0.021	0.211	
Canada	2000	0.010	5.406	67.822	-0.058	0.191	-0.248
	2015	0.049	5.100	82.964	-0.067	0.494	
Denmark	2000	0.035	6.694	87.822	-0.134	0.171	-0.434
	2015	0.065	7.790	91.823	-0.070	0.326	
Finland	2000	0.026	6.571	100.000	-0.204	0.188	0.293
	2015	0.002	5.600	95.192	0.090	0.092	
France	2000	0.070	4.570	68.319	-0.030	0.083	-0.430
	2015	-0.015	5.790	74.797	-0.001	0.132	
Germany	2000	-0.009	4.013	86.087	-0.083	0.008	0.619
	2015	0.043	5.940	78.494	-0.028	0.085	
Ireland	2000	0.078	6.500	91.212	4.801	0.167	-0.557
	2015	0.083	12.670	86.427	0.654	0.268	
Italy	2000	0.013	6.795	88.822	-0.045	0.148	0.509
	2015	-0.026	6.190	71.673	0.002	0.136	
Japan	2000	-0.031	4.560	42.633	0.008	0.225	0.437
	2015	0.016	5.820	60.745	-0.006	0.374	
Neths	2000	0.155	4.018	90.180	0.177	0.170	-0.638
	2015	0.030	5.560	90.409	0.132	0.174	
NZ	2000	-0.030	4.694	100.000	0.000	0.113	-0.167
	2015	0.115	7.300	89.985	-0.353	0.235	
Norway	2000	0.125	7.020	96.513	0.056	0.276	-0.110
	2015	0.039	8.552	97.542	0.030	0.467	
Portugal	2000	0.029	5.800	86.374	0.947	0.123	-0.002
	2015	0.005	8.510	93.753	-1.028	0.307	
Spain	2000	0.050	8.261	82.020	-0.644	0.210	-0.023
	2015	0.041	7.440	76.325	-0.606	0.322	
Sweden	2000	0.102	5.523	98.741	-0.079	0.141	0.036
	2015	0.132	5.600	94.117	-0.048	0.412	
Swiss	2000	-0.004	6.000	88.988	-0.081	0.151	0.239
	2015	0.031	7.290	88.094	-0.070	0.103	
UK	2000	0.140	6.341	46.545	-0.092	0.302	0.182
	2015	0.059	6.840	71.025	-0.047	0.276	
US	2000	0.059	8.597	28.108	-0.078	0.208	-0.324
	2015	0.054	11.710	46.398	-0.041	0.334	

Notes. In some countries the 3 bank ratio (New Zealand around 2000 for instance) has been used for some years because there were fewer than 5 banks, and where data are missing for one year we interpolate.

Our countries are Australia, Belgium (2008), Canada, Denmark (2008), Finland, France (2008), Germany (2008), Ireland (2008), Italy (2008), Japan (1997), Netherlands (2008), New Zealand, Norway, Portugal (2008). Spain (2008), Sweden (2008), Switzerland (2008), United Kingdom (2007) and the United States (2007), with crisis dates in brackets. Data on our core variables are reported by country in Table 1 for 2000 and for 2015. Across all 19 countries and over the period 1996 to 2016, capital ratios and concentration had a correlation of 0.58, suggesting that more capital was held by banking systems that were more concentrated. The Lerner index of market pricing power was also correlated positively with capital, albeit at 0.28, noticeably less than concentration. There was no link between the Boone competitiveness indicator and capital. Capital ratios rose in 14 countries between 2000 and 2015 and fell in 5, making defences on average, stronger. Concentration rose in 10 countries and fell in 9, whilst market power rose in 12 countries and fell in 7. According to the Lerner measure, 15 countries became less competitive. As we can see from the last column, only 7 countries saw capital rise in response to previous house price growth, suggesting defences weakened.

Most studies discussed above do not include measures of capital adequacy, in large part because data are sparse, especially at a national level, until the last few years. We have included all countries where we can obtain published data on the consolidated banking systems ratio of capital to assets (the inverse of the leverage ratio) in a form that is not risk weighted. This variable is correlated with our five-bank concentration ratio and with the Lerner index. If the capital ratio is excluded in an analysis of the impact of bank concentration and competition then some coefficients and standard errors on all variables will be biased, as will be the policy conclusions we subsequently make.

Bank capital is reported for compliance purposes once consolidated accounts are constructed at year-end and hence we can only use lagged values of the variable in an

early warning system[4]. Some variables are available within the year, but they can only be used in an early warning system (EWS) when it is clear that they are not endogenous. Our competition indicators are based on current data, and the five bank concentration ratio in particular is available in real time. We can regress this latter measure on a constant and on the current, once lagged and twice lagged crisis indicators. None of the crisis indicators are significant, and the regression has an R^2 of 0.000261 which is not significant. We thus conclude that concentration is exogenous to crisis incidence and does not bias other coefficients when included and that its own coefficient is also unbiased.

4. Estimating the impacts of Market Structure on Crisis Incidence

We estimate crisis probabilities using a logit model (following Barrell et al, 2010), including the lagged capital ratio as a defence against crises, alongside three-period lagged real house price growth as an indicator of bad lending decisions in the past. Many studies of crisis incidence include other variables[5], but as Barrell et al (2010) show, these retain significance only when important indicators such as bank capital ratios are omitted. We add our market structure indicators. Our logit model relates the probability that the dummy takes a value of one to the logit of the vector of *n* explanatory variables given by

$$\Pr ob(Y_{it} = 1) = F(\beta X_{it}) = \frac{e^{\beta' X_{it}}}{1 + e^{\beta' X_{it}}} \qquad (4)$$

where Y_{it} is the banking crisis dummy for country i at time t, β is the vector of

[4] Levels of bank capital will also be strongly affected by the occurrence of a crisis, and hence it is endogenous.

[5] These are the growth of real GDP, the real interest rate, the rate of inflation, the fiscal surplus (or deficit) as a percent of GDP and the money stock relative to foreign exchange reserves. The first four may be thought relevant for OECD banking crises, but they are not significant in studies of our period. The last variable may be more relevant to exchange rate crises which we do not analyse.

coefficients, X_{it} is the vector of explanatory variables and $F(\beta X_{it})$ is the cumulative logistic distribution. The log likelihood function is given by:

$$Log_e\ L = \sum_{i=1}^{n}\sum_{t=1}^{T}\left[\left(Y_{it}\log_e F\left(\beta' X_{it}\right)\right) + \left(1-Y_{it}\right)\log_e\left(1-F\left(\beta' X_{it}\right)\right)\right] \quad (5)$$

We report our results in Table 2 starting with a general baseline model which shows that the unweighted capital ratio significantly reduces crisis probabilities, and that rapid house price growth in the recent past raises crisis probabilities. These can be described as the causes of bad lending and the defences against them, as is argued in Barrell et al (2010)[6]. We add the current and lagged 5 bank concentration ratios to this model in column 2, and we note that the lagged value is significant and negative, whilst the current value is not, and hence it is dropped in column 3. The coefficient suggests that if concentration decreased over time or across countries then crisis incidence would rise significantly.

We cannot explain all crises, as we see from the Direct Call ratio where the projected probability exceeds the sample average and a crisis occurs and the False Call ratios (when a crisis does not occur) appended to columns 1, 2 and 3. The generalised information indicator, the receiver operating characteristic based Area Under the Curve (AUC), is significant, and is acceptable when we add concentration indicators in column 2. Adding the concentration ratio reduces the false crisis call rate quite noticeably and significantly raises the AUC, whilst dropping the current concentration ratio only marginally reduces the AUC and leaves the hit rate unchanged. The same cannot be said of an experiment where we drop capital from our regression, as we see in column 4. The coefficient on the concentration rises to 'soak up' the explanation provided by capital, and the direct hit rate falls to 7 of 13, and the AUC falls significantly as compared to columns 2 and 3. More concentrated systems appear to face less risks as they perhaps have taken on a better loan portfolio as suggested above, and less concentrated ones are more likely to take more extreme risks in order to increase the

[6] Barrell et al (2010) covered 14 of our 19 countries over an earlier time period, liquidity also had a role in predicting crisis incidence and we investigate its importance in the robustness section below.

chance of high profits. However, risks rise significantly when house price growth has been rapid in the past, as low quality loans have probably been made and they are more likely to default. It is clear that the more capital the banking system holds, the less likely it is to face a banking crisis, and more concentrated systems hold more capital. In our sample most crises take place in 2007-8, and hence we can ask if they reflect dimensions of change over time in our concentration inidcator, or reflect differences within the cross section. We would argue that neither dominate. The average five bank concentration ratio had been falling before the 2007-8 crises, and in 2006 it was lower than in any of the five previous years. The average five bank ratio in 2007 was 82.7, whilst it was 80.8 in the group of countries with crises, with the difference being only 0.5 standard deviations of the mean. Neither dimension dominates, and both will have contributed to the significance of the concentration ratio. The capital ratio was lower in 2007 than it had been in over a decade, whilst the countries that experienced crises in 2007-8 had the same average capital ratio (5.862 percent) as the full sample, suggesting that the cross-section dimension was not important in making capital a significant variable.

Table 2 Testing for Market Power

Sample: 1999 2016	Base Model	Adding Concentration	Preferred Lag	Test for Capital
Capital(-1)	-0.668	-0.284	-0.266	
	0.000	0.023	0.026	
Real House Price Growth (-3)	10.990	14.441	14.454	12.300
	0.013	0.003	0.002	0.006
Bank Concentration		0.035		
(5 bank)		0.479		
Bank Concentration(-1)		-0.063	-0.030	-0.047
(5 bank)		0.191	0.001	0.000
Area Under Curve (AUC)	0.649	0.724	0.714	0.681
Direct Call Ratio (DCR)	9 of 13	9 of 13	9 of 13	7 of 13
False Call Ratio % (FCR)	39.82	31.61	31.31	29.79

Note Probabilities from z statistic below coefficient

Descriptions of market structure do not tell us a great deal about the competitive structure of the economy or the contestability of the market. The former reflects both the nature of the firms in the market and the regulatory environment they face, with good regulation holding prices to consumers down at competitive levels even when banks would otherwise have monopoly power. Market contestability reflects the potential for competitive entry, which varies significantly between otherwise similar countries in our sample. Over half our countries are members of the EU, and thus face a single market in financial services where cross border banking is more common than elsewhere in our sample. This should change the environment in which banks operate, and their pricing decision on loans and deposits even when cross border lending is limited, as it is potential competition or contestability that then influences behaviour.

In Table 3 we first add the current and lagged Lerner index of market power and find that its current value is significant. The use of a current value limits our equation as an early warning system, but it does help us explain what factors might raise the incidence of crises. The insignificant lagged value in column 1 clearly does not add to our explanation. The direct hit ratio for the Lerner only regression is 10 out of 13, and the false crisis calls are low at 23 percent, and as such this is the best performing equation overall, with the highest AUC. The coefficients on capital and concentration are little changed from those in column 3 of Table 2, and both remain significant. In column two we replace the Lerner index with the Boone index, which is not significant, and nor is its lagged value, and the AUC is significantly lower than in column 1. The Boone indicator is a measure of competition in the market with a lower value indicating a more competitive environment. It should therefore pick up the importance of contestability, but it fails to do so. Our conclusions survive in column 3 where we add both the current Boone and Lerner indices to our base explanation, and the AUC is marginally lower than in column 1. In column 4 we add only the current Lerner index, and the AUC is marginally, but not significantly, lower than in column 3.

Our results in Table 3 suggest that there is little evidence that competition per se has an impact on financial stability, at least when indexed by the Laeven and Valencia definition of financial crises. However, more concentrated markets with more market power in the hands of the participants are significantly less likely to suffer financial crises. The importance of capital is not affected by the introduction of the market power indicator, and its coefficient is not significantly different from that in column 3 of Table 2.

Table 3 Testing for Market Power and Contestability

Sample: 1999 2016	Lagged and Current Lerner	Lagged and Current Boone	Current Lerner and Boone	Current Lerner
Capital(-1)	-0.303	-0.267	-0.258	-0.249
	0.034	0.028	0.036	0.041
Real House Price Growth (-3)	15.052	14.293	15.351	14.940
	0.002	0.003	0.002	0.002
Bank Concentration(-1)	-0.028	-0.030	-0.026	-0.027
(5 bank)	0.005	0.001	0.006	0.000
Lerner(-1)	2.669			
	0.355			
Lerner	-2.816		-2.296	-2.032
	0.015		0.019	0.031
Boone(-1)		0.795		
		0.195		
Boone		-1.327	-0.791	
		0.114	0.289	
Area Under Curve (AUC)	0.806	0.733	0.799	0.771
Direct Call Ratio (DCR)	10 of 13	9 of 13	9 of 13	9 of 13
False Call Ratio % (FCR)	23.08	30.7	27.66	28.27

Note Probabilities from z statistic below coefficient

Our results in Table 3 suggest that there is little evidence that competition per se has an impact on financial stability, at least when indexed by the Laeven and Valencia (2018) definition of crises. However, more concentrated markets with more market power in the hands of incumbent banks are significantly less likely to suffer financial crises. The importance of capital is not affected by the introduction of the market power indicator, and its coefficient is not significantly different from that in column 3 of Table 2.

The cost and production function-based estimates of market power are based on contemporary within year data, whilst capital is an end year accounts variable. As such it is likely to depend upon whether or not there is a crisis, and hence use of a current value would involve endogeneity. The same is also possibly true of the Lerner and Boone indices, but the effects will be less mechanical. We can regress both on a constant and on the current, once lagged and twice lagged crisis indicators, as discussed above for the concentration indicator. In no case are any of the crisis indicators significant, and the Lerner regression has an R^2 of 0.0026 whilst the Boone regression has an R^2 of 0.0048, neither of which are significant. We can conclude from this that both are exogenous to crisis incidence, and the inclusion of current values does not bias coefficients. We can clearly say that markets that display more market power for the incumbent firms are less likely to face financial crises.

5. Robustness

It is, of course, important to undertake some analysis of the robustness of our results, and we look at four important aspects, all of which are related to the current regulatory architecture. First, we ask if liquidity has mattered in these countries, and whether in the liberalised market after the mid-1990s, on book liquidity helped reduce the incidence of crises. We also look for an impact from the other major tool of the new regulatory framework, the BIS the cyclical credit gap. This measure takes the deviation from trend of the ratio of credit to GDP as an indicator of risky lending. There have also been repeated concerns about the impact of falling house prices on financial

stability, for instance as discussed in IMF(2019), and we investigate that issue in this section. In addition, the European Union has a Single Market, and this has extended to certain aspects of banking, and we discuss whether this has meant that concentration in national banking is no longer important for the evaluation of the impact of competition on bank behaviour, at least in Europe.

Table 4 Liquidity, Credit Gaps and the Role of Europe in testing for robustness

Sample: 1999 2016	Add Liquidity	Add Credit Gap	Falling House prices	Europe Only	Europe Only again
Capital(-1)	-0.223	-0.238	-0.224	-0.309	-0.584
	0.084	0.053	0.070	0.087	0.000
Real House Price Growth (-3)	13.013	12.382	13.139	13.102	12.307
	0.012	0.016	0.018	0.011	0.015
Bank Concentration(-1)	-0.023	-0.028	-0.023	-0.019	
(5 bank)	0.028	0.003	0.015	0.113	
Lerner	-1.949	-2.292	-2.295	-1.871	-2.624
	0.039	0.018	0.040	0.090	0.010
Liquidity(-1)	-0.043				
	0.374				
Credit gap(-1)		0.027			
		0.145			
Negative House prices (-1)			36.126		
			0.360		
Negative house prices (-2)			42.273		
			0.473		
Area Under Curve (AUC)	0.806	0.769	0.649	0.786	0.716
Direct Call Ratio (DCR)	8 of 13	9 of 13	9 of 13	8 of 12	8 of 12
False Call Ratio % (FCR)	27.96	27.36	24.01	30.42	34.17

Note Probabilities from z statistic below coefficient

In column 1 of table 4 we add on book liquidity to our preferred model from column 4 of Table 3, and we find that it is not significant. We use an IMF based measure of liquidity that does not take account of the complexities of the new regulations introduced after 2009 (see Appendix). This measure was significant in Barrell et al (2010) for the period 1981 to 2008, but it is not clear that it still mattered after the late 1990s, as our results show. They suggest that off book liquidity, either through the wholesale market (up until 2008) or from the Central Bank (from 2009) was sufficient to cover expected liquidity needs over this period. In column 2 of Table 4 can find no significant role for the BIS credit gap[7] despite its major role in the new regulatory framework. Both regressions perform reasonably well, with hit ratios around70 percent and false crisis calls at only 27 percent. The generalised information indicator, the AUC, is also reasonably high in these cases.

It is of course important to look at the relationship between house price growth and excess credit, as credit growth may lead to higher house price growth, which in turn may increase crisis probabilities (with house prices acting as an intermediary). Both real house price growth and the credit gap are stationary variables in our data set from 1996 and hence we can undertake Granger style causality tests to see if there is a statistical relationship between past credit gaps and current house prices increases. The results are reported in Table 5 where we test to see if credit gaps add anything to a univariate time series explanation of real house price growth. We regress real house price growth in our panel on lagged real house price growth and twice lagged real house growth, and on once and twice lagged credit gaps. Our test involves deleting the two lagged credit gap variables and seeing if that deletion is acceptable. If we undertake this test for the whole sample period, then there is evidence that the credit gap may influence house prices, both in European countries and in the whole sample. However, if we look at the causality structure from 1996 to 2007 then clearly there is no significant link from the credit gap to house price growth in any region. This matters a great deal as all our crises occurred by 2008, yet it is only after that date the gap was used as an instrument to attempt to stabilise economies by making capital ratios dependent on credit gaps.

[7] The credit gap measures deviations from the (Hodrick Prescott) trend in the credit to GDP ratio. Barrell, Karim and Macchiarelli (2020) also find that it is not significant.

Table 5 Causality links from the credit gap to house prices

	Full Sample	Full Sample	Europe	Europe
	1996-2016	1996-2007	1996-2016	1996-2007
Real House Price growth (-1)	0.818	0.870	0.828	0.806
	0.000	0.000	0.000	0.000
Real House Price growth (-2)	-0.167	-0.186	-0.177	-0.112
	0.001	0.009	0.004	0.178
BIS Credit Gap(-1)	0.000	-0.001	0.000	-0.001
	0.282	0.082	0.277	0.036
BIS Credit Gap(-2)	0.000	0.001	0.000	0.001
	0.999	0.045	0.000	0.073
Granger Test of Gap F-stat	3.536	2.053	4.261	2.260
(with constant) Prob	0.030	0.131	0.015	0.108

't' statistic below coefficient

Declining house prices can expose borrowers to risks of negative equity, when the value of the loan secured on a property exceeds the value of the property. This situation becomes acute when mortgagors lend more than the value of the property on the assumption that either house prices will rise, or the borrower can cover the debt. Negative equity causes stress, and in most of the economies we study there is evidence to suggest that house prices affect consumption decisions, with a fall in house prices leading to a reduction in consumption. This in turn leads to a slowdown in economic activity and to further weakness in house prices. Slowing activity may then lead to financial stresses, but as long as defaults on loans remain reasonable this

should not develop into a crisis. Defaults rates in periods of declining house prices depend in part upon bankruptcy law and have varied noticeably across our group of countries in the last two decades[8].

Falling house prices do not appear to have been a precursor of financial crises in 2007-8 in most countries in our sample. House prices as compared to a year previously were only falling in the US and in Germany at the end of 2007. In the latter case they had been falling for some years without a threat to the banking system, in part because negative equity was rare and also because of stringent bankruptcy laws. In the US, by 2007, falling house prices were causing serious problems for the banking system and for foreign banks that had bought structured products based on mortgages as mortgage default rates rose sharply, especially on subprime mortgages. These defaults were a major factor behind the US and UK crises in 2008 and the crises in Germany, Switzerland and other Europeans in 2008. We look at the impacts of falling house prices on crisis probabilities in column 3 of Table 4 and note that the effects are not significant, and that they reduce the ability of the model to explain crises, as the AUC falls significantly. In most countries it has been poor quality lending that has caused problems, not the collapse of the housing market.

Bank concentration ratios are of use where the country being measured also covers the market being studied. This is probably true in the US, Japan, Canada, Australia and New Zealand, but individual concentration ratios in Europe may not be good indicators of competition as cross border banking is common, and has increased sharply over the last 20 years, despite setbacks after the Euro Area Sovereign Debt crisis in 2011. In column 4 of table 4 we repeat our core regression, but only for the 14 European countries in our sample. The bank concentration indicator becomes insignificant, as it does not capture the effects of the possibility of the market being contestable by entry from near neighbours. In column 5 of table 3 we drop the concentration indicator, and find that capital, house prices, and our measure of market power, the Lerner Index, are all significant. We would suggest that Europe is very different from the five

[8] After the 2007 crisis, house prices in the UK began to fall but default rates did not rise noticeably, and hence the financial stress suffered by the banking system was not worsened. The US has had the least restrictive bankruptcy laws in our sample, and as a result it had the most significant rise in mortgage defaults after prices began to fall in early 2006.

independent countries in our sample, and that for them only a market power indicator shows a role for bank competition.

6. **Calibrating Macro Prudential Policy**

In our analysis we have a target variable, the probability of a crisis, and a core variable we might describe as a tool, the capital ratio. We can use our results to calibrate the increase in the level of capital ratios (that would have been) required to reduce the probability of a crisis down by 1 (and 2) percent over our whole sample period and to calculate the level of capital required to offset the impact of bad lending associated with house price increases. Additionally, we can look at the change in capital required in order to keep probabilities constant when there is a rise in competitiveness, or a fall in mark ups. In order to do these calculations for each set of results, we must invert the logit model described in (3) above using the parameters from the last column of Table 2 and also the last column of Table 3. We should note that this model can be written as a log odds, with p representing the probability

$$Log(P_{i,t}/(1-P_{i,t})) = \beta' X_{i.t} \quad (6)$$

Where β' is the vector of coefficients and X_{it} is a matrix of driving variables by time (t) for all countries (i). For our purposes we can separate out capital (Cap_{it}) and its coefficient β_c from the vector of coefficient and matrix of variables, leaving the vector β1 as the other coefficients and X1 as the rest of the matrix

$$Log(P_{i,t}/(1-P_{i,t})) = \beta_1 X1_{i,t} + \beta_c Cap_{i,t} \quad (7)$$

We may solve this for capital as the target variable, fixing the probability of a crisis, as we can see in equation 8. We can set a target for the probability, and then calculate the capital required to achieve that either period by period or on average over the whole time period given the values of the other variables in our logit. Of course, these variables may be themselves affected by the level of capital, but our results above do not suggest that this is likely.

$$Cap_{i,t} = \log[(P_{i,t}/(1 - P_{i,t}))/\beta_c] - \left[\beta 1' X 1_{i,t}/\beta_c\right] \quad (8)$$

We can also calibrate the impact of real house price increases and changes in the Lerner index on capital requirements when the objective is to keep the probability of a crisis constant. This involves taking the differential of (7) and setting it to zero, whilst assuming that there are no changes in the other driving variables. We may write this as

$$\delta Log(P_{i,t}/(1 - P_{i,t}) = 0 = \beta_{hp}(\delta \text{RHPG}_{i,t}) + \beta_L(\delta \text{Lerner}_{i,t}) + \beta_c(\delta \text{Cap}_{i,t}) \quad (9)$$

Rearranging this we may write

$$\delta Cap_{i,t}/\delta \text{RHPG}_{i,t} = -\beta_{hp}/\beta_c \quad (10)$$

and

$$\delta Cap_{i,t}/\delta \text{Lerner}_{i,t} = -\beta_L/\beta_c \quad (11)$$

We present our results in Table 6. Over our whole sample the capital ratio across our 19 country sample averaged 5.5 percentage points, and an increase of 1.4 percentage point would have reduced the probability of a crisis from the sample average of 3.8 percent to 2.8 percent, whilst an increase of 3.25 percentage points would have been required to reduce the crisis probability by 2.0 percent points. Clearly the relationship is non-linear: the costs rise as capital ratios increase, and these have to be offset against the gains from the reduction in crisis incidence. If equity capital is raised on the market it may well incur an average cost of 13 percent a year, whereas, bank debt (an alternative to capital) may only cost 3 percent a year. Hence the cost of borrowing from banks, all else equal, will rise by 10 basis points for every one percentage point increase in capital. This would in turn raise the user cost of capital to firms (and mortgage lending costs) by 10 basis points and would reduce output as a result. However, the costs associated with crises would fall, and so our calibrations illustrate that an optimal level of capital increase can identified.

Table 6 Calibrating Macroprudential Policy in a 19 country sample

To reduce sample average probability in whole sample	Reduce probability by 1% Increase in capital ratio	Reduce probability by 2% Increase in capital ratio
Crisis probability 3.8 (Table 3, column 4)	1.4	3.25
To keep constant sample average probability in European sample	Capital increase needed to offset effect of a 1% rise in real house prices	Capital increase needed to offset a 1 percentage point fall in the Lerner index
Crisis probability 4.8 (Table 4, column 4)	0.21	0.045

When house price increases have been excessive, capital requirements could increase to keep crisis probabilities constant. If the authorities thought that house price increases has raised overvaluations by 5 percent then a 1 percentage point increase in capital requirement would be needed to offset the problems this might entail. The authorities may also wish to increase competition to raise consumer welfare, or use supervision and regulation to reduce the net interest margin between borrowing and lending costs (and thereby reduce the Lerner index). Then, using our results for Europe on its own in Table 4, for every increase in competition or regulation that reduces the Lerner mark-up by one percentage point, banks would have to hold 0.082 percent more capital in order to offset the effects or increased risk on crisis probabilities. A general optimisation analysis of the impact of a reduction in market power suggests a 20 point reduction in the Lerner index would require an offset of around a 1 percent increase in the capital ratio in Europe in order to keep crisis probabilities constant. The overall effect would probably be a reduction in borrowing costs with no change in the incidence of financial crises that might follow from the initiative to increase competition on its own.

Of course, it is difficult to calibrate macroprudential policies so accurately as this, but the general message is clear. When house prices are rising in real terms by more than is reasonable then regulatory capital standards should be raised. Likewise, if competition is increasing or supervision and regulation is more effectively reducing bank profits, regulatory capital ratios should be increased. It is possible to calculate indicators of crisis probabilities for the immediate period after the end of our sample, and they suggest that capital standards may have needed to be raised in a number of countries. In 2019 projected probabilities exceeded the sample average (of 3 percent) in Canada, Germany, Japan, New Zealand and (in 2018 only) Australia and those countries should monitor the housing market; there are lesser concerns in the US, Switzerland, the Netherlands, Italy and France where predicted crisis probabilities for 2019 exceed 2 percent.

7. Conclusions

The stucture of banking markets and their impact on financial stability have been widely discussed, and they are both important issues for policy makers. More competitive markets raise welfare for consumers and reduce costs to producers, in turn raising output and consumer surplus further. However, there is some evidence that capital standards are lower in more competitive (or less concentrated) markets, and that more competition increases the risks banks may take whilst reducing the cover they might have for that risk from lower margins between borrowing and lending rates. Both of these will increase the risk of financial stress and the incidence of crises. But the scale of their impact is best judged when taking account of both together rather than looking at them in separate studies and policy analyses, as we discuss in the context of policy response calibration. Policy is often based on a belief that lending growth or excess credit are good predictors of crises, and hence their control is a core feature of current macroprudential policy. We demonstrate that this should not be the case as they are not good predictors when other factors are taken into consideration. We also show that, at least in the run up to the crises in 2007-8, excess credit does not cause house price growth. House price growth is itself a problem, and the risks associated with it need a clear macroprudential policy response.

We investigate a panel of 19 countries over the period from the late 1990s, looking at the roles of capital adequacy, house price growth and concentration measures along with competition indices from the New Industrial Economics literature. We find that increased concentration and increased market power both reduce crisis incidence, as does increased capital adequacy. We also note that concentration indices are not significant in contestable European markets, but indicators of market power are significant. As there is a strong correlation between concentration and capital adequacy the inclusion of both measures mean that we can investigate their individual effects, strengthening our conclusion that both matter to policy makers who wish to increase financial stability. It is clear from our results that policymakers who wish to increase competition in banking markets and reduce the market power of incumbent banks by making the market more contestable should accompany these measures with more diligent supervision and higher capital standards. The latter will reduce some of

the welfare and output benefits from greater competition, but they will reduce the welfare and output costs associated with a higher incidence of financial crises.

Data Appendix

Real house prices, Nominal house prices from BIS online database, quarterly 1974q1 to 2017q1, divided by OECD online database consumer prices for the same period, to convert to real and then annual averages taken before growth rates are calculated database for Australia Belgium Canada Denmark Finland France Germany Ireland Italy Japan Netherlands New Zealand Norway Portugal Spain Sweden Switzerland United Kingdom and United States.

Credit Gaps BIS online database taken quarterly and as an annual average.

The 5 bank concentration ratio, the Lerner Index and the Boone Indicator are all taken from the World Bank Global Financial Stability Indicators online database for Australia Belgium Canada Denmark Finland France Germany Ireland Italy Japan Netherlands New Zealand Norway Portugal Spain Sweden Switzerland United Kingdom and United States

The unweighted bank capital ratio variable is essentially the Basel III regulatory capital indicator for leverage and comes from the OECD Consolidated Banking Statistics Database and from the World Bank Global Financial Stability Indicators online database, as well as Norwegian and Swedish Central Bank sources.

Liquidity data are sourced from the IMF and calculated as the ratio of liquid assets to total assets: [reserves + claims on central government]/ [reserves + claims on central government + foreign assets + claims on private sector]

Post 2006 Canadian liquidity is calculated using Statistics Canada Data using:

> [Canadian dollar cash and cash equivalent + Canadian dollar total securities issued or guaranteed by Canada, Canadian province, Canadian municipal or school corporations]/ Total Assets

Post 2012 Norwegian liquidity data is calculated from Statistics Norway using:

> [Notes, coins and deposits] / Total Assets

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