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CALIBRATING MACROPRUDENTIAL POLICY

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Abstract: Policy proposals on the new international standards for bank capital and liquidity are being debated without any methodical evaluation of their effects on both crisis probabilities and concurrent social costs. Using data for 14 OECD economies for the years 1980 – 2007, we conduct a systematic evaluation of crisis determinants and find that bank capital adequacy, liquidity, the current account deficit and changes in house prices as being the principal factors associated with OECD banking crises. There is no evidence of procyclical risks being generated by credit or GDP growth. We explicitly quantify the regulatory changes to capital and liquidity that would required in each OECD economy over time in order to ensure systemic stability. We show that an international consensus on regulatory changes will generate "winners" and "losers" in terms of capital and liquidity adjustments, and we suggest that raising capital and liquidity standards by 4 percentage points across the board will reduce the average probability of a financial crisis to around 1%. Our results have important implications for the next generation of international banking regulations.

Keywords: Macroprudential policy, bank regulation, early warning models of banking crises

JEL classification: C52, E58, G21

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Introduction

An emerging consensus, particularly following the subprime crisis, is that there is a need to complement microprudential regulation, concerned with firm-level stability, with macroprudential regulation, which promotes systemic stability. The latter considers both the overall tightness of regulatory policies and whether they should vary over the cycle. However, proposals are being debated without any methodical evaluation of their effects on both crisis probabilities and concurrent social costs. Moreover, the differential impacts across countries have not been assessed, even though an international consensus on the next generation of regulations would surely be influenced by the diverse levels of regulatory tightening required by players in the international banking arena.

Procyclicality of systemic risks and how this can be mitigated is also being currently discussed. In this paper, and in Barrell et al (2009 and 2010 (a, b)) we argue that there is no strong evidence of procyclical patterns linked to GDP or credit in the factors driving the probability of a crisis occurring, and that macroprudential policy should not be calibrated to them. Rather our results suggest that if procyclical risks accumulate, this is related to asset prices and current account imbalances. During periods of economic growth, banks' collateral quality (linked to asset prices) is likely to be high, and they take on loans and securities whose quality can be questioned. These assets suffer heightened default risk during recessions necessitating increased capital holdings, and this will in turn exacerbate the downturn in activity by reducing the capacity of banks to lend. However the risk build up occurs, not because of higher economic growth per se, (and thus higher lending volume) but because the quality of lending deteriorates as related to asset prices. Meanwhile, the current account proxies potentially unsustainable wholesale funding on the liability side as well as economic overheating. Accordingly, macroprudential rules should be set as international benchmarks to be adjusted by domestic regulators who are privy to bank and economy specific behaviour[2]. If procyclicality does enter these rules it would have to be via paths that can legitimately be shown to have explanatory effects in the determination of crises, such as asset price developments.

Our contribution in this paper is twofold. Firstly, we conduct a systematic evaluation of crisis determinants and present a model that establishes bank capital adequacy, liquidity, the current account deficit and changes in house prices as being the principal factors associated with OECD banking sector crises, with the first two indicating the weakness of defences against the ravages induced by the second two variables. This contribution alone is important because current policy recommendations focus on the first two variables; policy makers can achieve a more refined regulatory response if they internalise the behaviour of current accounts and property prices. Moreover, in discussions on procyclicality mitigation the academic judgement veers towards provisioning linked to GDP and credit cycles. Since these two variables do not predict OECD crises in a consistent manner, we suggest any response to procyclicality needs to be more subtle; and property prices and current account deficits cannot be ignored. Accordingly, we estimate the regulatory changes required in response to the anomalous behaviour of OECD house prices and current accounts prior to the sub-prime crisis.

[2] In relation to this point we note the distinction between the use of risk weighted and un-weighted capital where according to ICMB-CEPR (2009) unweighted capital is appropriate for calibrating macroprudential policy since risk weightings' are balance sheet specific parameters. Accordingly, our estimation focuses on un-weighted capital adjustments. We return to this point in Section 4.

Our second contribution takes the current policy debate a step further: we explicitly quantify the regulatory changes to capital and liquidity that would be required in each OECD economy over time in order to ensure systemic stability. We show that an international consensus on regulatory changes will generate “winners” and “losers” in terms of capital and liquidity adjustments given a certain degree of crisis-risk-aversion of regulators. Overall, our results suggest an internationally uniform surcharge of 3.7% on capital and liquidity over 1998 – 2008 would have ensured that average banking crisis risk in the OECD would have been restricted to around 1%. Procyclicality arising from a (simulated) increase in house prices of 5 % suggests that countries such as the UK and US should have increased their capital and liquidity buffers by 4.4% and 2.7% respectively in 2008.

The paper is structured as follows. In Section 1, we consider the range of proposals for macroprudential regulation, from both the official sector and academia. Sections 2 and 3 form the investigation into OECD crisis determinants: in Section 2, we present crisis probability estimates derived in earlier papers (Barrell et al (2009 and 2010 a,b)). This model is estimated for 14 OECD countries over 1980-2008. However we also show that identical results could have been obtained over a sample as short as 1980-1997 and that the sub-prime crisis was predictable. In Section 3 the specification is estimated recursively each year from 1997 to 2007 to derive crisis probabilities over 1998-2008, showing it to be a useful tool for macroprudential surveillance. Section 4 presents our investigation into policy calibration: using the 1980-1997 estimates, we derive the changes in capital adequacy and liquidity ratios that would be needed to either return crisis probabilities to the sample mean or reduce them below that level both during and before the subprime crisis. We go on to assess what implications these patterns have, in terms of levels of target variables, changes in regulatory parameters and for the possibility of agreement on countercyclical regulatory policies. Section 5 concludes.

1 The debate on regulatory responses to financial crises

Our starting point is the model derived in Barrell et al (2010b) which confirms that capital adequacy, liquidity, property price growth and the current account balance are robust explicators of OECD banking crises. Since the first two variables are under direct supervisory control, we will first review the ongoing policy debate surrounding bank capital and liquidity requirements before we review the recent academic contributions that also stress the importance of capital and liquidity. In this context, procyclicality will also be discussed. The current debate is extremely dynamic as regulators attempt to catch up with deficiencies in the Basel II framework and so we will restrict our review to the most recent policy discussions.

The problem of capital and liquidity adequacy was addressed in Barrell et al (2009) who quantified the impact of capital adequacy and liquidity on banking crisis probabilities, and extended the analysis to undertake a cost and benefit evaluation of tighter standards. In the light of the regulatory deficiencies noted above, the Financial Stability Board had already begun to recognise the need for strengthened international capital and liquidity standards (2009). Based on the objective of creating less procyclical and more systemically stable financial markets, the Basel Committee on Banking Supervision is due to calibrate the new

capital requirements during 2010[3]. The quantity and quality of capital for individual banks and banking systems will be re-stipulated in a set of rules that are intended to apply in a similar way across all countries.

The BIS (2009a) consultative framework which emerged out of the FSB (2009) recommendations to G20 leaders was intended to flesh out the regulatory changes before the calibration stage ensued. Specifically, the BIS (2009a) proposals include measures to:

(i) Improve the quality of capital by subjecting common equity to regulatory adjustments. Previously, adjustments excluded the equity component of Tier 1 capital so that high Tier 1 ratios could be reported when actually the common equity fraction (which absorbs losses first) was low. In a similar vein, non-equity instruments can only be included after they have been shown to be loss absorbing in practice (e.g. subordinated instruments which issue discretionary payouts and which are unlikely to be redeemed).

(ii) Improve the quantity of capital since previously the maximum amount of Tier 2 capital held by a bank was dependent on how much Tier 1 capital had been issued. Moreover, the restriction that Tier 1 capital must exceed Tier 2 capital will be removed but will be replaced by unambiguous minimum Tier 1 requirements. The BIS (2009a) suggests explicit minima be applied to the different grades of capital, common equity, total Tier 1 and total capital

The FSB(2009) recognised that liquidity risk management should be considered from an ex-ante perspective (redefined liquidity ratios to prevent risk from accumulating) as well as ex-post (ensuring that authorities monitor banks' reliance on liquidity and foreign currency funding markets once liquidity risk is already accepted). Recommendations were made to the Basel Committee on Banking Supervision in order to redefine minimum liquidity standards which could be exceeded by countries at their discretion. Subsequently, BIS (2009b) put forward two new standards aimed to produce internationally consistent liquidity risk supervision as well as a minimum set of monitoring metrics for supervisors. These metrics are designed to cover the needs of individual banks, but they need to be supplemented by an understanding of, and a set of standards regarding, market liquidity as a whole. The need for liquidity is in large part a system wide requirement, and can be evaluated from crisis probability models and these should supplement the individual bank standards below.

The first new standard concerns the Liquidity Coverage Ratio which focuses on whether short term (30 day) funding shocks (which can be bank specific or systemic in source[4]) can be met. The ratio is constructed as the level of high quality liquid assets that covers net cash outflows based on scenarios envisaged by supervisors. In order to ensure the bank has sufficient liquidity up to day 30, and to buy time for the bank to take corrective steps, the ratio should continuously exceed 100% throughout the simulation month. High quality assets are defined as those that remain liquid when markets are stressed, are central bank acceptable and are unpledged as collateral to others.

Longer term liquidity problems are to be addressed via the Net Stable Funding Ratio (NSF) since the maturity-liquidity characteristics of a banks' balance sheet assets and the

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[3] The Financial Stability Board (2009) suggests that on average this will require large banks to at least double their capital buffers by the end of 2010. This is perhaps more stringent than the changes suggested in Barrell et al (2009)

[4] For example, bank specific funding shocks may arise from credit rating downgrades or a partial loss of deposits whereas the termination of unsecured wholesale funding is feasible after systemic risk increases.

contingent cash needs arising from off-balance sheet exposures become important. Consequently, scenarios are built using a 1 year horizon with the aim of reducing banks' wholesale funding. To avoid large-scale distress, the bank must ensure the ratio exceeds 100% over the entire simulation period. The benefits of this new supervisory measure are that it caters for off-balance sheet liquidity requirements (which were not built in to previous measures such as "net liquid assets") and that it reduces banks' incentives for regulatory arbitrage whereby assets are funded with securities whose maturity fall just beyond the supervisory horizon.

The procyclicality of the financial system (already apparent with Basel 1), seemed set to worsen with Basel 2 (Goodhart, 2005) which prompted banks to sell assets due to rating downgrades and higher capital charges associated with recessions. In aggregate this worsens borrower solvency further[5] and may spread credit rationing to other markets (Warwick Commission 2009). However recently, in recognition of the procyclical amplification of systemic risks during the sub-prime episode, BIS (2009a) proposed a macroprudential framework that complements the microprudential recommendations highlighted above. A countercyclical capital structure has been suggested so that banks accumulate capital stocks when output gaps are positive enabling them to better absorb losses during recessions. There are also recommendations for more forward looking provisioning so that future expected losses are accommodated in advance. This would reduce the impact of sudden increases in non-performing loans on balance sheets during business cycle downturns thereby dampening procyclicality further.

To ensure that regulatory changes actually transmit to reduced procyclicality, the BIS (2009a) advocates the use of longer historic time series to estimate default probabilities, that specific "downturn loss-given-default" estimates should be computed and that the risk functions that are used to map these losses to capital adjustments are revised accordingly. It has been suggested by CEBS (2009) that procyclicality should be addressed by modifying the existing Pillar 2 framework rather than via the introduction of new supervisory mechanisms. Their view is that internal-ratings-based (IRB) banks that assess credit risk using in-house models are more likely to be exposed to procyclical dynamics; banks should therefore focus on two capital components: buffers beyond the minimum regulatory requirement to accommodate business cycle downturns and buffers which are held against extreme events[6].

There have been a number of proposals that suggest capital requirements, either in terms of the regulatory minimum, or extra tranches above that minimum, should vary over time and should depend upon the potential state of the economy. Time varying capital requirements related to lending growth are recommended, alongside the purchase of catastrophe capital insurance by Kashyap et al. (2008). Goodhart (2005) suggests that capital requirements related to bank lending should be related to the rate of change of asset prices, while another alternative is to limit individual bank asset growth to a rate consistent with an inflation target (Warwick Commission 2009). In a widely-cited contribution, Brunnermeier et al (2009) recommend that credit growth be used as a guide in countercyclical regulatory policy, with the calibration being on the degree of credit growth considered to be consistent with the long run target for nominal GDP. An adjustment should perhaps be made for

[5] Even lacking such regulation, in trying to make themselves safer, banks may collectively generate systemic risk (for example by selling assets when the price of risk rises).

[6] Although CEBS (2009) focuses on the former capital adjustment, we note that our empirical estimates give an idea of the capital adjustments necessitated by tail events such as OECD crises.

assets and liabilities maturity mismatches, thus penalizing the financing of long run assets with short run liabilities[7]. In order to evaluate the relative strengths of these suggestions it is useful to look at them in the light of evidence on the factors associated with banking crises in the OECD, and Barrell et al (2010b) suggest that credit growth based rules may be less effective than those based on asset price growth. This issue is one of the main focuses of this paper. It is also useful to evaluate these proposals in the light of the recent academic literature which has also examined the impact of liquidity, capital adequacy, property price growth and current account deficits on crises. We next turn to that area first before looking at new empirical results on capital adequacy.

Acharya et al (2009) note that when banks hold risky assets during economic upturns, higher expected profits make these assets more acceptable as collateral. Consequently, liquidity provisioning becomes countercyclical[8]; banks hold less than the socially optimal amount of liquidity during booms[9]. Moreover, bank bailouts and unconditional support to healthy banks increases their ex-ante liquidity risk whereas liquidity support conditional on existing liquidity holdings forces them to hold more ex-ante liquidity. The revised FSB (2009) liquidity standards discussed previously may address these findings to an extent.

Diamond and Rajan (2009) discuss structural factors that promote under-provisioning of bank capital. During booms, short-term debt is cheaper than long-term capital and so short-term leverage dominates bank balance sheet compositions. Because the converse occurs during recessions, the authors note that countercyclical regulatory capital adjustments may be hard to implement in practice.

Although the regulatory debate has focused on capital and liquidity as target variables without an explicit framework for setting such standards in relation to systemic risks, the results for property prices and current accounts in Barrell et al (2010b) mirror recent academic discussions. Reinhart and Reinhart (2008) investigate 181 economies over the period 1980 – 2007 and find that capital account liberalisations have increased the prevalence of current account deficits. Moreover, in high income economies, significant current account deficits marginally increase the probability of a banking crisis occurring (as well as the likelihood of a sovereign debt crisis). In addition Reinhart and Rogoff (2008, 2009) observe that excessive property price growth was a feature of many post-world war II banking crises including Spain, Norway, Finland, Sweden and Japan and was particularly high in the US prior to the sub-prime episode alongside large increases in the current account deficit.

Mulligan et al (2008) note the impact of a property price crash on bank capital. After the collapse, investors will only demand mortgages with higher expected returns and consequently, the supply of capital decreases. Moreover, since the homeowner's loss is restricted to their housing equity, any remaining losses must be absorbed by bank

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[7] Capital buffers against downturns would be adequately provided if probabilities of default (PDs) are adjusted to incorporate recessions. The adjustment factor would then decrease in size when output gaps are negative (because existing PDs and "recessionary PDs" are now aligned) and increase during expansions. Such adjustments therefore translate into countercyclical provisioning. The FSA (2009) and Bank of England (2009) also advocate similar capital adjustments in order to reduce the procyclicality that arises from biased PD estimates.

[8] Some banks may hold excess liquidity but this is in anticipation of the impending crises caused by low aggregate liquidity which as these banks know will create profitable opportunities via fire sales of assets.

[9] The authors cite the GFSR (2008) which noted the deeper haircuts during the post sub-prime period when expected profits were low and risky assets became less pledgeable.

shareholders and their creditors. The latter may include public authorities if creditors include depositors.

Finally we note that any minimum standards imposed on banks in terms of capital adequacy and liquidity protection would also have to accommodate the insurance sector. The EU Commission (2009) has stressed the importance of a unified set of regulations between the banking, insurance and reinsurance sectors to ensure solvency of this interconnected system and accordingly their Solvency II directive is based on the Basel II framework. The UK Treasury (2008) estimates that by forcing the adequate capitalisation of insurers, for the UK at least the benefits will outweigh the costs of raised capital adequacy. However, these calculations are based on preliminary estimates of the revised minimum standards. Since the determination of the actual minimum standards advocated by regulators is currently ongoing, this paper aims to inform the regulators' task by empirically deriving changes to the existing capital and liquidity levels that would be required to ensure systemic stability in the OECD; this is discussed in the methodology which we present next.

2 An early warning system for crisis prediction

The Full Model (1980 – 2008)

The purpose of this section is to derive a robust model for crisis prediction. As noted above, Reinhart and Rogoff (2009) highlighted a common set of factors associated with OECD banking crises over the past 30 years, including the current account and asset prices, but did not quantify these effects econometrically. Barrell et al (2010a) went on to demonstrate explicitly that three variables, namely banks' unadjusted capital adequacy, narrow liquidity and residential property price growth, provide a parsimoniously significant specification for predicting OECD banking crises[10]. In further work, Barrell et al (2010b) showed that the current account balance is also an important predictor of OECD banking crises. The model, estimated over 1980 – 2008, is presented in Table 1A with the corresponding variable definitions.

Table 1B displays the validity of the model in terms of its ability to correctly classify crisis and non-crisis observations in-sample. The performance is excellent with 15 out of 20 crises correctly called and only 97 false calls, a low rate in this literature, and as Barrell et al (2010b) show, most are associated with countries that subsequently faced crises. The model has a Type II error rate of 28% and a Type I error rate of 25%.[11]

The most important macroprudential indicators are two banking sector "robustness" variables: unweighted capital adequacy[12] and liquidity, and two real economy "vulnerability" variables: residential real estate prices and the current account. Capital buffers banks against losses and shocks. Lower capital not only leaves banks more vulnerable to losses but also offers incentives for risk taking due to the moral hazard generated by the mispriced "safety net" of lender of last resort and deposit insurance.

[10] They supersede the traditional banking crisis determinants cited in the literature, such as GDP growth, credit growth and the M2/FX reserves ratio (see for example, Demirguc-Kunt and Detragiache, 1998, 2005) which are perhaps more relevant for emerging market economies.

[11] These results are based on a cut-off probability of 0.0555 (the sample likelihood of a crisis).

[12] As Brunnermeier et al (2009) note, risk weighting may be important for evaluation problems faced by individual banks, but may not be relevant for system wide properties as risk is endogenous within the financial system when a crisis occurs.

Equally, liquidity ratios show the degree to which banks are robust to sudden withdrawals by depositors or wholesale funders where these are important.

Table 1A: Logit estimation results, estimated over 1980-2008

Variable	Definitions	Coefficient	z-Statistic
LEV(-1)	Ratio of (non-risk weighted)capital and reserves for all banks to end of year total assets as shown by the balance sheet	-0.342	-4.1
NLIQ(-1)	Ratio of the sum of cash and balances with central banks and securities for all banks over end of year total assets	-0.113	-3.3
RHPG(-3)	Change in real residential property prices	0.079	2.4
CBR(-2)	Current account balance as % of GDP	-0.236	-2.8

Table 1B: In sample model performance based on correct calls

	Dep=0	Dep=1	Total
P(Dep=1)<=C	247	5	252
P(Dep=1)>C	97	15	112
Total	344	20	364
Correct	247	15	262
% Correct	72	75	72
% Incorrect	28	25	28

We would argue that crises are typically the result of poor quality lending, especially in real estate markets. Accordingly a boom in real estate prices foreshadows a crisis since when prices fall from unsustainable levels, overextended borrowers have strong incentives to default. Finally, current account deficits reflect a reduction in national net wealth and may be accompanied by monetary inflows that enable banks to expand credit excessively, generating and reflecting a high demand for credit, as well as boosting asset prices in an unsustainable manner.[13]

However, property price growth and current account deficits do not make a crisis inevitable since banking systems with sufficient capital and liquidity can absorb the losses without failures. The most toxic combination appears to be the unwinding of a boom characterised by overvalued asset prices and external imbalances, *accompanied* by a weak banking system. Macroprudential policy cannot directly address the macroeconomic imbalances (note that since financial liberalisation, credit is not usually seen as boosting asset prices) but rather can ensure that the banking system is robust and not vulnerable in the downturn[14].

[13] In addition foreigners may cease to be willing to finance deficits in domestic currencies if they consider their assets are vulnerable to monetization via inflation, and such a cessation can disrupt asset markets and banks' funding.

[14] Arguably a good example was the Spanish banking system in the sub-prime crisis which underwent a great deal of turbulence but did not suffer a crisis per se (apart from losses by local savings banks which are publically owned).

From a policy perspective, noteworthy exclusions[15] from the equation include credit growth, GDP growth, M2/reserves and real interest rates. These "traditional" variables were eliminated via a rigorous testing-down procedure which confirms they are less sensitive crisis predictors than asset price booms, lax bank regulation and accompanying current account imbalances. [16].

The Truncated Model (1980 – 1997)

In this section we investigate the robustness of the model in Barrell (2010b) by showing that estimations using a truncated sample make no difference to our specification. In addition, via the robustness tests on lag length we also show that current recommendations for capital adjustments linked to credit and GDP cycles are moot. Accordingly, we argue against direct linkages of macroprudential rules to GDP or credit as suggested by some authors above. Table 2A shows the model can be estimated over a period as short as 1980-97 and still capture the same pattern of effects on crisis probabilities[17]. The in-sample predictive performance shown in Table 2B is virtually identical to the 1980-2008 model, with Type 2 errors of 28% and Type 1 errors of 25%.

Table 2A: Logit estimation results (1980-1997)

Variable	Coefficient	z-Statistic	Prob.
LEV_EXT(-1)	-0.3839	-3.1540	0.0016
NLIQ(-1)	-0.1046	-2.6070	0.0091
RHPG(-3)	0.0813	2.0934	0.0363
CBR(-2)	-0.3327	-2.1502	0.0315

Table 2B: In sample performance

	Estimated Equation		
	Dep=0	Dep=1	Total
P(Dep=1)<=C	143	3	146
P(Dep=1)>C	55	9	64
Total	198	12	210
Correct	143	9	152
% Correct	72	75	72
% Incorrect	28	25	28

To show the steps used to obtain the 1980 – 1997 specification, in Table 3 we present the general to specific approach which starts by including all the "traditional" crisis determinants. We tested the most general equation (i.e. (1) in Table 3) to see whether longer lags applied to credit or GDP growth. For credit growth the first lag was most significant, whereas for GDP growth it was the second lag[18]. Conducting a similar nest to that shown above, we found that GDP was also not significant after testing down with the second lag also. In other words, there appears to be no procyclical contribution to crisis probabilities from these two macro variables.

[15] Our result for the insignificance of credit expansion is nevertheless consistent with Mendoza and Terrones (2008) who found that credit booms often link to banking crises in emerging market economies but less often in OECD countries.

[16] To ensure our final policy recommendations are robust, we address the validity of our model which in Barrell et al (2010b) is shown to be invariant to the separate exclusion of major countries (US, US and Japan, Japan, UK, Norway, Sweden and Finland). Also this specification, if estimated up to 2003, remains stable and capable of forecasting the subprime crisis a number of years ahead. We also assessed up to the third lag of credit and GDP growth and found similar results.

[17] Of course, this is to some extent unsurprising since all of the crises except the subprime took place over the period 1980-95.

[18] Albeit with a "t" value of only 1.3.

Table 3: General to specific estimation for the 1980-1997 sample

Step	(1)	(2)	(3)	(4)	(5)	(6)	(7)
LEV(-1)	-0.339 (1.7)	-0.339 (1.8)	-0.348 (1.9)	-0.347 (1.9)	-0.417 (2.9)	-0.345 (2.7)	-0.384 (3.2)
NLIQ(-1)	-0.106 (1.8)	-0.106 (1.9)	-0.108 (2.0)	-0.113 (2.2)	-0.126 (2.7)	-0.104 (2.5)	-0.105 (2.6)
RHPG(-3)	0.091 (1.9)	0.091 (1.9)	0.089 (1.9)	0.095 (2.4)	0.09 (2.4)	0.086 (2.3)	0.081 (2.1)
CBR(-2)	-0.434 (2.3)	-0.434 (2.3)	-0.441 (2.4)	-0.438 (2.4)	-0.418 (2.3)	-0.3 (1.9)	-0.333 (2.2)
DCG(-1)	-0.101 (1.5)	-0.101 (1.6)	-0.1 (1.6)	-0.1 (1.5)	-0.108 (1.7)	-0.053 (1.0)	
YG(-1))	0.277 (1.5)	0.277 (1.5)	0.274 (1.4)	0.279 (1.5)	0.29 (1.5)		
BB(-1)	0.022 (0.2)	0.02 (0.2)	0.023 (0.2)				
M2RES(-1)	-1.51E-05 (0.2)	-1.52E-05 (0.2)					
INFL(-1)	-0.0012 (0.1)						
RIR(-1)	-0.054 (0.3)	-0.055 (0.6)	-0.055 (0.6)	-0.06 (0.7)			

Table 4: Out of sample probabilities from 1980-1997 model

	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
BG	0.005	0.004	0.003	0.004	0.009	0.005	0.007	0.014	0.025	0.048	**0.070**
CN	0.032	0.054	0.056	0.033	0.018	0.022	0.026	0.037	0.030	0.036	0.042
DK	0.015	0.041	**0.060**	0.046	0.048	0.029	0.043	0.030	0.042	0.030	**0.113**
FN	0.004	0.006	0.011	0.007	0.000	0.000	0.000	0.004	0.002	0.007	0.008
FR	0.025	0.018	0.012	0.014	0.040	0.028	0.032	0.053	**0.100**	**0.193**	**0.218**
GE	0.026	0.027	0.029	0.045	**0.058**	0.031	0.016	0.020	0.007	0.007	0.007
IT	0.001	0.002	0.002	0.009	0.017	0.020	0.026	0.039	0.034	0.054	0.019
JP	**0.071**	0.025	0.009	0.010	0.007	0.007	0.003	0.002	0.001	0.001	0.002
NL	0.020	0.018	0.050	0.049	**0.157**	**0.141**	**0.079**	0.028	0.017	0.019	0.007
NW	0.011	0.006	0.039	0.016	0.001	0.001	0.006	0.003	0.002	0.001	0.001
SD	0.019	0.016	0.034	0.048	0.039	**0.058**	0.017	0.006	0.009	0.011	0.008
SP	0.005	0.006	0.010	0.028	0.043	0.044	0.047	**0.096**	**0.266**	**0.516**	**0.580**
UK	0.049	**0.060**	**0.088**	**0.173**	**0.203**	**0.201**	**0.115**	**0.207**	**0.282**	**0.277**	**0.254**
US	0.025	0.032	0.044	**0.074**	**0.081**	**0.067**	**0.103**	**0.064**	**0.075**	**0.097**	**0.125**

Note: cut off threshold is 0.05714; bold indicate values greater then or equal to the threshold

Given the practical relevance of our model, Table 4 presents out-of-sample crisis probabilities where the cut-off probability for a crisis call is the in-sample figure of 0.057. The model predicts the subprime crisis in the UK and US, and flags sever problems for some time in advance, as well calling Belgium and France. It also predicts instability in Spain, which can be seen in the context of the asset price and lending booms in that country. The model calls a banking crisis in Japan in 1998, much as the IMF (2005) suggests, and crises are also called during house price bubbles in Denmark and the Netherlands in 2000 and 2002-4 respectively, as well as the stress associated with the rescue of Commerzbank in Germany in 2002, although none of these are noted as crises in our papers.

Having shown robustness of the model, we can invert it to obtain estimates of desirable regulatory changes in capital and liquidity, both on average over time. As we suggest the model could have been available by 1998 we first emulate its use by re-estimating it, adding data in turn for each year from 1998 to 2008, and then computing crisis probabilities one year ahead. This exercise simulates the procedures that could have been available to policy makers undertaking macroprudential surveillance working in real time. These forecast crisis probabilities could have been used to determine the ex-ante regulatory tightening that would have been necessary to prevent the sub-prime crisis.

3 Using the model in macroprudential surveillance

To illustrate the potential use of our specification as a macroprudential tool, we re-estimate the baseline model presented in Table 1A to obtain a series of rolling crisis probabilities shown in Table 5. For example, to compute the one-year-ahead crisis probability in 1998, we estimate the model using data for the period 1980 – 1997. This process is repeated until the entire estimation period 1980 – 2007 is consumed. In each case, the in-sample average crisis probability is used as a cut-off threshold to distinguish between crisis and non-crisis calls. Even if policy makers in the US, UK and France had decided to estimate our model one year prior to the sub-prime crisis they would have had time to enact regulatory changes that may have prevented the crisis from materialising.

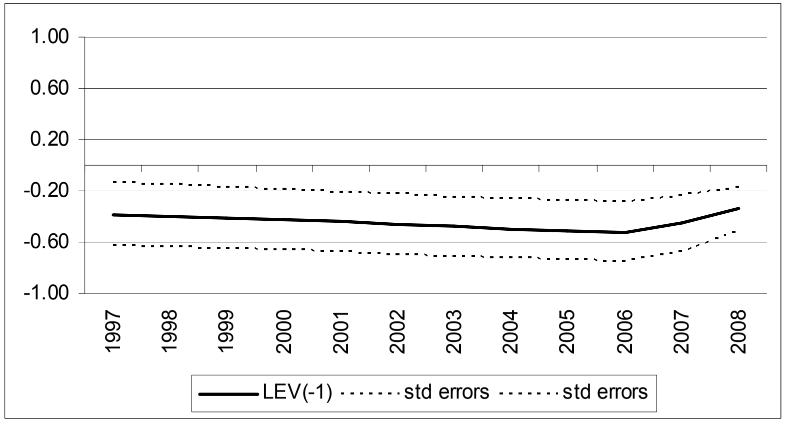
In the next section we use this model to quantify the regulatory changes that would have been necessary to reduce crisis probabilities. Note that we are not implying that other forms of macroprudential analysis are not useful. We consider that both quantitative approaches such as the above and qualitative methods such as "Financial Stability Reports" have a role to play. Nevertheless, we believe that such models can play an important role in policy calibration exercises, also in providing a reality check against suggestions that "this time it's different". Chart 1 shows the recursive coefficients over the rolling sample period. Again, the equation shows itself to be remarkably stable, and the coefficients always significant at the 5% level except RHPG (-3) in 2007.

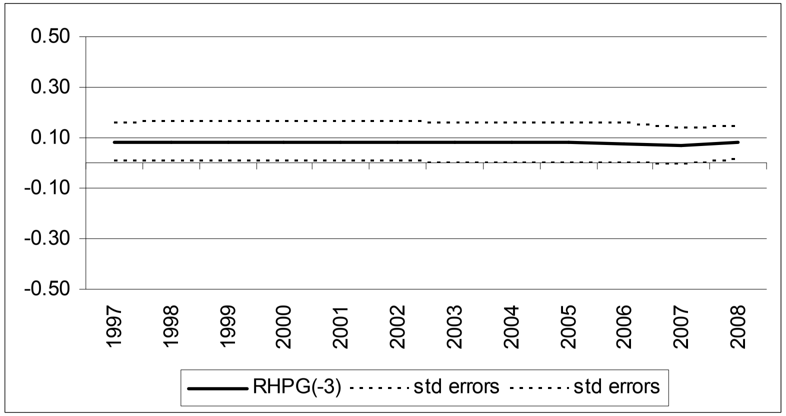
Table 5: Out of sample rolling probabilities

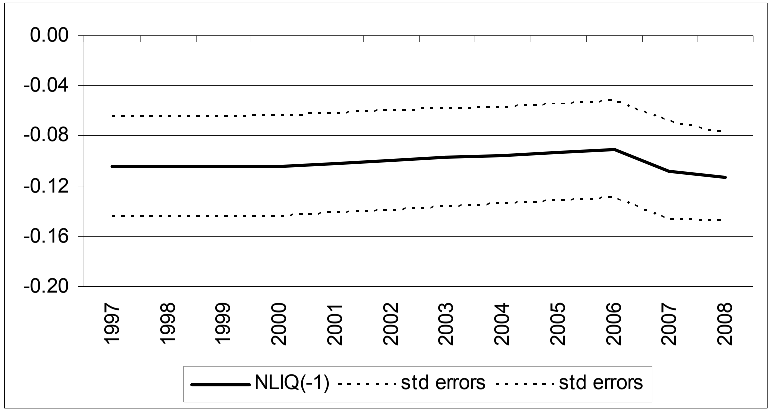
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
BG	0.005	0.003	0.003	0.003	0.006	0.003	0.003	0.008	0.014	0.027	0.033
CN	0.032	0.052	**0.051**	0.026	0.011	0.012	0.014	0.019	0.013	0.015	0.023
DK	0.015	0.038	**0.055**	0.034	0.032	0.015	0.021	0.012	0.016	0.007	**0.044**
FN	0.004	0.005	0.008	0.004	0.000	0.000	0.000	0.001	0.000	0.001	0.002
FR	0.025	0.016	0.010	0.011	0.029	0.018	0.019	0.033	**0.066**	**0.137**	**0.153**
GE	0.026	0.025	0.026	0.041	**0.054**	0.024	0.010	0.012	0.003	0.003	0.002
IT	0.001	0.002	0.002	0.007	0.013	0.013	0.016	0.025	0.018	0.030	0.013
JP	**0.071**	0.023	0.007	0.007	0.005	0.005	0.002	0.001	0.000	0.000	0.001
NL	0.020	0.016	0.042	0.036	**0.122**	**0.096**	**0.047**	0.011	0.005	0.005	0.002
NW	0.011	0.005	0.034	0.010	0.000	0.000	0.001	0.001	0.000	0.000	0.000
SD	0.019	0.014	0.028	0.036	0.025	0.032	0.006	0.001	0.002	0.002	0.002
SP	0.005	0.005	0.008	0.024	0.036	0.034	0.033	**0.062**	**0.217**	**0.493**	**0.675**
UK	0.049	**0.057**	**0.079**	**0.157**	**0.176**	**0.152**	**0.077**	**0.134**	**0.199**	**0.197**	**0.251**
US	0.025	0.029	0.038	**0.062**	**0.064**	**0.046**	**0.070**	0.039	**0.045**	**0.052**	**0.109**
Prob threshold	0.057	0.054	0.050	0.048	0.045	0.043	0.041	0.039	0.037	0.036	0.040

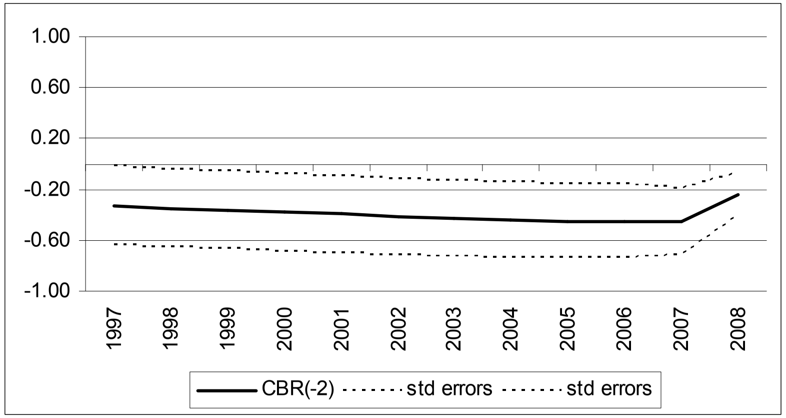
Note: figures in bold exceed the cut-off threshold.

Chart 1: Recursive coefficients on the rolling estimates (with bands for 2 standard errors)









4. Using the model to calibrate macroprudential policy

Although it is impossible to remove the possibility of a crisis from occurring it is possible to analyse how changing minimum capital and liquidity requirements could keep the probability of a crisis below certain threshold values. We can generate a menu of regulatory changes that would reduce crisis probabilities to an acceptable level. In terms of policy options, and in line with Section 1, we focus on financial variables, liquidity and capital adequacy, which regulators are free to manipulate: The macroeconomic crisis determinants (property price growth and the current account balance) do not appear in our menu because they are not regulatory targets, and as noted are likely to be only tangentially affected by banking regulation per se.

We use three alternative definitions of "acceptable crisis probability": one is the in-sample crisis probability and the other two are subjectively imposed criteria. The rationale for using the in-sample probability is that it represents the historic benchmark crisis rate which is not biased by policy makers' preferences. The subjective criterion however, allows the policy maker to use a more (or less) stringent level of acceptable crisis likelihood. Our in-sample crisis probability up to 2008 is 0.055, a crisis every 16 years, while our subjectively imposed criteria are respectively 0.03 which translates to one crisis every 33 years whilst our second subjective threshold is more stringent: 0.01 which translates to one crisis every 100 years. Obviously to bring crisis probabilities in line with the latter definitions will require more rigorous changes to liquidity and capital adequacy levels.

Accordingly, we calculated the required regulatory adjustment to obtain a consistent maximum level of risk in each year and for each country. These give the necessary adjustments to observed levels of leverage and narrow liquidity required to offset risks to financial stability generated by both the current changes in the macro variables and also the current levels of the regulatory variables. We undertook this for all 14 countries and all years, and we summarise the country-year data, first year-by year and second, country by country[19]. We generate three sets of probabilities as above for 0.01 and 0.03 (subjective probabilities) and 0.055 (the sample probability over 1980-1997, as well as for 1980-2008). For each case we generate means, medians and maxima for capital adjustment, liquidity adjustment and both together.

Looking at the year by year variables in Table 6, it is evident that a simple cyclical adjustment to the regulatory parameters is not required. Rather there is a fairly persistent upward shift in the required adjustment; implying crisis risk has on average been increasing. Underlying this are of course long lasting housing booms as well as largely structural balance of payments deficits. Obviously the adjustment is much greater with the lower target crisis probability. But equally, the standard deviation in each column is not high, implying that the cyclical adjustment to regulatory variables need not be very large in order to ensure ongoing stability of the financial system. This is even the case for the maxima case, where we are seeking to protect against banking crises "anywhere in the world". If banking crises are in any way potentially contagious then policy makers should consider setting the year maxima as a target if it is not possible to adjust regulatory capital on a contingent country by country basis.

[19] we should bear in mind that the regulatory adjustment will be zero in country-years where the model probability is below the threshold.

Table 6: Year by year analysis of required regulatory adjustment

	Year means			Year medians			Year maxima		
prob = 0.01	Both	lev(-1)	nliq(-1)	Both	lev(-1)	nliq(-1)	Both	lev(-1)	nliq(-1)
1998	1.3	1.7	5.9	1.2	1.6	5.6	4.0	5.2	19.2
1999	1.1	1.5	5.3	0.8	1.1	3.8	3.5	4.3	16.5
2000	1.3	1.9	6.9	0.9	2.4	6.4	4.1	5.1	20.2
2001	1.4	1.9	7.5	0.8	2.1	5.4	5.5	6.8	27.7
2002	1.6	2.1	8.8	1.0	2.0	5.5	5.5	6.9	29.4
2003	1.4	1.7	8.0	0.7	0.9	4.3	5.1	6.2	28.5
2004	1.0	1.3	6.2	0.3	0.9	2.3	3.6	4.4	21.5
2005	0.1	0.1	0.4	0.0	0.0	0.0	0.9	1.0	5.2
2006	1.5	1.8	9.5	0.2	0.5	1.8	7.8	9.2	50.0
2007	1.7	2.0	11.4	0.3	0.4	2.2	7.4	8.7	49.8
2008	2.0	2.7	10.9	0.2	1.1	2.4	9.3	11.5	48.5
Total mean	**1.3**	**1.7**	**7.3**	**0.6**	**1.2**	**3.6**	**5.2**	**6.3**	**28.8**
SD	**0.5**	**0.7**	**3.1**	**0.4**	**0.8**	**2.0**	**2.4**	**2.8**	**14.8**

	Year means			Year medians			Year maxima		
prob = 0.03	Both	lev(-1)	nliq(-1)	Both	lev(-1)	nliq(-1)	Both	lev(-1)	nliq(-1)
1998	0.2	0.3	1.0	0.0	0.0	0.0	1.8	2.3	8.5
1999	0.2	0.3	1.0	0.0	0.0	0.0	1.3	1.7	6.4
2000	0.4	0.5	2.0	0.0	0.0	0.0	2.0	2.5	9.8
2001	0.5	0.6	2.3	0.0	0.0	0.0	3.4	4.3	17.4
2002	0.6	0.8	3.5	0.0	0.0	0.0	3.6	4.4	19.1
2003	0.5	0.6	2.6	0.0	0.0	0.0	3.1	3.8	17.7
2004	0.3	0.4	1.8	0.0	0.0	0.0	1.7	2.1	10.3
2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2006	0.8	1.0	5.3	0.0	0.0	0.0	5.9	7.1	38.0
2007	0.9	1.1	6.1	0.0	0.0	0.0	5.7	6.6	38.2
2008	1.3	1.6	6.8	0.0	0.0	0.0	7.5	9.2	39.1
Total mean	**0.5**	**0.6**	**2.9**	**0.0**	**0.0**	**0.0**	**3.3**	**4.0**	**18.6**
SD	**0.4**	**0.5**	**2.2**	**0.0**	**0.0**	**0.0**	**2.3**	**2.7**	**13.9**

	Year means			Year medians			Year maxima		
prob = 0.055	Both	lev(-1)	nliq(-1)	Both	lev(-1)	nliq(-1)	Both	lev(-1)	nliq(-1)
1998	0.0	0.1	0.2	0.0	0.0	0.0	0.5	0.7	2.5
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.3
2000	0.1	0.1	0.3	0.0	0.0	0.0	0.8	1.0	3.8
2001	0.2	0.2	0.9	0.0	0.0	0.0	2.2	2.7	11.3
2002	0.3	0.3	1.5	0.0	0.0	0.0	2.4	2.9	12.8
2003	0.2	0.3	1.2	0.0	0.0	0.0	2.0	2.4	11.3
2004	0.1	0.1	0.5	0.0	0.0	0.0	0.6	0.8	3.7
2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2006	0.5	0.6	3.5	0.0	0.0	0.0	4.9	5.8	31.5
2007	0.6	0.7	4.1	0.0	0.0	0.0	4.6	5.4	31.0
2008	0.9	1.1	4.8	0.0	0.0	0.0	6.3	7.9	33.2
Total mean	**0.3**	**0.3**	**1.5**	**0.0**	**0.0**	**0.0**	**2.2**	**2.7**	**12.8**
SD	**0.3**	**0.4**	**1.8**	**0.0**	**0.0**	**0.0**	**2.2**	**2.6**	**13.0**

As regards the suggestions for levels policy adjustment which are generated, looking at the upper left quadrant of Table 7 we can highlight that across 14 OECD countries, a 1.7 % rise in leverage or a 7.7 % rise in liquidity will reduce the average probability of crisis to 0.01 across time. Alternatively, both could be increased by 1.4 %. In terms of protecting countries on average against the worst year, this would need on average a capital increase of 4.6 percentage points, or liquidity up by 19.8 percentage points or both up by 3.7

percentage points. This will still leave some countries with a probability of having a crisis that is greater than 1 percent in some years, however

Table 7: Country averages for required regulatory adjustment

		Prob=0.01			Prob=0.03			Prob=0.055		
		Country mean	Country median	Country maximum	Country mean	Country median	Country maximum	Country mean	Country median	Country maximum
Mean	Both	1.41	1.11	3.70	0.52	0.29	1.88	0.27	0.14	1.07
	lev(-1)	1.73	1.42	4.59	0.63	0.35	2.32	0.32	0.17	1.32
	nliq(-1)	7.77	6.20	19.83	2.94	1.64	9.87	1.54	0.81	5.62
SD	Both	1.21	1.44	2.24	0.75	0.83	2.07	0.51	0.53	1.81
	lev(-1)	1.47	1.67	2.77	0.91	1.02	2.57	0.62	0.65	2.24
	nliq(-1)	6.83	7.87	12.34	4.33	4.70	11.06	3.01	3.02	9.52

Turning to the country by country data, (see Table A1 in the Appendix) we note the significant variance between required capital and liquidity standards. So for example the capital adjustment for 1% crisis probability ranges from zero in Finland to 5.3 % the UK. This variability is evident in Table 7 which shows a much higher standard deviation than do the year by year standards. Although the focus of policy discussions has been on procyclicality, our results suggest that such country differences have to be reconciled before international reforms can be agreed upon.

We now consider the question: what are the country-specific changes to capital and liquidity that would be required to maintain a crisis probability of 1 %? Asking the question in this way allows us to focus on the risk in terms of (a) cross-sections and (b) aggregates. From a cross-sectional perspective, we are interested in the corrections required to maintain a 1% probability in each and every country individually. For example, given the mean liquidity and capital adequacy observed in the UK over the period 1998-2007, we can compute the equal changes to both that are required to maintain a 1% crisis probability over the same period, and then we can average those changes and regard it as a regulatory target. Columns 1 and 2 in Table 8 (top panel) show the actual data and columns 3 and 4 show the country-specific adjustments to leverage and liquidity together and to leverage alone which display considerable heterogeneity: countries such as the US, UK, Japan and Spain require much larger adjustments relative to others.

Columns 5 and 6 could be seen as regulatory targets, in that they are respectively the averages of column 3 and 4. These are the averages across both countries and time of the targets required to keep probabilities at 1 percent year by year. This does not however reduce average probabilities to one as the logistic function is non-linear and the average probability will marginally exceed one with these targets. We assume this is achieved by spreading the required systemic adjustment equally amongst each economy; the adjustment factor applied to each country is identical and is equivalent to the average adjustment across all countries and years. It is interesting to note the different "contributions" that each country must make to ensure systemic stability given their underlying adequacies in liquidity and leverage. These are presented in columns 7 – 9 of Table 8 which show the extent to which countries have over or undershot the international requirement. Negative figures for economies such as Belgium, Canada and Denmark imply they are overcapitalised compared to the international agreement because the adjustments to maintain their own crisis probabilities at 1% are lower than the international adjustments. Unless they have reasons to hold capital above the international minimum, these countries would lose if they signed up to international agreements: they would be required to hold

more costly capital even though their contribution to OECD risk might be relatively small. In contrast, countries such as Spain, UK and US are winners because their own average capital adjustments (due to their higher crisis risks) are already higher than the international requirements. By entering international agreements they could hold less capital than required and therefore not pay for the negative systemic externalities they generate.

Table 8: Levels of leverage and liquidity required for 0.01 probabilities (based on equal adjustment of both)

Column	1	2	3	4	5	6	7	8
	Observed average over 1998-2007		Country specific levels of liquidity and leverage needed to reduce all prob. to 0.01 or below		Leverage & liquidity required by international agreement to reduce average prob. to 0.01		Under or overshoot	
Top Panel	lev	nliq	lev+liq	lev alone	lev+liq	lev alone	lev and nliq	lev
Belgium	3.51	22.74	2.11	2.56	3.70	4.59	-1.59	-2.03
Canada	5.40	9.39	3.31	4.15	3.70	4.59	-0.39	-0.44
Denmark	6.07	5.54	3.35	4.15	3.70	4.59	-0.36	-0.44
Finland	9.12	8.29	0.00	0.00	3.70	4.59	-3.70	-4.59
France	4.46	13.93	5.08	6.25	3.70	4.59	1.38	1.66
Germany	4.15	16.28	3.12	3.79	3.70	4.59	-0.59	-0.80
Italy	6.97	17.51	1.74	2.14	3.70	4.59	-1.97	-2.45
Japan	4.40	25.14	3.96	5.19	3.70	4.59	0.26	0.60
Neths	3.67	7.08	4.72	5.80	3.70	4.59	1.02	1.21
Norway	6.25	5.20	2.34	2.87	3.70	4.59	-1.36	-1.72
Sweden	5.71	6.75	2.38	2.90	3.70	4.59	-1.32	-1.69
Spain	7.87	13.65	9.32	11.48	3.70	4.59	5.62	6.89
UK	6.10	5.38	6.08	7.63	3.70	4.59	2.37	3.04
US	9.37	6.87	4.35	5.34	3.70	4.59	0.65	0.75
Mean	5.93	11.70	3.70	4.59	3.70	4.59		
SD	1.88	6.64	2.24	2.77	0.00	0.00		

Column	1	2	3	4	5	6	7	8
Bottom Panel	2007 figure		Own standard to reduce 2008 prob. to 0.01		Interational agreement for 2008 (0.01 average)		Under or overshoot	
	lev	nliq	lev+liq	lev alone	lev+liq	lev alone	lev and nliq	lev
Belgium	4.31	13.07	2.11	2.56	2.23	2.77	-0.13	-0.21
Canada	5.45	7.99	1.43	1.75	2.23	2.77	-0.80	-1.02
Denmark	5.83	1.23	2.60	3.28	2.23	2.77	0.37	0.51
Finland	8.33	5.68	0.00	0.00	2.23	2.77	-2.23	-2.77
France	3.81	10.93	5.08	6.25	2.23	2.77	2.85	3.48
Germany	4.13	12.78	0.00	0.00	2.23	2.77	-2.23	-2.77
Italy	8.04	20.54	0.31	0.51	2.23	2.77	-1.92	-2.26
Japan	3.90	30.31	0.00	0.00	2.23	2.77	-2.23	-2.77
Neths	3.96	4.57	0.00	0.00	2.23	2.77	-2.23	-2.77
Norway	5.15	2.12	0.00	0.00	2.23	2.77	-2.23	-2.77
Sweden	5.55	4.72	0.00	0.00	2.23	2.77	-2.23	-2.77
Spain	7.02	7.50	9.32	11.48	2.23	2.77	7.09	8.71
UK	5.19	4.39	6.08	7.63	2.23	2.77	3.84	4.86
US	10.20	6.75	4.35	5.34	2.23	2.77	2.12	2.57
Mean	5.78	9.47	2.23	2.77	2.23	2.77		
SD	1.94	7.87	2.94	3.62	0.00	0.00		

To place the above analysis in the context of the sub-prime episode, we repeat the calculations specifically for 2008 (Table 8, bottom panel). Although countries such as

Denmark held sufficient capital and liquidity over the entire sample period it is clear that during the crisis they should have raised their standards. On the other hand, Canada and Norway for instance actually showed an improvement in their positions in 2008 relative to their average standards. At the same time, risky countries such as the UK, US, France and Spain had developed such degrees of systemic risks in 2008 that their capital and liquidity surcharges increase substantially beyond their period averages. These costs could have been mitigated if adequate provisions had been held in the decade preceding the sub-prime episode and they show the extent to which vulnerabilities had built up in these economies due to inadequate regulations.

One use of the estimates above could be to calibrate fixed minima and guides to maxima of a procyclical policy based on the averages and maxima respectively. In other words, the average results at the chosen level of risk, (either country specific or at an international level), can give the minimum standards for levels of capital. The mean values in the top panel of Table 8 suggest a rise of liquidity and leverage of around 3.7 %. However, countries such as the UK, the US and France are left with crisis probabilities in excess of 1% and this may be considered important. If the international agreement is seen as a way of 'tying hands' then there is a case for raising the regulatory level of capital and liquidity together by 4.35% which reduce probabilities everywhere and brings it down to 1% in the US over both the sample average and in 2008. These results suggest capital and liquidity should be raised by at least 4 %. This could be worked out either on a country specific, global average or worst case basis (e.g. 12 % more leverage as in Spain). Of course maxima should not be set in stone and if the situation is objectively worse than 2008, then capital should reflect it.

Calculating fixed minima and guides to maxima is only part of a procyclical adjustment. There is a question what variables can be used to guide the cyclical adjustment. We noted above that a simplistic rule based on GDP or credit growth, as recommended by many official and academic commentators, are not appropriate. Our work suggests that the appropriate adjustment for procyclicality requires the country to calculate the trade-off between house prices, current account balances and regulatory variables over time. Since there is nonlinearity in a logit equation, there is not a simple rule that can be derived. Nevertheless, we can show examples of countercyclical policy by illustrating how policy should adapt to higher house price growth or current account imbalances.

Table 9 offers a possible illustration, showing how much tighter regulation must be with 5% higher house price growth. The scenario with the higher house prices is deducted from the actuals, so nothing else changes. It can be seen that the regulatory adjustment is greater, as would be expected, with higher house price growth, but the relationship is not 1:1 – it depends also on the other regulatory and non regulatory variables in the model. A given growth rate of house prices is more threatening to financial stability when there is also low capital and liquidity as well as a current account deficit. Compare for example 2003 in the UK and 2007 in Spain that have the same house price growth but very different regulatory prescriptions. It is clear that macroprudential rules for dealing with procyclicality can only be fully expressed in terms of the full equation and the probabilities it generates. Note again that there are marked cross country differences even between these four cases.

Table 9: Change in regulation required for retaining sample mean probability (0.0555) with 5% higher house price growth

	France		Spain		UK		US	
	Regulatory adjustment	Actual RHPG (-3)	Regulatory adjustment	Actual RHPG (-3)	Regulatory adjustment	Actual RHPG (-3)	Regulatory adjustment	Actual RHPG (-3)
1998	0	-3.2	0	-0.1	0.58	-2.5	0	0.8
1999	0	1.3	0	-1.7	1	0.2	0	1.5
2000	0	0.8	0	0	1.9	6.2	0.4	1.8
2001	0	1.7	0	3.8	3.5	8.9	1.5	4.2
2002	0.1	7.5	0.3	5.3	3.8	9.5	1.7	3.1
2003	0	6.2	0.4	4.7	3.8	13.7	1.2	4
2004	0	6.1	0.5	6.1	2.5	6.1	2.2	5.4
2005	0.7	7.2	2.1	12.5	3.9	14.3	1.1	4.9
2006	2.2	10	4.6	14.1	4.8	13.9	1.5	4.3
2007	3.7	13.4	6.8	13.4	4.7	10.1	2.1	6.7
2008	4	13.6	7.3	10.2	4.4	3	2.7	8.4

Our overall conclusion on countercyclical regulatory policy is that commentators focusing on GDP and credit growth are incorrect – it is not the cycle per se but bad lending and the consequent vulnerability of the banking system which cause crises. Hence it is bad lending, as expressed by property booms and current account deficits that require macroprudential policies to counteract them. On the other hand, there could be indirect links from credit and GDP which could indirectly justify their use in countercyclical "rules". Accordingly, we finally look at the relation between GDP and credit on the one hand and house prices and current accounts on the other. This gives a view as to whether there could be a usable proxy relationship. As shown in Table 10, there are indeed some Granger causalities,[20] albeit mainly between credit growth and house prices (and even then not in the US). But these patterns are not common across countries, again suggesting that international agreement would be hard to reach. And the best prescription remains to use the estimated links from house prices and the current account to crises directly.

Table 10: Granger causality across the sample and in individual countries over 1980-2007

		Panel	BG	CN	DK	FN	FR	GE	IT	JP	NL	NW	SD	SP	UK	US
GDP>CBR		Y	N	N	N	N	N	N	N	N	Y	Y	N	N	N	N
GDP>RHPG		Y	N	N	N	N	N	N	N	N	N	N	N	N	Y	N
CG>CBR		Y	N	N	N	N	N	Y	N	N	Y	Y	Y	Y	N	N
CG>RHPG		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N

Equations are estimated for the right hand side variable as defined in the text using three lags of itself and three of the "independent" variables GDP (GDP growth) or CG (credit growth). A positive result in terms of significance of the latter is shown by Y and a negative one by N.

Conclusions

Low levels of liquidity and low levels of capital along with recent house price booms and current account imbalances have been shown to be the major explanatory variables driving crisis probabilities in OECD countries. We have shown that these variables 'cause' or are useful for predicting crises over the period 1980 to 2008, and that the same variables are

[20] The panel result is in a sense misleading as it captures any single countries' significant causality.

significant in explaining crises in the OECD up until 1997. Hence it would have been possible to use this model to evaluate the probability of crises between 1998 and 2008. And we show that we can "call" the US crisis accurately, as well as those in France, Belgium and the UK both in sample and forecasting using the 1980-1997 model.

We can also estimate the model recursively each year to derive a year-ahead forecast over periods when it is more plausible that the authorities would have good estimates of the right hand side variables. Furthermore, the model allows us to calibrate prudential policy to keep the crisis probability below a chosen threshold. These can be usefully input to the debate on macroprudential regulation in that these prescriptions could be either "levels" increases in capital and liquidity to be sustained at all times or a "target" level to be attained at the peak of the boom in a countercyclical macroprudential policy. We show what path macroprudential policy could have followed to offset specific macroeconomic risks to banks. A degree of compromise would be needed to ensure that countries could agree on a single macroprudential adjustment. We show also that rules based on GDP or credit growth are less appropriate than a full calculation of systemic risk based on the current model of house prices, current accounts, leverage and liquidity.

We conclude by noting that the analysis is incomplete for not allowing for the costs of regulation since higher capital and liquidity requirements induce banks to raise lending margins, hence adversely affecting the user cost of capital, investment and the capital stock. As derived in detail for the UK in Barrell et al (2009), deciding on the appropriate level of regulatory tightening necessitates a balancing of such costs of regulation with the benefits of lower crisis risk that we have estimated in this paper.

Table A1: **Country by country analysis of required regulatory adjustment**

		Prob=0.01			Prob=0.03			Prob=0.055		
		Country mean	Country median	Country maximum	Country mean	Country median	Country maximum	Country mean	Country median	Country maximum
Belgium	Both	0.38	0.00	2.11	0.02	0.00	0.18	0.00	0.00	0.00
	lev(-1)	0.45	0.00	2.56	0.02	0.00	0.19	0.00	0.00	0.00
	nliq(-1)	2.26	0.00	10.94	0.06	0.00	0.71	0.00	0.00	0.00
Canada	Both	1.26	0.63	3.31	0.22	0.00	1.19	0.00	0.00	0.00
	lev(-1)	1.57	0.71	4.15	0.27	0.00	1.42	0.00	0.00	0.00
	nliq(-1)	6.51	4.44	15.80	1.06	0.00	5.52	0.00	0.00	0.00
Denmark	Both	0.00	0.00	0.00	0.26	0.00	1.24	0.00	0.00	0.00
	lev(-1)	1.49	1.30	3.35	0.31	0.00	1.56	0.00	0.00	0.00
	nliq(-1)	1.85	1.52	4.15	1.26	0.00	6.10	0.00	0.00	0.00
Finland	Both	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	lev(-1)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	nliq(-1)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
France	Both	1.77	1.15	5.08	0.66	0.00	3.14	0.36	0.00	2.00
	lev(-1)	2.13	1.30	6.25	0.79	0.00	3.88	0.43	0.00	2.48
	nliq(-1)	10.24	6.50	29.87	3.96	0.00	18.12	2.15	0.00	11.04
Germany	Both	1.24	1.54	3.12	0.16	0.00	1.17	0.00	0.00	0.00
	lev(-1)	1.57	1.83	3.79	0.20	0.00	1.44	0.00	0.00	0.00
	nliq(-1)	6.37	8.35	16.56	0.85	0.00	6.31	0.00	0.00	0.00
Italy	Both	0.42	0.31	1.74	0.00	0.00	0.00	0.00	0.00	0.00
	lev(-1)	0.54	0.51	2.14	0.00	0.00	0.00	0.00	0.00	0.00
	nliq(-1)	2.60	1.51	12.02	0.00	0.00	0.00	0.00	0.00	0.00
Japan	Both	0.51	0.00	3.96	0.17	0.00	1.85	0.05	0.00	0.54
	lev(-1)	0.65	0.00	5.19	0.21	0.00	2.31	0.06	0.00	0.70
	nliq(-1)	2.43	0.00	19.15	0.78	0.00	8.54	0.22	0.00	2.46
Netherlands	Both	1.71	1.25	4.72	0.61	0.00	2.78	0.24	0.00	1.60
	lev(-1)	2.12	1.74	5.80	0.75	0.00	3.41	0.29	0.00	1.96
	nliq(-1)	9.28	5.81	25.63	3.35	0.00	14.96	1.32	0.00	8.57
Norway	Both	0.21	0.00	2.34	0.02	0.00	0.24	0.00	0.00	0.00
	lev(-1)	0.26	0.00	2.87	0.03	0.00	0.30	0.00	0.00	0.00
	nliq(-1)	1.03	0.00	11.37	0.11	0.00	1.19	0.00	0.00	0.00
Sweden	Both	0.89	0.67	2.38	0.04	0.00	0.35	0.00	0.00	0.00
	lev(-1)	1.09	0.71	2.90	0.05	0.00	0.44	0.00	0.00	0.00
	nliq(-1)	4.62	3.11	12.50	0.23	0.00	1.80	0.00	0.00	0.00
Spain	Both	2.97	2.08	9.32	1.80	0.20	7.48	1.44	0.00	6.35
	lev(-1)	3.57	2.47	11.48	2.17	0.21	9.24	1.73	0.00	7.85
	nliq(-1)	17.63	11.91	50.00	10.85	0.90	39.06	8.70	0.00	33.18
UK	Both	4.28	5.10	6.08	2.47	3.09	4.19	1.44	1.99	3.14
	lev(-1)	5.25	6.03	7.63	3.02	3.80	5.26	1.76	2.44	3.88
	nliq(-1)	23.67	27.69	34.96	13.87	17.39	22.87	8.26	11.30	16.39
US	Both	2.63	2.75	4.35	0.86	0.78	2.48	0.18	0.00	1.33
	lev(-1)	3.27	3.30	5.34	1.06	0.94	3.07	0.22	0.00	1.65
	nliq(-1)	14.31	15.95	22.50	4.84	4.72	12.95	0.97	0.00	6.97
Summary										
Mean	Both	1.31	1.11	3.47	0.52	0.29	1.88	0.27	0.14	1.07
	lev(-1)	1.71	1.42	4.53	0.63	0.35	2.32	0.32	0.17	1.32
	nliq(-1)	7.34	6.20	18.96	2.94	1.64	9.87	1.54	0.81	5.62
SD	Both	1.27	1.44	2.45	0.75	0.83	2.07	0.51	0.53	1.81
	lev(-1)	1.48	1.67	2.79	0.91	1.02	2.57	0.62	0.65	2.24
	nliq(-1)	7.01	7.87	13.01	4.33	4.70	11.06	3.01	3.02	9.52

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