Banking Concentration and Financial Crises

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Abstract: There are large and long-lasting negative effects on output from recurrent financial crises in market economies. 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.

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Introduction

The financial crises in 2007 and 2008 have left a long and depressing shadow over the North Atlantic economies. Not only did output fall sharply after those crises, but output growth has also been slow since 2009. We look at the role of bank concentration and banking market competition in influencing the frequency of crises, whilst taking into account capital adequacy defences against systemic bank failures as well as the role of property prices in driving them. We argue that rejecting a role for capital adequacy in explaining post 1980 financial crises is misjudged. In the financially liberalising world that followed on from the collapse of Bretton Woods system in the early 1970s banks on-balance sheet capital has been an important defence against the risk of crises. We follow Barrell et al (2010) in our choice of variables in our experimental design when investigating financial crisis incidence, and in addition we investigate the role of bank concentration and bank efficiency and market power, using standard concentration indices as well as indicators derived from the New Industrial Economics literature

We review the literature on banking market structure and its impact on financial stress and banking crises, concluding that the results on links between these indicators and crises is at best mixed. It is important when undertaking an evaluation of market structure links to crises to take account of both the causes of and defences against crises, as estimates that exclude them will have biased coefficient estimates unless structural indicators and the causes and defences are orthogonal. We also look at indicators of market structures and discuss their relevance for our analysis, and we include them in aggregate models of crisis incidence, adding a new dimension to that literature.

We look at the factors determining crisis incidence and discuss the data set covering unrisk-weighted capital adequacy, property price growth, banking concentration and competition indicators, and suggest that capital adequacy and concentration are not orthogonal. The growth of house prices has been commonly linked to crises as well, and we include them in our empirical work, in addition to capital adequacy and our competition indicators. In addition, we look at the relationship between house price growth and consumer credit growth and suggest that the link is not strong. We stress the Laeven and Valencia (2018) crisis definition, which is tighter than the one used in Barrell et al (2010).

In our analysis of robustness, we investigate whether credit growth and on balance sheet liquidity have a role as causes of 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. During the same period banking systems seem to have been able to rely on either market based or central sources of liquidity rather than on balance sheet assets. We also evaluate the relative important of competition and concentration indices in Europe and show that market contestability is more important than banking market concentration in the determination of crises in Europe.

Crises have been endemic in market based, or capitalist, economies, and they became increasingly common in OECD countries by decade after the ending of the crisis free Bretton Woods period of financial repression between 1940 and 1972. The Bretton Woods system was crisis free in part because financial systems were tightly controlled, and the liberalisation of controls has been seen as a major factor affecting crisis incidence. However not all crises in the last 40 years have followed on from liberalisation. We would argue that liberalisation of banking markets, and the growth of housing related lending has been a factor behind a number of crises in the post Bretton Woods era.

We discuss the design of policy in the light of our results and suggest that macroprudential policy would benefit from being based on recent house price growth indicators, and that we could also adjust capital standards in the light of changes in the competitive environment within which banks work. Our models also allow us to evaluate risks to the macro-economy, and we look at the implications for crisis probabilities in our economies, and discuss the risks associated with the recent slowdown in housing markets in our economies.

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. The literature on the causes of crises is summarised in Bordo and Meissner (2016) and they bring out several strands, ranging 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 by the Bank for International Settlements in a sequence of staff papers by Borio and Drehmann (2009) and others, 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 it is clear that financial stress levels are affected by market structure. The objective of this paper is to redress this imbalance in the literature and include market structure indicators in our analysis.

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 on how many banks, and what proportion of loans are non-performing vary, and a number of definitions of crises have emerged. 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 focus on the former definition in this paper, as it focuses on the scale of losses made by a banking system that has made too many poor quality lending decisions given the scale of defences it has against loan defaults. These decisions may either be as a result of bank actions, taking on more risk when they make lending decisions, or from borrowers actions in hiding risks from their lenders.

Banking market structure is an important topic in the literature on financial stability with Beck et al. (2006) finding that increased market concentration reduces 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 include system wide bank capitalisation ratios or property price growth, as we do. The relationship between stability and competition/concentration is not clear and theory and empirical evidence seem to be inconclusive, with conflicting and ambiguous findings, with results depending upon what models of bank behaviour are used, as Allen and Gale (2004) stress. 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.

[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.

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, 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 market becomes 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 the 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 as they know there is a high chance of failure and hence returns are one sided. The higher default risk of entrepreneurs affects financial institutions and 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 does suggest that more concentrated markets are associated with higher capital ratios, higher income volatility and higher insolvency of banks, supporting the idea that even though banks retain more capital in less competitive markets, their level of capitalization is not high enough to counterbalance the impact of default risk of higher risk-taking institutions.

Banking markets

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

incorporated 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 costs estimates based on a translog cost function. The World Bank publishes these measures for banking systems in the World Financial Indicators Database. 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:

$$\begin{aligned}\text{Ln}(Cit) = {} & a_0 i + b_0 \ln(Qit) + b_1(0.5[\ln(Qit)]^2) + a_1 \ln(W_1 it) + a_2 \ln(W_2 it) + \\ & b_2(0.5\ln(Qit)*\ln(W_1 it)) + b_3(0.5\ln(Qit)*\ln(W_2 it)) + a_3 \ln(W1it)*\ln(W2it) + \\ & + a_4(0.5[\ln(W_1 it)]^2) + a_5(0.5[\ln(W_2 it)]^2) + \text{technical progress trends} + uit\end{aligned} \quad (1)$$

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, W_2 is the ratio of other expenses to total assets which we use as a proxy for input price of labour and capital[3]. Marginal cost is calculated by taking the derivative of Cit with respect to Qit, and this is then used for calculating the Boone and Lerner indicators which vary over time as the 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 popularised 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.

$$\text{Ln}(\text{Profits}_{it}) = a - b_t \text{Ln}(C_{it}) \quad (2)$$

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

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

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 output Qi can be written

$$\delta Q/\delta Qi/(Q/Qi) = \eta(P)\ [(P-MC)/P] \quad (3)$$

where P is the market price calculated as total bank revenue over assets, and $\eta(P)$ 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).

Data issues in models of crisis incidence

Our data set is more constrained than in some cross-country studies as we wish to use published data on capital adequacy and house price growth indicators over a reasonably long period, and this restricts us to 19 countries from the mid-1990s. 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 for the 1990s. The data covers 19 countries from 1996 to 2017 and is sourced from the BIS, IMF and the OECD along with the GFDI database, supplemented by the New Zealand Reserve Bank, Bank of Canada and Statistics Norway[4]. The dependent variable, the crisis dummy, is taken from Laeven and Valencia's (2018) crisis database. The countries we study 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) United States (2007) with crisis dates in brackets.

Data on our core variables are reported in Table 1 for 2000 and for 2015 for each country. Across all 19 countries and over the period 1996 to 2016 capital 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. As we can see from Table 1, 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, whilst 15 countries became less competitive as indexed by the Boone measure. As we can see from the last column, only 7 countries saw capital rise in response to previous house price growth over the whole period, suggesting defences weakened.

The timing of availability and relationship between variables in our data set matters both for policy makers and for the econometrics we undertake. 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 capital in a form that is not risk weighted. This variable is correlated with our five-bank concentration ratio and with the Lerner index. If

[4] See statistical appendix.

the capital ratio is excluded in an analysis of the impact of bank concentration and competition then the coefficient on concentration, and the standard errors on all variables, will be biased. Incorrect policy conclusions on the importance of concentration in banking will then be drawn.

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.

Bank capital is an end year measure and is only available after the end of the year, when consolidated accounts are constructed, and hence we can only use lagged values of the variable in an early warning system. Levels of bank capital will also be strongly affected by the occurrence of a crisis, and hence it is endogenous. 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 effectively 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 significant, and the regression has an R^2 of 0.000261 which is not significant. We can conclude form this that it is exogenous to crisis incidence and does not bias other coefficients when we include it and its own coefficients is also unbiased.

Estimating the impacts of Market Structure on Crisis Incidence

We estimate crisis probabilities using a logit model (following Barrell et al, 2010), including lagged capital 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, but as Barrell et al (2010) show, many of these are only significant when we omit important indicators such as the level of bank capital. We look at some indicators for liquidity and for excess lending in our robustness section. 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

$$\mathrm{Prob}(Y_{it}=1)=F(\beta X_{it})=\frac{e^{\beta' X_{it}}}{1+e^{\beta' X_{it}}} \tag{4}$$

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

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

We report our results in Table 2 starting with a general baseline model which shows that unweighted capital 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 it argued in Barrell et al (2010). In that paper, covering 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 It would appear that the growth of off balance sheet sources of liquidity, both market based and central bank provided, obviates the need for this variable in our cross section starting in the late 1990s. 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. As concentration decreases over time and over space then crisis incidence rises significantly.

Of course, our explanation is not perfect, and we cannot explain all crises, as we see from the generalised information indicator, the AUC[6], which is significant, and from the Direct Call (or

[6] This is derived from signal extraction problems in the use of radar, and an AUC of 0.5 is as good as tossing a coin, and anything above 0.80 is excellent discrimination. However, this indicator gives no weight to the relative importance of a direct call as compared to a false call, and hence we report those as well.

crisis hit) ratio and the False Call ratios appended to column 1, 2 and 3. Adding the concentration ratio reduces the false crisis call rate quite noticeably. The same cannot be said of capital and we see in column 4. The coefficient on 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 column 2. More concentrated systems appear to face less risks as they perhaps have taken on a better loan portfolio as suggested above. 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. However, the more capital the banking system holds, the less likely it is to face a banking crisis.

Table 2 Testing for Market Power

Sample: 1999 2016	Base	Concentration	Preferred	No 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)	0.702	0.747	0.714	0.681
Direct Call Ratio (DCR)	9 of 13	9of 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. Moore than half our countries are members of the EU, and as such they face a single market in financial services where cross border banking is more common than in the rest of 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 can change behaviour.

In Table 3 we first add the Lerner index of market power and find that its current value is significant. The use of a current value reduces the use of our equation as an early warning system, but it does help us explain what factors might raise the incidence of crises. We also include the insignificant lagged value in column 1, but it 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 in the paper with the highest AUC. The coefficients on capital and on 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 lower than in column 3. Our results 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

	Lagged and Current	Lagged and Current	Current Lerner	Current Lerner
Sample: 1999 2016	Lerner	Boone	and Boone	
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

The cost and production function-based estimate of market power is 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 not true of the Lerner and Boone indices. We can regress both on a constant and on the current, once lagged and twice lagged crisis indicators. 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. We can conclude from this that both are exogenous to crisis incidence, and they do not bias other coefficients when we include them, and their own coefficients are also unbiased. We can clearly say that markets that display more market power for the incumbent firms are less likely to face financial crises.

We have noted above that omitting a variable that is significant and important that is correlated with a significant and important variable that is included will bias the coefficient on the included variable and lead to policy conclusions that can be questioned. That is clear here in both Table 2 and table 3, as capital and concentration are positively correlated. When we include capital and concentration, they are both significant, but when we exclude one of them the coefficient on the other increases in magnitude and becomes more significant. Hence the effectiveness of increased capital is exaggerated if we omit concentration measures, and policy makers may be misled in thinking they have done enough to reduce crisis risks by increasing capital by a small amount when a larger increase was needed. Concentration and capital are

correlated, but and both reduce crisis incidence. So does market power, at least as measured by the Lerner index, but an increase on market power does not impact on the efficacy of concentration or the importance of capital in preventing crises.

Robustness

It is of course important to undertake some analysis of the robustness of our results, and we look at three 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 whether on book liquidity helped reduce the incidence of crises in our countries. The Basel III regulations require a set of complicated liquidity provisions which go far beyond the adequacy of on book liquidity, and we do not test for the new regulatory definitions of liquidity here as they were not in place before 2009. 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. 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 banking at a national level 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	Europe Only	Europe Only (2)
Capital(-1)	-0.223	-0.238	-0.309	-0.584
	0.084	0.053	0.087	0.000
Real House Price Growth (-3)	13.013	12.382	13.102	12.307
	0.012	0.016	0.011	0.015
Bank Concentration(-1)	-0.023	-0.028	-0.019	
(5 bank)	0.028	0.003	0.113	
Lerner	-1.949	-2.292	-1.871	-2.624
	0.039	0.018	0.090	0.010
Liquidity(-1)	-0.043			
	0.374			
Credit gap(-1)		0.027		
		0.145		
Area Under Curve (AUC)	0.702	0.747	0.714	0.681
Direct Call Ratio (DCR)	8 of 13	9 of 13	8 of 12	8 of 12
False Call Ratio % (FCR)	27.96	27.36	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, and we find that it is not significant, suggesting 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. Perhaps more importantly, when we add the BIS credit gap in column 2, indicating deviations from the (Hodrick Prescott) trend in the credit to GDP ratio, we find that it is not significant. Even though excess credit worries play a major role in the new regulatory framework, there is no evidence that excess credit, rather than low quality lending, has played a noticeable role in raising crisis probabilities in the last 20 years. Two major planks of the regulatory architecture appear to play little role in the determination of the probability of a crisis occurring over the last 20 years. Both regressions perform reasonably well, with hit ratios of around 70 percent and false crisis calls at only 28 percent or so.

Bank concentration ratios are of use where the country being measured also covers the market being studied. This is probably true to 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 3 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 a near neighbour. In column 4 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 independent countries in our sample, and that for them only a market power indicator shows and role for bank competition.

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, and in turn this 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 causality tests, and the results are reported in Table 5. We regress real house price growth in our panel on lagged real house price growth and twice lagged real house growth, and we also include the lagged gap and the gap lagged twice. Our Granger test involves deleting the two lagged variables and seeing if that deletion is acceptable. If we undertake this for the whole sample, then the gap may cause house prices in our sample, both in European countries and in the whole sample. However, if we look at the causality from 1996 to 2007 then clearly there is no significant link from the gap to house price growth. Either in the whole sample in in Europe. This matters a great deal as all our crises have occurred by 2008, and after that date the gap was used as an instrument to attempt to stabilise house prices. That this worked does not help us understand the causes of crises.

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)	0.817826	0.869589	0.828276	0.806013
	0	0	0	0
Real House Price growth (-2)	-0.167438	-0.185593	-0.17697	-0.111544
	0.0014	0.0088	0.0038	0.1781
BIS Credit Gap(-1)	-0.000379	-0.000882	-0.000404	-0.001118
	0.2821	0.082	0.2766	0.0361
BIS Credit Gap(-2)	5.30E-07	1.06E-03	-5.56E-05	1.01E-03
	0.9988	0.0452	0	0.0732
Granger Test of Gap F-stat	3.536164	2.053396	4.261419	2.259771
(with constant) Prob	0.0301	0.1307	0.015	0.1076

Calibrating Macro Prudential Policy

In our analysis we have a target variable, the probability of a crisis, two variables we might describe as tools, the capital ratio and the liquidity ratio, and a number of driving variables. In our last section we argued liquidity no longer acted as a tool as it had been substituted for by market and government provided liquidity. However, capital still mattered, and we can use our results to calibrate the level of capital (that would have been) required to keep the probability of a crisis down to 1 percent over our whole sample period. and to calibrate what level of capital

would be 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 of the set of results we must invert the logit model described in (3) above using the parameters from the last columns of Table 3, and the last column of Table 4. We should note that this model can be written as a log odds relationship, with p representing the probability

$$\text{Log}(p_{it}/(1-p_{it})) = \beta' X_{it} \quad (6)$$

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 β1 as the other coefficients and X1 as the rest of the matrix

$$\text{Log}(p_{it}/(1-p_{it})) = \beta 1' X1_{it} + \beta_c Cap_{it} \quad (7)$$

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.

$$Cap_{it} = \log(p_{it}/(1-p_{it}))/ \beta_c - \beta 1' X1_{it} /\beta_c \quad (8)$$

In Table 4 below we calculate the change in the average level of capital that would be required to keep the average probability of a crisis to one percent.

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 setting the differential of 7 to zero, along with the changes in the other driving variables, liquidity ratios and the current account. We may write this as

$$d\text{Log}(p_{it}/(1-p_{it})) = 0 = \beta_{hp} dRPHG_{it} + \beta_L dLerner_{it} + \beta_c dCap_{it} \quad (9)$$

Rearranging this we may write

$$dCap_{it}/dRPHG_{it} = -\beta_{hp}/\beta_c \quad (10)$$

and

$$dCap_{it}/dLerner_{it} = -\beta_L/\beta_C \quad (11)$$

We set out our results in Table 6. Over our whole period 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, and the costs rise as capital ratios increase, and these have to be offset against the gains. If equity capital is raised on the market it may well have an average cost of 13 percent a year, whist, bank debt, an alternative to capital may only cost 3 percent a year. Hence the cost of borrowing, all else equal, will rise by 10 basis points for every one percentage point increase in capital (and reduction in other borrowing which is cheaper). This would in turn raise the user cost of capital to firms (and mortgage lending cost) by 10 basis points and would reduce output as a result. However, crisis incidence would fall, and some optimal level of capital increase can be found.

When house price increases have been excessive capital requirements would have to be increased to keep crisis probabilities constant. This is perhaps the most effective active macroprudential policy we can suggest given our results, as many problems in the run up to crises appear to be housing market related. If the authorities wish to increase competition, or better still use supervision and regulation to reduce the margin between borrowing and lending costs (and hence reduce the Lerner index) then for every increase in competition or regulation that reduces the Lerner mark-up by one percentage point then banks would have to hold 0.045 percent more capital in order to offset the effects or increased risk on crisis probabilities. Some optimisation analyses of the impact of a reduction in market power can be undertaken, suggesting a 20 point reduction in the Lerner index having to be offset by 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.

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

Of course, it is difficult to calibrate macroprudential policies so closely as this, but the general message is clear. When house prices are rising in real terms by more than is reasonable then raise capital standards. If competition is increasing or supervision and regulation is becoming more effective in reducing bank profits, increase capital standards. An appendix table sets out some indicators of crisis probabilities for the whole of our estimation period, whist another sets out indicators of crisis probabilities for the current period. They suggest that capital standards may need to be raised in a number of countries. Currently Germany, Japan, New Zealand and probably Australia should look at issues with the housing market, and there are lesser concerns in the US, Switzerland, the Netherlands, Italy, France and Canada where predicted crisis probabilities for 2019 exceed 2 percent.

Conclusions

The nature 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 welfare 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, and we discuss the calibration of policy responses. 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 standard. 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.

However, some crises are missed. In particular we find it difficult to explain the crises in Germany, Switzerland, the Netherlands and Portugal, which may in part be because of international factors. Banks in Germany and Switzerland were heavily involved in the US market where there was securitisation of complex assets, and they made significant losses on loans to the US housing market. The crises in Portugal and in the Netherlands were linked to problems in their neighbours, Belgium and Spain respectively, and not so much to domestic factors. There are also other factors that make, such as managerial incompetence, exuberance or fraud that make crises difficult to predict, and it is clear that good supervision is as important as good regulation.

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 variable 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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Appendix Table A1 Predicted Crisis Probabilities from Table 3 column 4 (Figures in bold indicate probabilities in excess of the sample average)

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Australia	0.0074	0.0168	0.0257	0.0081	0.0126	0.0314	**0.1376**	**0.1393**	0.0267	0.0141	0.0288	**0.0463**	0.0162	0.0222	**0.0566**	0.0080	0.0123	0.0242
Belgium	0.0375	**0.0392**	**0.0730**	**0.0694**	0.0369	0.0360	**0.0592**	**0.0650**	**0.0775**	**0.0961**	**0.0953**	**0.0485**	0.0186	0.0203	0.0169	0.0128	0.0120	0.0123
Canada	0.0278	0.0333	0.0146	0.0274	0.0177	0.0190	**0.0420**	**0.0432**	**0.0437**	**0.0390**	**0.1103**	**0.0497**	0.0165	0.0075	0.0298	0.0134	0.0169	0.0147
Denmark	**0.0441**	**0.0551**	0.0291	0.0209	0.0193	0.0200	0.0164	0.0169	**0.0524**	**0.1834**	**0.3150**	0.0190	0.0043	0.0018	0.0150	0.0042	0.0035	0.0093
Finland	0.0209	**0.0890**	0.0329	**0.2384**	**0.1604**	0.0019	0.0097	0.0102	0.0144	0.0235	0.0301	0.0194	0.0101	0.0216	**0.0583**	0.0193	0.0226	0.0218
France	**0.0449**	0.0336	**0.0496**	**0.0977**	**0.0915**	**0.0700**	**0.0755**	**0.1392**	**0.2240**	**0.2713**	**0.1380**	**0.0668**	0.0227	0.0106	**0.0398**	**0.0387**	0.0198	0.0167
Germany	0.0301	0.0226	0.0303	0.0354	0.0316	0.0261	0.0227	0.0246	0.0219	0.0307	0.0252	0.0198	0.0337	0.0260	0.0269	0.0257	0.0295	0.0308
Ireland	**0.0432**	**0.0908**	**0.1645**	**0.1134**	**0.0390**	0.0190	0.0359	**0.0887**	**0.0758**	**0.0700**	**0.0830**	0.0182	0.0032	0.0012	0.0014	0.0005	0.0003	0.0034
Italy	0.0168	0.0152	0.0096	0.0152	0.0174	0.0194	**0.1414**	**0.0564**	**0.0596**	**0.0476**	**0.0392**	0.0262	0.0109	0.0092	0.0214	0.0210	0.0113	0.0089
Japan	**0.0457**	0.0371	0.0346	0.0313	0.0316	0.0230	0.0197	0.0103	0.0142	0.0217	0.0240	0.0374	0.0190	0.0219	0.0377	0.0248	0.0202	0.0252
Netherlands	**0.0808**	**0.0897**	**0.0780**	**0.2511**	**0.2821**	**0.0797**	**0.0479**	0.0356	0.0378	0.0310	**0.0504**	0.0366	0.0212	0.0112	0.0134	0.0104	0.0048	0.0049
New Zealand	**0.0502**	0.0368	0.0115	0.0243	0.0123	0.0155	**0.0469**	**0.1544**	**0.1169**	**0.0753**	0.0292	**0.0436**	0.0038	0.0063	0.0090	0.0060	0.0149	0.0267
Norway	0.0235	0.0276	0.0263	0.0276	**0.0498**	0.0163	0.0150	0.0078	**0.0416**	0.0296	**0.0402**	**0.0409**	0.0033	0.0058	0.0132	0.0158	0.0107	0.0044
Portugal	**0.0406**	0.0247	0.0102	0.0225	0.0212	0.0215	0.0204	0.0171	0.0123	0.0263	0.0292	0.0229	0.0188	0.0123	0.0103	0.0137	0.0097	0.0063
Spain	0.0072	0.0108	0.0121	0.0225	0.0101	0.0134	**0.0435**	**0.0694**	**0.0799**	**0.0529**	**0.0557**	**0.0344**	0.0083	0.0069	0.0115	0.0027	0.0010	0.0020
Sweden	0.0148	0.0314	**0.0570**	**0.0457**	**0.0549**	0.0248	0.0150	0.0220	0.0347	**0.0399**	**0.0562**	**0.0498**	0.0110	0.0255	0.0342	0.0114	0.0107	0.0195
Switzerland	0.0130	0.0140	0.0153	0.0162	0.0199	0.0308	0.0291	0.0239	0.0300	0.0260	0.0290	0.0200	**0.0608**	0.0354	0.0291	0.0294	0.0269	**0.0655**
UK	**0.0655**	**0.0815**	**0.1620**	**0.1405**	**0.1914**	0.0235	**0.0956**	**0.1019**	**0.0564**	0.0232	**0.0565**	**0.0550**	0.0070	0.0051	0.0261	0.0072	0.0150	0.0154
USA	0.0281	**0.0381**	**0.0551**	**0.0436**	**0.0441**	**0.0404**	0.0367	**0.0399**	**0.0665**	**0.0751**	0.0211	0.0025	0.0006	0.0020	0.0041	0.0027	0.0099	0.0222

Appendix Table A2 Predicted Crisis Probabilities from Table 3 column 4 in the forecast period

	Australia	Belgium	Canada	Denmark	Finland	France	Germany	Ireland	Italy	Japan	Netherlan	New Zealand	Norway	Portugal	Spain	Sweden	Switzerlan	UK	US
2016	0.0232	0.0123	0.0143	0.0099	0.0151	0.0159	0.0291	0.0038	0.0084	0.0254	0.0045	0.0282	0.0044	0.0054	0.0022	**0.0317**	**0.0337**	0.0250	0.0048
2017	0.0285	0.0097	0.0177	0.0103	0.0143	0.0180	**0.0319**	0.0242	0.0143	0.0196	0.0144	0.0198	0.0031	0.0060	0.0091	0.0105	0.0285	0.0070	0.0032
2018	**0.0304**	0.0115	0.0216	0.0189	0.0096	0.0158	**0.0399**	0.0055	0.0143	0.0298	0.0207	**0.0487**	0.0050	0.0081	0.0155	0.0098	0.0270	0.0137	0.0111
2019	0.0191	0.0106	0.0499	0.0151	0.0157	0.0238	**0.0457**	0.0043	0.0236	**0.0329**	0.0263	**0.0646**	0.0046	0.0227	0.0181	0.0193	0.0228	0.0152	0.0269