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Against the background of the acknowledged importance of off-balance-sheet exposures in the sub prime crisis, we seek to investigate whether this was a new phenomenon or common to earlier crises. Using a logit approach to predicting banking crises in 14 OECD countries we find a significant impact of a proxy for the ratio of

Public commentary on the sub-prime crisis has highlighted the role of banks off-balance sheet (henceforth OBS) activities (Barrell and Davis, 2008). Figures stressing the exposure of banks to OBS risks have been widely cited[1]. Structured investment

models for banking crises along with other key macroprudential indicators. The first step is to estimate the amount of OBS activity of the banking system of each sample country. The literature on estimating OBS at a macro level is limited. One exception is Boyd and Gertler (1994) who questioned whether US banks share of intermediation had been maintained by a shift to OBS activity.[4] They used the rate of return for on-balance sheet assets to derive a measure of OBS assets according to the scale of non-interest income. It was assumed that non-interest income[5] was generated by implicit off-balance sheet assets with the same risk and return characteristics as on-balance sheet activity as indicated by net interest income. The exception was fee-based off-balance sheet activities (trust-type activities and service charges on deposits) which the authors classed as "non-risky" forms of income. The authors note that a similar form of capitalization of certain OBS activities that entailed risk exposure was required under Basel 1 for capital adequacy purposes (where this was to provide credit equivalents).

Feldman and Lueck (2007) replicated the Boyd-Gertler calculations for US data up to 2006. They found that capitalizing non-interest income gave a roughly constant share of banks in total intermediation despite a decline in the share of on balance sheet assets, illustrating the growing importance of OBS activity. They noted limitations to the Boyd-Gertler approach, notably the assumption that banks generate equal profitability from on and off-balance sheet assets, but nonetheless found it plausible. Clearly, if banks are more competitive in traditional lending than in non-interest generation,[6] the latter could include a wider margin and hence OBS assets could be overestimated by this method, and hence its use as a way of calculating the share of intermediation undertaken by banks may be questioned. However, income from off-balance sheet activities may contain information about the risk banks face, even if it is not a good measure of their assets. We focus on relative income shares below.

Further relevant contributions are from Stiroh (2004; 2006) who examined the effects of the ratio of non-interest income to total income on measures of bank risk and return in the US. The author found that at the aggregate level, declining volatility of total income occurred over 1984-2001 despite rising volatility of non-interest income. Lower total income volatility reflects instead lower volatility of interest income. At a bank level, rising shares of non-interest income were associated with unchanged returns but higher risk. This work provides an a priori justification for expecting OBS activity, linked in the works cited above to non-interest income, to be associated with banking crisis risk at the macro level.

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[4] The pattern of growing non-interest income and its implications for intermediation were also noted by Rogers (1998), who pointed out that from the late 1960s onwards, US banks had reduced their reliance on interest income from traditional activities. Instead, they placed increasing importance on the fee-based incomes they generated from securitization.

[5] Non interest income comprises revenue from banks' securitizations and other off-balance sheet and non-interest activities (which also include loan sales, backup lines of credit, and risk sharing through derivatives) as well as profits on proprietary trading, fees and service charges on deposits, securities underwriting fees and commissions on brokered securities transactions for third parties. However the non-interest income figures reported by the OECD do not decompose the revenues generated by these different activities.

[6] De Bandt and Davis (2000) in a study of the competitiveness of banking systems found that the competitive position for interest-generating and non-interest generating activities varied between countries. In the US the non-interest income market was found to be a more competitive than that for interest income, while in France the opposite was true. In Germany and Italy positions were comparable.

Our methodology for deriving an OBS proxy using OECD banking sector data

The significant variables in Barrell, Davis, Karim and Liadze (2010) were unweighted bank capital adequacy[8] (bank capital/total bank assets), bank liquidity ratios (liquidity as a proportion of total bank assets) and real house price growth. The reasons for this result are twofold – originally, crisis models tended to exclude the new variables due to lack of data for global samples, and secondly, crisis determinants have been shown to differ across country groups (e.g. between Asia and Latin America, see Davis, Karim and Liadze, (2011)).

Capital adequacy and liquidity can be regarded as defences against crises, while

To select our set of "traditional" determinants, we followed Demirguc-Kunt and Detragiache, (2005) who estimated over 1980-2002 for 94 countries with 77 crisis episodes[13]. Their potential predictors included real GDP growth, the rate of growth of real domestic credit, the real short term interest rate, and inflation. We also utilise these general indicators of economic activity. To accommodate the financial sector they included the fiscal balance, the ratio of money to foreign exchange reserves, the change in the credit to GDP ratio, the dollar exchange rate and changes in the terms of trade. Again, we utilise these variables, except for the latter three as they are more

banks. To test the hypothesis that risky securitisation generated systemic risk, as opposed to traditional OBS activity (which was viewed as risk reducing), we use two OBS variables in our initial model: a general level of OBS activity (defined as the ratio of off-balance sheet income/ total income) and this same level interacted with a post-2003 dummy. If the latter is significant at the cost of the former we can attribute a particular risky effect to securitisation without having to know the relative risk-return trade-offs between normal OBS transactions and risky securitisation.

Turning to our dependent variable, our dataset includes 23 crises in OECD countries. Over half the crises are from the World Bank Crisis Database covering 1974-2002, (Caprio et al 2003) as used in Barrell, Davis, Karim and Liadze (2010). That paper has crises in Canada in 1983, Denmark in 1987, the US in 1988, Italy and Norway in 1990, Finland, Sweden and Japan in 1991, France in 1994, whilst in the UK there are crises in 1984, 1991 and 1995. For the crises episodes in 2007 and 2008 we have used the crises dates from Laeven and Valencia (2010), who classified Belgium, Denmark, France, Germany, the Netherlands, Spain and Sweden in crisis by 2008 and the US and UK in 2007. The authors treat the 2008 crisis in the US and the UK as a continuation of 2007 crisis, while we treat 2007 and 2008 as individual crises since 2008 was induced by the collapse of Lehman Brothers.

A priori, we made no assumptions regarding the relative importance of our crisis predictors, even though Barrell, Davis, Karim and Liadze (2010) showed the "new" determinants to be superior to the "traditional" ones. We therefore adopt a general to specific approach whereby a starting regression accommodating our full set of determinants (lagged 2) is used to iteratively delete the most insignificant variable during each subsequent round of regressions.

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	1	2	3	4	5	6	7	8
	0.234	0.25	0.229	0.234	0.234	0.273*	0.256*	0.28**
	(0.176)	(0.131)	(0.117)	(0.115)	(0.113)	(0.063)	(0.08)	(0.05)
	0.039**	0.04**	-0.33***	-0.516***	-0.316***	0.041***	0.039***	0.038***
	(0.02)	(0.017)	(0.00)	(0.001)	(0.00)	(0.00)	(0.00)	(0.00)
	-0.111**	-0.112**	-0.112**	-0.115***	-0.123***	-0.114***	-0.115***	-0.14***
	(0.013)	(0.012)	(0.012)	(0.009)	(0.003)	(0.004)	(0.004)	(0.00)
	-0.329***	-0.334***	0.039**	0.034***	0.036***	-0.302***	-0.315***	-0.293***
	(0.00)	(0.00)	(0.016)	(0.006)	(0.003)	(0.00)	(0.00)	(0.00)
	-0.526***	-0.525***	-0.524***	-0.329***	-0.514***	-0.438***	-0.471***	-0.457***
	(0.001)	(0.001)	(0.001)	(0.00)	(0.001)	(0.00)	(0.00)	(0.00)
	0.101	0.104	0.098					
	(0.223)	(0.202)	(0.240)					

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ote: *,**,*** indicate significance on 90%,95%,99% levels correspondingly
P-values in parentheses, (-2) indicates a variable is lagged by 2 years.

The results of this sequential elimination process are reported in Table 1. It can be seen that throughout all stages of the elimination process, the first five variables in the table (namely leverage and liquidity ratios, real GDP growth, the current account balance/GDP ratio and post-2003 OBS activity) are generally significant with slight variation in their parameters. The opposite is true for all the remaining variables, all of which were highly insignificant. In particular we find that the full sample off balance sheet ratio is eliminated in the process, suggesting that over most of the period it did not raise risks, but rather reallocated them properly.

These results show that in OECD countries, growth in real output and lower defenses from less stringent bank regulation, along with current account imbalances and recent OBS activity were the most important factors driving the probability of a banking crisis occurring between 1980 and 2008. Although lax monetary policy and credit booms may at times contribute to banking crises, they are not the most powerful discriminators between times of crisis onset and other periods in OECD countries. The pertinent result is the significance of post-2003 OBS activity as opposed to the general level of OBS activity for the whole sample period. This clearly accords with the findings of Acharya and Richardson (2009), Altubas et. al. (2009) and other commentators

	Baseline	US Excluded	UK Excluded	Japan, Denmark & Norway Excluded
2003 Dummy*OBS Income/Total	0.038***	0.038***	0.043***	0.039***
	(0.00)	(0.00)	(0.00)	(0.00)
	-0.14***	-0.139***	-0.15***	-0.165***
	(0.00)	(0.00)	(0.00)	(0.00)
	-0.293***	-0.255***	-0.303***	-0.245***
	(0.00)	(0.002)	(0.001)	(0.005)
	-0.457***	-0.491***	-0.491***	-0.446***
	(0.00)	(0.00)	(0.00)	(0.00)
GDP Growth (-2)	0.28**	0.315**	0.352**	0.312*
	(0.05)	(0.044)	(0.026)	(0.073)

Note: *,**,*** indicate significance on 90%,95%,99% levels correspondingly
P values in parentheses, (-2) indicates a variable is lagged 2 years

To counteract the possibility that our results are driven by specific crisis prone countries, we ran robustness tests by eliminating the two countries that have the most crises in our sample: the US and the UK (3 and 5 crises respectively). A separate robustness exercise was conducted by eliminating Japan, Denmark and Norway simultaneously. These countries reported negative non-interest income at points during our estimation period which may have affected our constructed OBS variable such that the significance of post-2003 OBS activity hinges on these countries non-interest income series. The results of these tests are summarised (relative to our baseline specification) in table 3 which shows our results to be robust to the exclusion of the US and UK and also

Variable	
GDP growth(-2)	0.297** (0.043)
Narrow Liquidity(-2)	-0.114** (0.013)
Bank Dummy*(2003 Dummy*OBS Income/Total Income(-2))	0.006 (0.727)
Current Balance (%GDP)(-2)	-0.296*** (0.001)
2003 Dummy*OBS Income/ Total Income (-2)	0.037*** (0.005)
Bank Dummy	-0.63 (0.308)
Leverage(-2)	-0.471*** (0.00)

Note: *,**,*** indicate significance on 90%,95%,99% levels correspondingly
P values in parentheses, (-2) indicates a variable is lagged 2 years
Bank dummy 0 in market based Canada, Denmark, Sweden, UK and US, one elsewhere

There are a number of ways to investigate the importance of a variable to a logit model, with looking at marginal effects being the most common. However, in this case it is more useful to look at the effects of the change in OBS after 2003 by setting its parameter to zero in the estimated logit and projecting crisis probabilities over the period. In Belgium, Denmark, Italy, the Netherlands, Sweden, and the US, where we called a crisis, we would not have expected one if there had been no change in off balance sheet activity after 2003, and there would only have been positive calls in Spain, the UK and France, where in the first two the current balance was poor given bank capital that was available, or liquidity too low given other factors in the latter

(1980 - 2008)	all countries	excluding USA only
OFF BALANCE SHEET does not Granger cause PROPERTY PRICES (2 lags) **F-stat (probability)**	1.72 (0.18)	1.60 (0.20)
PROPERTY PRICES do not Granger cause OFF BALANCE SHEET (2 lags) **F-stat (probability)**	4.13** (0.02)	3.85** (0.02)

Note: *,**,*** indicate significance on 90%,95%,99% levels correspondingly

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Note: *,**,*** indicate significance on 90%,95%,99% levels correspondingly
P-values in parentheses, (-2) means a variable is lagged 2 years

To construct our early warning system, we repeat the general to specific exercise for 1980 – 2006 by including the level of OBS activity at 2 lags as before, but this time replacing the post-2003 OBS variable with house price growth at 3 lags, albeit over the whole period. Table 6 shows the deletion sequence of the variables, ending with the final specification which includes liquidity, capital adequacy, current account balances and property price growth as crisis determinants. Essentially, property prices

capture the risky securitisation practices of banks prior to 2007 and the concurrent business cycle dynamics which made borrowing seem affordable and risky lending seem justified. To ensure this relationship is robust we re-estimate the model in column 8 but exclude the US where house price falls played a major role in the subprime crisis. These results, in column 8[a], show that the link between property prices and securitisation was not driven solely by dynamics in the US, allowing us to utilise the model in column 8 as our early warning system.

The in-sample performance (see Table 7) of this specification is good: 75% of crises during 1980 – 2006 are correctly identified with a cost of false calls in only 26% of non-crisis cases. The number of false calls in the three years in the run up to crises is noticeable, and we calculate them in Table 8, and if we include these as ‚true (but early) calls the overall false call rate falls to 23.5 per cent.

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(Based on Column 8, Table 6.)
Using the in sample proportion of crisis years (0.0357) as a cut-off
Note Dep is the (binary) dependent variable

The out of sample performance should be evaluated in terms of the ability of the full model to call the sub-prime crises that occurred after the 1980 – 2006 estimation period. If this early warning model had been used for forecasting purposes in 2006, policy makers would have had at least a year to deal with the impending crises in the US, Belgium and France, as well as being in a position to recognise there might be contagion for such a sustained set of problems in these countries. Indeed, as we can see from Table 8 this model was flagging up the possibility of a crisis in the UK as early as 2004, and in Spain as early as 2005.

Table 9 summarises the out-of-sample accuracy of our early warning model, which is the main purpose of this part of the estimation exercise. The model is able to predict 7 out of the 11 crises that subsequently materialised. It misses the Netherlands, which was a spillover through a jointly owned bank (Fortis) from Belgium, and it also misses Denmark and Sweden, which was a marginal call, as well as Germany. In the latter case the implications of the purchase of US sourced ABS to hold on balance sheet were difficult to draw, but the systematic nature of warnings elsewhere should have been leading regulators everywhere to take account of the risk they were facing. As the assets were US housing market related, and this variable was indicating problems in the US, it should have been read as doing so in Germany as well. This out-of-sample accuracy rate is extremely good in comparison to other crisis models in the literature such as those underpinning the latest Basel III capital regulations (see Borio and Drehmann, 2009).

Belgium	1	0	1	0	1	
Canada	7	1	6	0	6	
Denmark	0	0	0	0	0	
Finland	5	1	4	0	4	
			12	3		prior 3 years (1994)
				1		prior 1 years (2008)
Germany	0	0	0	0	0	
Italy	2	0	2	0	2	
Japan	3	0	3	0	3	
Netherlands	2	0	2	0	2	
Norway	3	1	2	2	0	prior 2 years (1990)
Sweden	2	0	2	0	2	
Spain	3	1	2	2	0	prior 2 years (2008)
				3		prior 3 years (1991)
				2		prior 2 years (2007)
US	3	1	2	0	2	

Based on Column 8, Table 6)

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OUT-OF-SAMPLE CRISES (2007, 2008) (Country-year)	CORRECT IDENTIFICATIONS BY MODEL
Belgium-08	✓
Denmark-08	
France-08	✓
Germany-08	
Netherlands-08	
Spain-08	✓
Sweden-08	
UK-07	✓
UK-08	✓
USA-07	✓
USA-08	✓

(Based on Column 8, Table 6, which proxies OBS with House Price Changes)

The change in the nature of off balance sheet activity after 2003 from risk diversification towards regulatory arbitrage driven securitisation is widely believed to have left banks without sufficient capital to cover the risks they were facing. This paper demonstrates clearly that this was the case, showing for the first time that off balance sheet activity contributed significantly to crisis probabilities after 2003. However, it is not clear that this variable could have been used in an early warning system to call the subprime crisis, but movements in house prices are found to Granger cause our off balance sheet indicator and hence it is possible to substitute this into a warning system prior to 2006 . If we do so we show that it would have been relatively easy to call the subprime crisis in advance, and policy may have

De Bandt, O. and Davis, E.P. (2000), "Competition, Contestability and Market Structure in European Banking Sectors on the Eve of EMU", *Journal of Banking and Finance*, 24, 1045-1066.

Demirgüc-Kunt, A., and Detragiache, E., (1998), "The Determinants of Banking Crises

We use total non-interest income as the basis of our measure of OBS activity, and net interest income as a measure of on balance sheet activity, adjusting each for provisions. Our approach is distinct from Boyd and Gertler (1994) in that we take the ratio of these two aggregates from the income statement as an indicator of off balance sheet activity (adjusted for provisions) for 14 countries. In contrast, Boyd and Gertler use US data and adjust OBS activity down for fee-based off-balance sheet activities, estimate a figure for implicit OBS assets and compare it with figures for on balance sheet assets. We consider that fee-based income is far from risk-free due to risk of volatile demand for such services as well as reputation risks that may arise from it. Hence the inclusion of such activity in total OBS activity is in our view justified[17].

ratio for the US for the entire sample period for illustrative purposes and can clearly observe a considerable increase in OBS activity since 1995.

	Belgium	Canada	Denmark	Finland	France	Germany	Italy	Japan	Neths	Norway	Spain	Sweden	UK	US
1980	0.13	0.23	0.40	0.40	0.17	0.23	0.37	0.26	0.31	0.21	0.17	0.35	0.29	0.27
1985	0.22	0.27	0.67	0.54	0.17	0.24	0.31	0.27	0.29	0.33	0.19	0.41	0.39	0.35
1990	0.21	0.33	0.21	0.50	0.26	0.32	0.26	0.34	0.31	0.38	0.21	0.29	0.48	0.38
1995	0.34	0.37	0.39	0.21	0.63	0.24	0.25	0.23	0.35	0.25	0.27	0.34	0.46	0.34
2000	0.52	0.57	0.49	0.40	0.66	0.43	0.40	0.08	0.49	0.28	0.40	0.54	0.46	0.43
2003	0.44	0.50	0.44	0.58	0.62	0.37	0.36	0.16	0.43	0.29	0.37	0.46	0.54	0.45
2004	0.36	0.50	0.48	0.40	0.65	0.26	0.35	0.07	0.43	0.28	0.36	0.45	0.61	0.43
2005	0.39	0.52	0.48	0.34	0.62	0.40	0.35	0.13	0.47	0.30	0.38	0.52	0.63	0.43
2006	0.58	0.55	0.55	0.38	0.77	0.38	0.43	0.09	0.52	0.29	0.44	0.69	0.65	0.44
2007	0.63	0.54	0.52	0.43	0.80	0.38	0.38	0.03	0.57	0.30	0.43	0.58	0.61	0.45
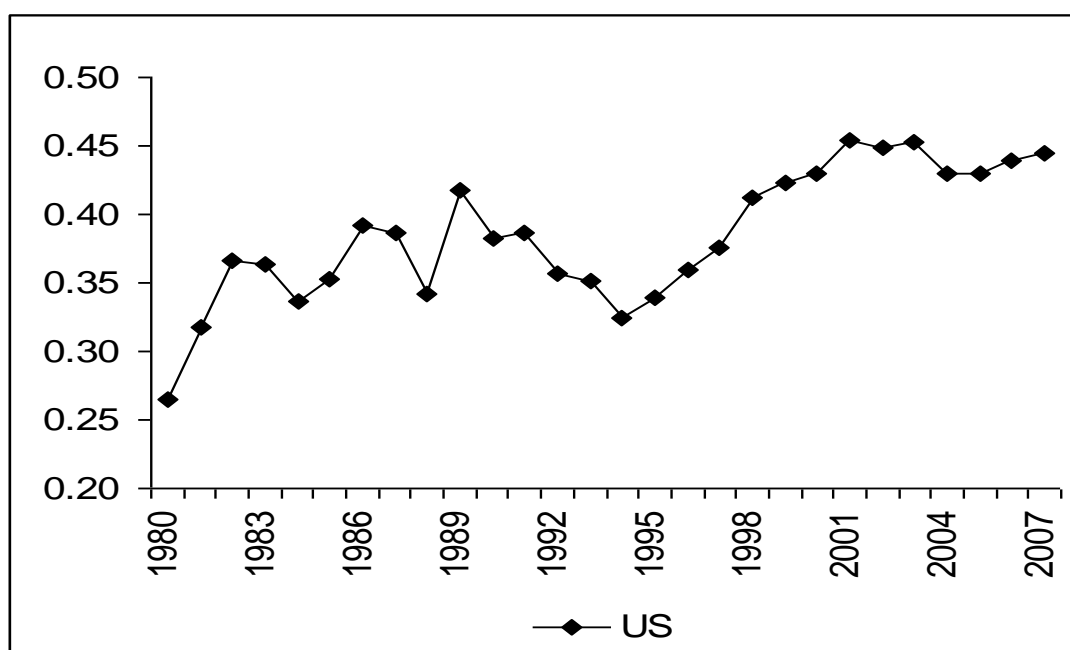
GDP growth	
2003 Dummy*OBS Income/Total Income	
Narrow Liquidity	
Current Balance (% GDP)	
Leverage	
Budget Balance as % GDP	
M2/Rreserves	
OBS Income/Total Income	
Inflation	
Real Interest Rate	
Real house Price Growth	
Real Credit Growth	

NIGEM stands for National Institute Global Economic Model, National Institute of Economic and Social Research