Bank capital: excess credit and crisis incidence

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There are large and long-lasting negative effects on output from recurrent financial crises in market economies. Policy makers need to know if these financial crises are endogenous and subject to policy interventions or are exogenous events like earthquakes. We survey the literature about the links between credit growth and crises over the last 130 years. We then go on to look at the determinants of financial crises both narrowly and broadly defined in market economies, stressing the roles of bank capital, available on book liquidity, property price bubbles and current account deficits. We look at the role of credit growth, which is often seen as the main link between the macroeconomy and crises, and stress that it is largely absent. We look at the role of the core factors discussed above in market economies from 1980 to 2017. We suggest that crises are largely unrelated to credit developments but are influenced by banking sector behaviour. We conclude that policy makers need to contain banking excesses, not constrain the macroeconomy by directly reducing bank lending.

Keywords: Financial Stability; Banking Crises; Macroprudential Policy.

1. 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. It has been common to link this crisis, and others to the twin problems of excessive credit growth and the subsequent unsustainable

1. We would like to thank the referees for this journal and conference participants in Santiago de Chile, Dublin and New York for useful comments on this paper. All errors remain ours.

growth of asset prices, and, particularly, property prices. The link between credit growth and bank based financial crises has been emphasised in a series of papers covering a period of over 130 years of history in 17 developed economies by Schularick and Taylor (2012), Jordà, Schularick and Taylor (2011) and Jordà, Richter, Schularick and Taylor (2017) and has been supported by the views and the publications of the Bank for International Settlements (BIS).[2] The evidence to link crisis incidence to credit growth over the last forty years is, however, weak, and evidence of the link from earlier periods may not be relevant for the analysis of policy problems in a set of financially liberalised advanced economies. The prevailing view in the economics profession, and the policy community, is that constraining credit growth is essential for preventing a new round of financial crises. In this paper we evaluate this proposition and attempt to understand the causes of financial crises in advanced economies over the last forty years.

We look at the role of the defences against systemic bank failure, capital and liquidity as well as at the role of property prices and of credit growth as the potential problems driving crises. We argue that rejecting a role for capital adequacy in explaining financial crises is misjudged. In the financially liberalising world that followed on from the collapse of Bretton Woods system in the early 1970s it is clear that capital has been an important defence against the risk of crises, even if it was not significant in earlier historical periods. We conclude that the emphasis on credit growth and its control is misjudged and reduces the chances of preventing a new wave of damaging crises.

In the next section of the paper we review the related literature on the factors driving crises over the last 130 years, and we re-emphasise the conclusion of Bordo (2018) that there is little evidence to support the importance of credit growth over this period. House price bubbles have been commonly linked to crises as well, and we look at these in the third section, building on a sequence of papers by Barrell and Karim (eg Barrell *et al.* 2010, Karim *et al.* 2013). In this section we discuss logit models of financial crises over the period 1980 to 2017 using published data from international organisations on capital, liquidity, current accounts and real house price growth for 14 countries. We also investigate the evidence that the growth of lending, or credit, fuelled crises. Our basic models work well, catching two thirds

2. This paper and those mentioned in this paragraph focus on banking crises, not foreign exchange driven financial crises. The causes of such crises would not be the same as those studied here.

of crises, whilst adding various excess credit indicators does not enhance them. In the fourth section we stress the relevance of the Laeven and Valencia (2018) crisis definition, which is tighter than the one used in the earlier sections, and we demonstrate that our conclusions on the roles of house prices and credit also hold in this tighter framework, even when we add data five extra countries for the last 20 years of our data. In section five we use our results to calibrate macroprudential policy responses. In our last section we draw conclusions for policy and for research. In addition, the importance of the defences against crises, capital and liquidity, is discussed.

2. Defining and explaining crises

There has been an extensive technical and historical literature on the causes and consequences of crises, and it has expanded rapidly since 2007. For the sake of brevity, we do not discuss the consequences of crises, but rather focus on their causes and policy responses to them. 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 in and Reinhart and Rogoff (2009) and Bordo (2018) through simple univariate early warning indicators used by Kaminsky and Reinhart (1999) and by the Bank for International Settlements in a sequence of staff papers by Borio and Drehmann (2009) and others in subsequent papers, to more sophisticated logit based models as in Barrell *et al.* (2010) and Schularick and Taylor (2012). These approaches are compared in Davis and Karim (2008) and they come down firmly in favour of the last method. The causes of banking crises remain disputed with Borio (2014) and Jordà, Schularick and Taylor (2011, 2013) and Jordà *et al.* (2018) strongly supporting the view that excess credit growth is a major factor in driving banking crises. Bordo (2018) disputes this and suggests that only the 1929-1933 crisis and the 2007-8 crises showing links to credit growth, and this view is also advanced by Kiley (2018) who shows that credit has contributed little to the explanation of the crises Jordà, Schularick and Taylor examine, even if it is statistically significant. We study only the post Bretton Woods era in similar countries, and we draw the conclusion that credit (no longer) matters (much) in driving financial crises.

Research by Barrell *et al.* (2010) and Karim *et al.* (2013) suggested that house price growth and current account deficits affected crisis incidence, but credit growth did not. These papers also found a role for

bank capital and for liquidity, and we describe these two as the defences against the excesses associated with the problem indicators, housing and current accounts. However, Jordà *et al.* (2018) in a long historical study find a limited role for bank capital as a precursor for crises either in the post 1870 world or in the post World War II world in 17 advanced countries. The crises they choose are different from those in Barrell *et al.* (2010), but they overlap, and for our countries their crises and those in the Laeven and Valencia (2018) study are essentially the same. Contrary to their findings we demonstrate that in the post 1980 world capital has a major role to play in the determination of crisis probabilities.

Crises have been endemic in market based, or capitalist, economies, and they became increasingly common in OECD countries after the ending of the crisis free 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 directly from specific liberalisation measures, and some forms of liberalisation such as the removal of interest rate caps may have reduced crisis incidence, as Barrell *et al.* (2018) show.

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 to cover their short-term losses and they are potentially insolvent. We use the book based equity value of the banking system which is essentially the difference between their loans, or assets, and their liabilities or deposits, and hence it is the sum that is available to cover losses on assets whilst still being able to pay back all non-equity liabilities. As such our measure of bank capital relative to liabilities is not risk weighted, as a risk weighted measure does not indicate the ability to repay debts. 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 World Bank (Caprio *et al.*, 2005) and those from the IMF in Laeven and Valencia (2018)[3] who use a much more restrictive set of criteria. The timings of crises differ in these databases, and between vintages of them.

3. The post Great Financial Crisis study of this topic has benefitted from a sequence of papers from Laeven and Valencia on crisis dating, starting in 2008. Inevitably the timing of crises changed as new information on past events became available.

We have complete, published data for 14 countries from 1980, Belgium, Canada, Germany, Denmark, Spain, Finland, France, the UK, Italy, Japan, the Netherlands, Norway, Sweden and the US. When we add data for the post 1996 period, we include five more countries Australia, Ireland, New Zealand, Portugal, and Switzerland. A statistical appendix details our sources.

3. Simple models of financial crises

We model OECD 14 countries from 1980 to 2017 using logits, and we base our results on Barrell *et al.* (2010). We use data published by the OECD on the consolidated banking systems of our countries (no others are available from this source) on non-risk-weighted capital in the banking system and IMF data on narrow liquidity in the system. Karim *et al.* (2013) and Kiley (2018) emphasise the role of current accounts and of real house price growth rates in leading to crises, as these are associated with poorly considered lending by banks to companies and individuals respectively. We look at relatively parsimonious logit models to explain crises and include standard significant variables from studies such as Barrell *et al.* (2010, 2018) and Karim *et al.* (2013). We exclude variables that are shown to be insignificant in Barrell *et al.* (2010) and a range of other studies. 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.

We start with the Caprio *et al.* (2005) description of crises used by Barrell *et al.* (2010), and they identify them in Canada (1983), Denmark (1987), the US (1984), Norway (1987), Sweden and Finland and Japan (1991), France (1994) and marginally the UK (1984, 1991, 1995). In Barrell *et al.* (2018) we added crises in the UK and US in 2007 and had crises in 2008 in Belgium, Denmark (and 2009), France, Germany (and 2009), Italy the Netherlands, Spain (and 2011), the UK, the US and Sweden[4].

4. The crises in Spain (2011), and Germany and Denmark (2009) do not appear in Laeven and Valencia (2018), although they show in earlier online versions. Their deletion would raise our hit rate to 20 of 24 and leave the model essentially unchanged. We keep them here to make our results comparable with Barrell *et al.* (2018).

We use the cumulative logistic distribution which relates the probability that the dummy for crises takes a value of one to the logit of the vector of n explanatory variables:

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

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 which is used to obtain actual parameter estimates is given by:

$$\mathrm{Log}_e L = \Sigma_{i=1}^{n} \Sigma_{t=1}^{T} [(Y_{it} \log_e F(\beta' X_{it})) + (1 - Y_{it}) \log_e (1 - F(\beta' X_{it}))] \quad (2)$$

Our results are reported in Table 1 below. The first column repeats the basic analysis in the early warning systems in of Barrell *et al.* (2010) and Karim *et al.* (2013) over a longer period, and the results remain robust. As we have the intention to construct a warning signal, or Early Warning System (EWS) we use only lagged variables to explain crisis incidence. This is also necessary as capital and liquidity are balance sheet variables, reported at end of year, and hence are probably endogenously determined, and affected by crises within the year.

The most significant variable is capital, with crises probabilities being reduced when banks have more capital. The other defence, liquidity, is also significant, reducing crisis probabilities noticeably. The causes of problems are current accounts and the growth of house prices. A deterioration of the current account increases crisis probabilities significantly, suggesting that lower quality lending increases. Kiley (2018) uses only deficits, but we consider that both sides of zero matter. If there are good structural reasons for a surplus (or a deficit) in a country, then a deterioration in the surplus may involve a resort to more risky lending as patterns of finance change. We include the third lag in real house price growth as this was preferred in earlier work, and it remains significant in the longer sample. We posit that when house prices are rising most rapidly banks are more willing to lend to more risky borrowers, and at some time in the future their mistakes will be uncovered by defaults on loans in excess of the rate they had built into the mark-up over the deposit rate. We have no empirical reason to assume that bad loans only turn up when house prices fall after the boom, although this may happen, and hence we do not describe this variable as picking up the housing cycle.

Table 1. **Basic models of crises**

	Base	Total Credit	Cons Credit	BIS Credit Gap
		1981-2016		
Current account (-1)	-0.1303	-0.1281	-0.1122	-0.1146
	0.018	*0.020*	*0.042*	*0.033*
Capital(-1)	-0.3205	-0.3113	-0.3600	-0.3531
	0.000	*0.000*	*0.000*	*0.000*
Real House Price Growth(-3)	0.0786	0.0754	0.0584	0.0591
	0.005	*0.022*	*0.101*	*0.048*
Liquidity(-1)	-0.1272	-0.1285	-0.1491	-0.1233
	0.000	*0.000*	*0.000*	*0.000*
test(-1)		0.0551	0.0073	0.0367
		0.445	*0.927*	*0.493*
test(-2)		0.0409	0.0535	-0.0102
		0.641	*0.641*	*0.908*
test(-3)		-0.1108	-0.0002	0.0077
		0.135	*0.998*	*0.892*
Area Under Curve (AUC)	0.669	0.676	0.671	0.671
Direct Call Ratio (DCR)	21/27	19/27	21/25	22/27
False Call Ratio % (FCR)	33.01	32.24	31.17	30.25

Notes: Probabilities under coefficients Cols 1, 2 and 4, 27 crises with 504 obs., prob 0.0536.

As one focus of this paper is the role of credit in driving crisis incidence, in Columns 2 to 4 we add a set of variables associated with lending growth. All are derived from BIS data, as are our real house prices. We first add annual data on the growth in real total credit in column 2, with three lags, and then in column 3 we add the growth in real consumer credit again with three lags, and finally we add the BIS estimate of the gap between credit to GDP and trend credit to GDP which is based on data for real total credit and uses a Hodrick Prescott filter to estimate the gap. The gap uses a great deal of past information on both credit and on GDP. The role of the gap is investigated further in Barrell *et al.* (2018).

There are a number of ways to evaluate logit models, and the simplest are probably the hit and miss ratios, which we denote Direct Calls and False Calls. A Call is when the projected probability for a time period exceeds the sample average, which in columns 1, 2 and 4 is the sample average proportion of crises in our data set of 5.212 percent. Our basic model hits 21 out of 27 crises in our 36-year data set, and hence is giving a reasonable warning. The crises in Denmark in 1987,

Germany in 2008/9, Italy in 1990 and 2008 and Spain in 2011 are not picked out by the basic model, whilst all others have predicted probabilities in excess of the sample average. However, the basic model also has 33 percent of its calls in excess of the sample average, and we describe this as the False Call (or False Positive) ratio. Up to half the false calls are in the three years before a crisis or the three years after, and hence prompt corrective action would have been appropriate or unnecessary in these cases, and only about one sixth of our time periods are covered by genuine false calls. These also tend to be concentrated in crisis prone countries such as the UK, and hence we can see them as useful indicators rather than pure false calls.

Evaluating whether a model is good depends upon the weights one puts on making correct calls for actions as against the number of times action is called for when it is not necessary. If crises are expensive but prompt corrective action is cheap and effective then the Direct Call and False Call rates will have different weights, which we would expect them to have. However, it is useful to have a statistic that builds in a simple trade-off between Direct and False Calls, and to do so we also report the widely used Area Under the Curve (AUC) indicator. 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 0.85 is excellent discrimination. The AUCs in Table 1 are significant.

When we add three lags in the BIS credit indicators the AUC improves marginally, but not significantly, and in each case the real house price growth indicator becomes less significant. We can jointly eliminate the three real total credit growth variables in column 2, as a Wald deletion test of Chi2 of 2.972 is accepted with a probability of 0.395. When we include real total credit growth the model makes two fewer Direct Hits. The Direct Hit ratio is higher for real consumer credit, at 21 out of 25 crises. The real consumer credit data is more limited than that for real total credit, and we have two fewer crises to explain. A Wald deletion test of the three consumer credit variables in column 3 is passed with a Chi2 of 1.189 and a probability of 0.756. The Direct Hit ratio is higher than in our base case when we add the BIS credit gap, but the Gap is not close to significant at any lag. A Wald deletion test of the three BIS credit gap variables is passed with a Chi2 of 2.906 and a probability of 0.406.

The links between real house price growth and crisis incidence are clear, and when in column 3 we add real consumer credit growth to a

model with capital, liquidity, current accounts and house prices, the latter variable becomes insignificant. The growth rates of real house prices and real consumer credit are not orthogonal, as the coefficient on the former changes when we add the latter, and hence it is possible that house prices are picking up some of the relationship between credit growth and crisis incidence. We would judge that there is a little evidence linking consumer credit, house prices and financial crises, with house prices acting as the intermediary. In none of our experiments do we find a convincing case for adding BIS based credit variables, but in all of them (a shortage of adequate) capital and liquidity remain significant determinants of crises.

4. Robustness to crisis definitions, coverage and timeframe

Financial stress is common if not endemic, as Romer and Romer (2017) show, but not all periods of stress turn in to periods of rupture. As noted above, we start with the Caprio *et al.* (2005) definition of a financial crisis, which was that the proportion of non-performing loans to total banking system assets was greater than 10%, or the public bailout cost exceeded 2 percent of GDP, or systemic crisis caused large scale bank nationalisation, and if not, emergency government intervention was sustained. Crises could also occur when bank runs were observed, but these have been rare in our set of countries since 1980. The definitions were tightened and updated by Laeven and Valencia (2018), who stressed the role of public sector interventions, and they revised and extended the dataset. The Laeven and Valencia revision raised the threshold bailout cost to 3 percent of GDP and focused on crises that Caprio *et al.* (2005) had noted as systemic. The crises in in 2007-8 that we and they include can all be described as systemic. In this section we study the Laeven and Valencia (2018) crises in the UK and the US in 2007 as well as Belgium, Denmark, France, Germany, Italy the Netherlands, Spain, and Sweden in 2008. They have pre 2007 crises only in Japan (1997) and Finland, Norway and Sweden (1991).

In the first two columns of Table 2 we evaluate our model over our full time period using the Laeven and Valencia definitions of crises. We repeat a regression from Table 1 in the first column, and then add three lags in the BIS Credit Gap in column 2. The pattern is the same as in Table 1. Column 2 has a higher AUC than column 1, and the same hit ratio and a higher False Calls ratio, but the AUC gain is not particularly

large. The common coefficients are essentially the same, whilst the credit gap contributes nothing to the explanation. In the equation with the BIS Credit Gap for the full period in column 2 the credit gap contributes little to the explanation, and a Wald exclusion test is passed with a Chi2 of 0.473 with a probability of 0.924.

Table 2. **Testing for changes in definition and scope**

	Fourteen countries		Nineteen Countries			
	Base	With Gap	Base	With Gap	Short	with Gap
	1981-2016		1997-2016		2004=2016	
Current account (-1)	-0.0738	-0.0717	0.0038	0.0044	0.0044	0.0069
	0.290	*0.300*	*0.928*	*0.916*	*0.911*	*0.863*
Capital(-1)	-0.4896	-0.5102	-0.5160	-0.5225	-0.4907	-0.4814
	0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
Real House Price Growth(-3)	0.1068	0.1014	0.0816	0.0715	0.1040	0.0942
	0.004	*0.014*	*0.062*	*0.127*	*0.027*	*0.067*
Liquidity(-1)	-0.1344	-0.1308	-0.0848	-0.0830	-0.0681	-0.0687
	0.000	*0.001*	*0.058*	*0.065*	*0.161*	*0.161*
test(-1)		0.0083		-0.0089		0.0039
		0.913		*0.852*		*0.940*
test(-2)		-0.0172		0.0427		0.0302
		0.888		*0.593*		*0.728*
test(-3)		0.0264		-0.0258		-0.0368
		0.728		*0.644*		*0.532*
Area Under Curve (AUC)	0.7441	0.7485	0.722	0.716	0.703	0.708
Direct Call Ratio (DCR)	10/14	10/14	9/14	10/14	9/13	9/13
False Call Ratio (FCR)	31.43	32.04	37.16	37.16	39.68	38.06

Notes: Probabilities under coefficients, crisis probabilities in cols 1,2 is 2.78%, cols 3,4 is 3.68%, cols 5,6 5.26%.

We should note that capital and liquidity are significant in our full period experiments, even those with the more restricted crisis definition in Table 2. This is contrary to the post 1945 results in Jordà *et al.* (2017) and would lead us to very different policy conclusions from theirs for the current, post Bretton Woods, period. If we added the 35 years between the end of the Second World War to the start of our data, we would add no crises until after 1972, and then only crises in the UK and Spain. The pre-1972 period was one where real credit growth was very stable because of financial repression, and so were real house prices in most countries. Over the same period capital varied across time and countries, much in the same way as it did from

1980, at least as far as estimates in Jordà *et al.* (2017) suggest. Hence it would not surprise us if capital became insignificant if we added those observations to our data, and the lack of growth in credit up until 1972 meant that it seemed to explain (the lack of) banking crises. However, we think the liberalised post-Bretton Woods era should be explained by different factors than the repressed 1940s to early 1970s, and it does not surprise us that our results differ from those of Jordà *et al.* (2017) and hence so do our policy conclusions.

We also look at the incidence of financial crises in 19 OECD countries over the last 20 years. Adding five countries, Ireland, Portugal, Switzerland, Australia and New Zealand using published data shortens the timeframe for our experiments. We have crises in Japan (1997), the UK and the US in 2007 as well as Belgium, Denmark, France, Germany, Ireland, Italy the Netherlands, Portugal, Spain, Sweden and Switzerland in 2008. We argue that in the liberalised 21st century bank capital ratios have mattered, even when there was regulatory arbitrage especially after the beginning of the implementation of Basel II from 2004. This was undertaken by banks in order to reduce the total amount of capital held by large banks and has often been seen as one cause of the crisis in 2007-2008.

In columns 3 and 4 of Table 2 we report on logits for the 20 year period from 1997 for these 19 countries, and in column 3 we repeat our baseline model over the shorter but wider sample, and it has a strong and significant role for capital and for lagged real house price growth. However, as in our previous regressions on the restricted Laeven and Valencia definition of crises we find no role for the current account deficit in these advanced economies. More significantly, it is not clear that liquidity, as measured here is significant. This may reflect the growth of reliance on effective off balance sheet provision of liquidity in the interbank market. In column 4 we add three lags in the BIS Credit Gap indicator and they are not significant, much as in the 14 country sample above over a longer period. A deletion test on the three gap indicators is passed with a Chi2 of 0.673 with a probability of 0.879.

The regulatory regime changed during this time period, with the full introduction of Basel II at the start of 2008. However, many banks began to change their capital standards in advance of this tightening of regulation, in part because of pressure from domestic regulators, but also as a display of their strength to the market and their preparedness

for the new regulatory regime. We would judge that the new regulations were having some impact from 2004, and we repeat our analysis from that date in columns 5 and 6 of Table 2. The results are little changed by starting one or two years later. Once again capital standards are significant determinants of crisis probabilities, with countries that had banking systems with higher levels of capital being less likely to experience crises. Real house price growth lagged three periods remain very significant, whilst the current account is not. Liquidity levels become less significant over this period than in the longer data set from 1997, perhaps because wholesale markets became more prominent as a provider of liquidity, or perhaps because central banks were providing it 'without stint' from early 2009 onwards. A deletion test on the three gap indicators is passed with a Chi2 of 0.553 with a probability of 0.907.

The overall performance of these models is good, with an AUC that is highest for the longer sample. However, some crises are missed. In particular we sometimes find it difficult to explain the crises in Germany, Portugal, Spain, the US and Italy in 2008. The US crisis may be better explained by the securitisation of complex assets rather than simple housing market factors, and the crises Spain and Portugal we linked, and were driven by factors associated with post EMU membership booms in those countries.

5. 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 that after 2004, at least, 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 periods, starting in 1981and in 1997 to calibrate what level of capital would be required to offset the impact of bad lending associated with house price increases. In order to do these calculations for each of the set of results using the Laeven and Valencia definition of a crisis we must invert the logit model described in Equation (1) above using the parameters from the first and third columns of Table 2. We should note

that this model can be written as a log odds relationship, with p representing the probability

$$\text{Log}\,(p_{it} / (1 - p_{it})) = \beta' X_{it} \tag{3.1}$$

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 $\beta 1$ as the other coefficients and $X1$ as the rest of the matrix

$$\text{Log}\,(p_{it} / (1\text{-}p_{it})) = \beta 1' X1_{it} + \beta_c\, Cap_{it} \tag{3.2}$$

We may solve this for capital as the target variable, fixing the probability of a crisis, as we can see in Equation (4). 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.

$$Cap_{it} = \log\,(p_{it}/(1 - p_{it}))/\,\beta_c - \beta 1' \text{X1}_{\text{it}} / \beta_{\text{c}} \tag{4}$$

Over our whole period the capital ratio across our 14 country sample averaged 5.5 percentage points, and an increase of 2.0 percentage point would have reduced the probability of a crisis from the sample average of 2.78 percent to 1 percent. Our more limited time periods would have required higher increases in capital ratios, although the period from 1997 to 2016 has a higher capital ratio (5.9 percentage points) than the whole period, reflecting the significant increase in capital ratios after the financial crisis. In order to get the crisis probability down from 3.7 percent to 1 percent over the 1997 to 2016 period capital would have had to increase by 2.3 percentage points on average, and hence probably by 4.6 percentage points in the 10 year run up to 2008 and not thereafter.

Increases in bank equity capital on this scale would inevitably have had macroeconomic consequences. Equity capital costs significantly more than the interest rate paid on bank deposits or on corporate bonds issued by banks. A proportionate shift from these sources of borrowing by banks to equity funding of their lending portfolio would have increased borrowing costs for their customers. This would have reduced the level of bank lending as a percent of GDP and raised the cost of capital to firms wishing to make investments. Output in the

economy would then have been marginally lower than it would otherwise have been, but the chances of destructive crises would also have been lower as banks would have had a stronger buffer to absorb mistakes.

6. Conclusions

Our results suggest that crisis probabilities are driven by variations in capital and liquidity –the defences – as well as by the current account and house prices – the problem lending indicators. There appears to be no role for any overall lending or credit indicator in any crisis model in the post 1980 OECD. This does not mean we have an excellent understanding of the factors driving crises, and we would not expect one, as Caprio and Honahan (2015) discuss. Crises are difficult to explain, and even in our best models some countries remain difficult to evaluate. In no case do we have an explanation of the crisis in Italy in 1990 or Germany and Italy in 2008. The first is not included in Laeven and Valencia but is in our base model. The German crisis in 2008 was the result of over-ambitious involvement in the US sub-prime market by small and medium sized banks, many of them in public ownership. They were perhaps misled on the risks in the US mortgage backed securities market because there had been a thriving market in such securities in Germany since 1919. It is hard to model lack of wisdom in poorly regulated banks.

There are other causes of crises that are even harder to model. The collapse of Continental Illinois, the seventh largest bank in the US, in 1984 was the result of internal fraud rather than general bad lending. The bank had been involved in commercial and industrial lending, especially in energy, and one member of staff took on significant, but faulty, assets in return for a side payment. It is hard to catch that with a general macro model. The two Italian crises in 1990 and 2008 are perhaps even harder to explain, but they bring to mind an in interchange on page 215 in Donna Leon's 2015 Venice based crime novel "By its Cover" concerning a call from police Commissario Brunetti to the Venice Casino Director: "Ah, Dottor Brunetti" he heard the Director say in his friendliest tones, "how may I be of service?" "Dottor Alvino," Brunetti responded, honey in his voice, "I hope things are fine down there" "Ah," came the drawn out sigh, "as well as can be" "Still losing money?" Brunetti asked, using his best bedside manner. "Unfortu-

nately, yes. No one can explain it." Brunetti could, but this was a friendly call.

When we are modelling crises, it is important to look at evidence, and not assume we know answers. Logit models allow for numbers of factors and allow testing and also allows us to look at causes of problems and defences against them. We would conclude that capital requirements are the best macroprudential tool, and that some concern should be shown for liquidity, but that this is a complex issue. Obviously, policy should respond to imbalances, but there are few reasons for constraining credit growth. Policy should respond to any macro factors affecting crisis incidence, but our evidence suggests that it will be limited to trying to deal with excess house price growth, and if such bubbles cannot be contained, strengthening defences against a collapse in loan quality.

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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.
- Real Total Credit: Credit from banks to private non-financials from BIS online database quarterly 1974q1 to 2017q2, 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.
- Real Total Consumer Credit: Credit from banks to households and NPISHs from BIS online database quarterly 1974q1 to 2017q2, converted to real and to growth rates in the same way as real house prices. Start dates vary by country, with Spain, Sweden and Belgium starting in 1982, whilst Netherlands starts in 1992 and Denmark in 1996.
- Real Credit Gaps BIS online database with additions for 1980 from Barrell, Karim and Macchiarelli (2018) for Canada and Finland using BIS data on total credit and GDP in an equivalent filter.
- The annual current account to GDP data are taken from the OECD online database
- The unweighted bank capital variable comes from the OECD Consolidated Banking Statistics Database for data before 1995 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 data is calculated from Statistics Norway using:

  [Notes, coins and deposits] / Total Assets