

Accounting for country specificities in predicting banking crises: A Conditional Moments Approach

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Presentation outline

- ▶ Role of indicators and thresholds
- ▶ Methods to obtain thresholds:
 - Traditional signalling approach
 - Conditional moments approach
- ▶ Conditional moments approach
 - Empirical implementation
 - Results



Role of indicators and thresholds

- ▶ The European Systemic Risk Board (ESRB) strongly encourages Member States to develop sound macro-prudential policy strategies to frame macro-prudential policy actions.
 - Linking the ultimate objectives of macro-prudential policy to instruments and indicators.
 - Leading indicators and associated thresholds, which could serve as a basis for guided discretion on the activation of macro-prudential instruments.

- ▶ Signalling approach: a model issues a signal (or warning) when one or more indicators exceed a particular threshold.

- ▶ Several types of thresholds:
 - On individual indicators vs. on aggregate measures (e.g., logit banking crisis probabilities).
 - Pooled (cross-country) vs. country-specific thresholds.
 - Unconditional vs. conditional.



Methods to obtain thresholds: overview

Method	Pros	Cons
Simple moments	<ul style="list-style-type: none">• Simple.• Only based on indicators' distribution.• Low data requirements.	<ul style="list-style-type: none">• Ad hoc: simply based on past information, not accounting for pre-crisis vs. normal times.• Assumption on moment/percentile.
Conditional moments	<ul style="list-style-type: none">• Simple.• "Economic" foundation (conditional on pre-crisis vs. normal times).• Only based on indicators' distribution.	<ul style="list-style-type: none">• Assumption on prediction horizon.• Assumption on moment and confidence level.• Large data requirements (sufficient amount of crisis events to condition on).
Objective function-based (traditional signalling approach)	<ul style="list-style-type: none">• "Economic" foundation (conditional on pre-crisis vs. normal times).	<ul style="list-style-type: none">• More "complex".• Assumption on prediction horizon.• Assumption on objective function.• Large data requirements (sufficient amount of crisis events to condition on).



Methods to obtain thresholds: traditional signalling approach

Objective function-based	
Step 1	Determine relevant crisis/distress event on which to condition
Step 2	Assume prediction horizon
Step 3	Distinguish pre-crisis observations (prediction horizon), crisis observations (to be dropped) and normal times
Step 4	Determine for a grid of thresholds whether a signal (indicator exceeding thresholds) is given or not
Step 5	Determine for each threshold whether or not the signals (not) given are correct (see confusion matrix)
Step 6	Calculate for each threshold the objective function
Step 7	Select the threshold for which the objective function is optimised

- ▶ Confusion matrix (step 5):

	pre-crisis	normal
signal	A	B
no signal	C	D

- ▶ Policymaker's loss function (steps 6 and 7):

$$L = \theta \frac{C}{A + C} + (1 - \theta) \frac{B}{B + D}$$

- ▶ Sensitivity of thresholds to preference parameter θ ...
- ▶ Country-specific thresholds?

- ▶ Note: AUROC is based on $\frac{A}{A+C}$ as a function of $\frac{B}{B+D}$, as obtained from all possible thresholds in the grid in Steps 4 and 5. AUROC evaluates an indicator, not an indicator-threshold combination.



Methods to obtain thresholds: conditional moments approach

	Conditional moments
Step 1	Determine relevant crisis/distress event on which to condition
Step 2	Assume prediction horizon
Step 3	Distinguish pre-crisis observations (prediction horizon), crisis observations (to be dropped) and normal times
Step 4	Calculate cross-country average indicator level for pre-crisis observations and normal times
Step 5	Obtain confidence bounds on cross-country average indicator level for pre-crisis observations and normal times
Step 6	Use obtained confidence bounds to obtain thresholds.

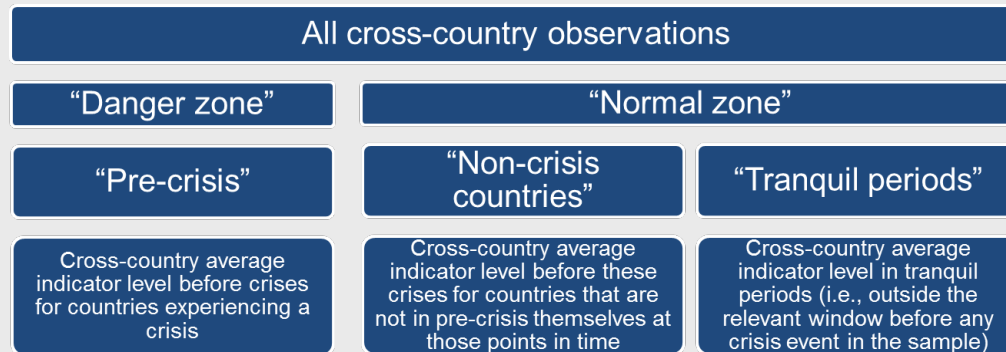
- ▶ Novel methodology to identify leading indicators and associated thresholds to predict the occurrence of banking crises.

- ▶ Country-specific thresholds based on pooled (cross-country) data.
 - Substantial improvement in signalling power.
- ▶ Thresholds are not dependent on assumptions on an objective function.
- ▶ Zones with different intensity of the signal, which convey more information to the policymaker.

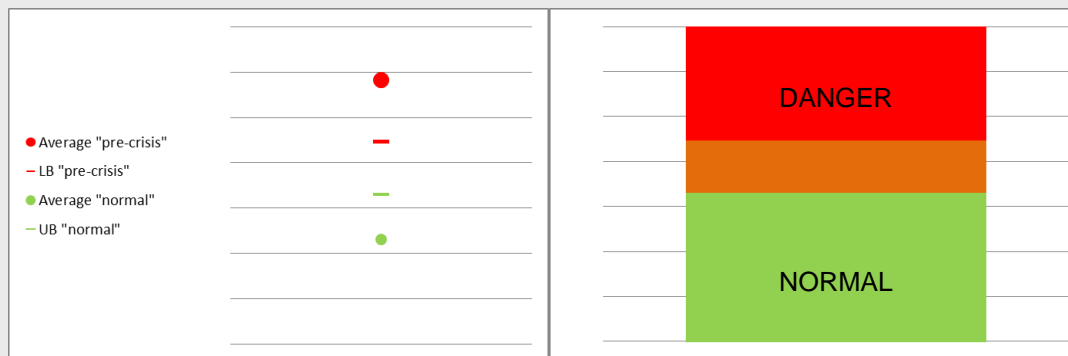


Conditional moments approach: steps 4-6

- ▶ For a given prediction horizon, we compare the 1st moment (the average) for pre-crisis observations with the 1st moment (the average) of the indicator in “normal times”.
 - Observations consistent with “normal times” may be split in two subsamples (“non-crisis countries” and “tranquil periods”) to better account for false alarms.



- ▶ Confidence bounds around 1st moments are then used to calculate thresholds that determine zones corresponding to different intensities of the signal.



Empirical implementation: pooled

- ▶ The methodology is implemented in a linear regression framework, using pooled (cross-country) data.
- ▶ In the baseline specification, we regress each indicator ($Y_{k,t}$) on two (or three) dummy variables corresponding to the two (or three) subsamples: pre-crisis and normal (or pre-crisis, non-crisis countries and tranquil times).

$$Y_{k,t} = \alpha_1 \text{pre-crisis}_{k,t} + \alpha_2 \text{normal}_{k,t} + \varepsilon_{k,t} \quad (1)$$

- ▶ The coefficients on each dummy represent the (pooled) conditional moments:

$$E[Y_{k,t} | \text{pre-crisis}_{k,t} = 1] = \alpha_1$$
$$E[Y_{k,t} | \text{normal}_{k,t} = 1] = \alpha_2$$

- ▶ The bootstrapped confidence bounds around the estimated coefficients are used to obtain the thresholds for the normal and danger zones.
 - LB “pre-crisis” is the 5th percentile of the α_1 distribution.
 - UB “normal” is the 95th percentile of the α_2 distribution.



Empirical implementation: country specificities

- ▶ The methodology allows accounting for country specificities:
 - Pure level effects → country dummies

$$Y_{k,t} = \alpha_1 \text{pre-crisis}_{k,t} + \alpha_2 \text{normal}_{k,t} + \sum_k \beta_k \text{country}_k + \varepsilon_{k,t} \quad (2)$$

Now the conditional moments for country k are:

$$E\left[Y_{k,t} \mid \text{pre-crisis}_{k,t} = 1, \text{country}_k = 1\right] = \alpha_1 + \beta_k$$
$$E\left[Y_{k,t} \mid \text{normal}_{k,t} = 1, \text{country}_k = 1\right] = \alpha_2 + \beta_k$$

Bootstrapped confidence intervals on $(\alpha_1 + \beta_k)$ and $(\alpha_2 + \beta_k)$ result in **country-specific thresholds** for the normal and danger zones. Country specificities are captured as:

- **level** effects by the country dummies (no country-specific difference between pre-crisis and normal).



Empirical implementation: country specificities

- Level and interaction effects → country dummies + additional controls $X_{k,t}^i$

$$Y_{k,t} = (\alpha_1 + \sum_i X_{k,t}^i \gamma_i^{pre-crisis}) pre-crisis_{k,t} + (\alpha_2 +$$



Data

- ▶ Database on banking crises by Babecky et al. (2012)
- ▶ 15 EU countries in the period 1970-2014 ([Table 3](#))
 - Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the United Kingdom
 - 26 crisis episodes
- ▶ Data on potential early warning indicators from public sources (ECB, OECD, BIS, Eurostat)
- ▶ 4 categories of variables: credit variables (both structural and cyclical), real estate variables (both price and quantities), interest rates and other macroeconomic variables ([Table 4](#))
- ▶ Pre-crisis period considered from 5 to 12 quarters before the onset of a banking crisis



Results

Evaluation of pooled thresholds (equation 1) at the level of the entire sample:

- ▶ Different assumptions on the specification of the policymaker's loss function may lead to substantial differences in binary early warning thresholds and their signalling performance.
- ▶ The signalling performance of our methodology is similar to that of that of a traditional binary early warning methodology where thresholds are computed optimizing a policymaker's loss function (with equal weights assigned to Type I and Type II errors, [Table 6](#)).



Results

Evaluation of pooled (equation 1) and country-specific (equation 2) thresholds at the individual country level:

- ▶ Country-specific thresholds substantially improve the signalling power of the conditional moments approach ([Table 8](#)).
 - On average (across countries and indicators), TPR increases from 56 to 62 percent and FPR drops from 33 to 28 percent.
 - The country-specific approach outperforms the pooled approach in 1/3 of the cases; the reverse is true in 1/5 of the cases.

- ▶ We are currently extending the analysis along the lines of equation (3).
 - Type of control variables to consider?
 - Cross-sectional vs. intertemporal correlations between Y and X.
 - ...



ANNEX



Table 3: List of banking crises

country	start	end	country	start	end
Austria	2008Q1	2008Q4	Italy	1994Q1	1995Q4
Belgium	2008Q1	2008Q4	Luxembourg	2008Q1	2008Q4
Denmark	1987Q1	1992Q4	Netherlands	2008Q1	2008Q4
	2008Q3	2008Q4	Portugal	2008Q1	2008Q4
Finland	1991Q1	1995Q4	Spain	1977Q1	1985Q4
France	1994Q1	1995Q4		2008Q1	2008Q4
	2008Q1	2008Q4	Sweden	1991Q1	1994Q4
Germany	1974Q2	1974Q4		2008Q3	2008Q4
	1977Q1	1979Q4	United Kingdom	1974Q1	1976Q4
	2008Q1	2008Q4		1984Q1	1984Q4
Greece	1991Q1	1995Q4		1991Q1	1995Q2
	2008Q1	2008Q4		2007Q1	2007Q4
Ireland	1985Q1	1985Q1			
	2008Q1	2008Q4			

Source: Babecky et al. (2012).



Table 4: Overview of potential early warning indicators

<i>Credit variables</i>	<i>Real estate variables</i>	<i>Other macroeconomic variables</i>
Total private credit to GDP	Nominal residential real estate price growth	Nominal GDP growth
Household credit to GDP	Real residential real estate price growth	Real GDP growth
NFC credit to GDP	Price to income ratio	Unemployment rate
Bank credit to GDP	Price to rent ratio	Inflation rate
Non-bank credit to GDP	Price to income ratio growth	Current account deficit to GDP
Total private credit to GDP gap	Price to rent ratio growth	Real effective exchange rate
Household credit to GDP gap	Investment in dwellings to GDP	Government debt to GDP
NFC credit to GDP gap	Investment in other buildings to GDP	Government debt to GDP growth
Bank credit to GDP gap	Value added construction to GDP	Nominal stock market growth
Non-bank credit to GDP gap	Interest rates	Real stock market growth
Total private credit growth	Nominal government 10y bond yield	
Household credit growth	Real government 10y bond yield	
NFC credit growth	Nominal 3m money market rate	
Bank credit growth	Real 3m money market rate	
Non-bank credit growth	Mortgage market rate	
Bank credit share	Floating mortgage market rate	
Non-bank credit share	Fixed mortgage market rate	

Notes: Gaps are calculated as the deviation from the one-sided Hodrick-Prescott filter with $\lambda=400,000$. Price to income and price to rent levels are expressed as the percentage deviation of the all-sample average.



Results

Table 6: Pooled conditional moments approach vs. binary early warning thresholds

	<i>Conditional moments</i>					<i>EW with $\theta = 0.5$</i>					
	notgreen	red	TPR	FPR	NTS	threshold	TPR	FPR	NTS	#crises	
credit variables											
Household credit to GDP gap	1.34	3.07	0.68	0.22	0.32	0.37	0.85	0.48	0.57	21	
Household credit to GDP	47.27	56.28	0.52	0.24	0.46	33.31	0.92	0.58	0.62	21	
Total private credit to GDP gap	3.74	7.65	0.55	0.22	0.40	5.41	0.51	0.28	0.56	24	
Bank credit to GDP gap	2.05	5.55	0.53	0.19	0.36	5.86	0.40	0.18	0.45	24	
Bank credit to GDP	75.38	83.60	0.59	0.25	0.43	93.31	0.43	0.16	0.37	24	
real estate variables											
Price to income ratio	-4.60	10.54	0.74	0.14	0.19	13.81	0.48	0.11	0.23	20	
Price to rent ratio	-3.96	11.54	0.71	0.18	0.25	10.41	0.57	0.18	0.32	23	
Price to income ratio growth	2.52	4.45	0.61	0.29	0.48	7.43	0.39	0.15	0.38	20	
Real residential real estate price growth	4.31	5.57	0.55	0.32	0.58	7.82	0.45	0.20	0.44	23	
Nominal residential real estate price growth	9.38	10.54	0.57	0.32	0.56	10.25	0.53	0.33	0.61	23	
interest rates											
Nominal government 10y bond yield (-)	6.64	6.58	0.68	0.51	0.75	4.05	0.60	0.07	0.12	19	
Real government 10y bond yield (-)	3.35	2.88	0.74	0.37	0.50	2.44	0.68	0.27	0.40	17	
Fixed mortgage market rate (-)	4.81	4.57	0.68	0.24	0.34	4.87	0.72	0.33	0.46	11	
Floating mortgage market rate (-)	4.22	3.60	0.61	0.27	0.45	4.59	0.82	0.54	0.66	12	
Real 3m money market rate (-)	2.47	2.21	0.70	0.53	0.76	0.90	0.53	0.28	0.54	13	
other macroeconomic variables											
Nominal stock market growth	16.39	18.65	0.59	0.35	0.60	7.62	0.83	0.53	0.63	20	
Real stock market growth	15.64	15.97	0.56	0.36	0.65	4.20	0.88	0.55	0.62	17	
Real effective exchange rate	99.79	101.20	0.51	0.24	0.46	98.30	0.97	0.43	0.45	13	
Inflation rate	2.71	3.51	0.46	0.19	0.42	1.64	0.84	0.67	0.79	17	
Nominal GDP growth	6.63	7.36	0.43	0.30	0.68	3.77	0.88	0.69	0.79	19	
average all indicators	-	-	0.56	0.33	0.60	-	0.60	0.38	0.59	19.34	
#higher TPR	24	#higher TPR and lower FPR				7	# lower NTS				27
#lower FPR	27	#lower TPR and higher FPR				0	# indicators				44

[Back](#)



Table 8: Country level evaluation of pooled vs. country-specific conditional moments approach

	<i>pooled</i>						<i>country-specific</i>						#crises		
	TPR		FPR		TPR		FPR		TPR		FPR				
	mean	min	max	mean	min	max	mean	min	max	mean	min	max			
credit variables															
Household credit to GDP gap	0.70	0.00	1.00	0.17	0.00	0.45	0.87	0.38	1.00	0.15	0.00	0.38	21		
Household credit to GDP	0.53	0.00	1.00	0.28	0.00	1.00	0.86	0.00	1.00	0.24	0.01	1.00	21		
Total private credit to GDP gap	0.51	0.00	1.00	0.22	0.01	0.51	0.59	0.00	1.00	0.20	0.05	0.42	24		
Bank credit to GDP gap	0.54	0.00	1.00	0.18	0.00	0.48	0.72	0.00	1.00	0.16	0.00	0.31	24		
Bank credit to GDP	0.56	0.00	1.00	0.24	0.00	1.00	0.62	0.00	1.00	0.20	0.00	0.70	24		
real estate variables															
Price to income ratio	0.73	0.00	1.00	0.11	0.00	0.31	0.68	0.00	1.00	0.12	0.00	0.23	20		
Price to rent ratio	0.79	0.50	1.00	0.14	0.00	0.34	0.71	0.00	1.00	0.12	0.00	0.28	23		
Price to income ratio growth	0.55	0.00	1.00	0.28	0.00	0.69	0.51	0.00	1.00	0.31	0.00	0.69	20		
Real residential real estate price growth	0.52	0.00	1.00	0.30	0.00	0.72	0.56	0.00	1.00	0.32	0.00	0.52	23		
Nominal residential real estate price growth	0.54	0.00	1.00	0.29	0.00	0.62	0.56	0.00	1.00	0.30	0.00	0.45	23		
interest rates															
Nominal government 10y bond yield (-)	0.73	0.00	1.00	0.53	0.31	0.86	0.73	0.00	1.00	0.43	0.26	0.61	19		
Real government 10y bond yield (-)	0.78	0.00	1.00	0.37	0.13	0.73	0.75	0.00	1.00	0.41	0.14	0.71	17		
Fixed mortgage market rate (-)	0.71	0.00	1.00	0.28	0.00	1.00	0.74	0.25	1.00	0.21	0.00	0.40	11		
Floating mortgage market rate (-)	0.56	0.00	0.88	0.28	0.00	1.00	0.74	0.13	1.00	0.21	0.00	0.60	12		
Real 3m money market rate (-)	0.72	0.00	1.00	0.53	0.18	0.71	0.75	0.00	1.00	0.44	0.24	0.61	13		
other macroeconomic variables															
Nominal stock market growth	0.64	0.33	0.88	0.35	0.18	0.50	0.70	0.38	1.00	0.36	0.26	0.50	20		
Real stock market growth	0.59	0.19	0.88	0.37	0.16	0.51	0.74	0.50	1.00	0.35	0.28	0.47	17		
Real effective exchange rate	0.51	0.25	0.88	0.23	0.02	0.71	0.86	0.00	1.00	0.06	0.00	0.22	13		
Inflation rate	0.46	0.00	1.00	0.19	0.00	0.64	0.47	0.00	1.00	0.19	0.06	0.38	17		
Nominal GDP growth	0.40	0.00	1.00	0.30	0.00	0.83	0.58	0.00	1.00	0.27	0.16	0.35	19		
average all indicators	0.56	0.00	1.00	0.33	0.00	1.00	0.62	0.00	1.00	0.27	0.00	1.00	19/34		
#higher TPR	507	#higher TPR and lower FPR						214	#country-indicator combinations						646
#lower FPR	376	#lower TPR and higher FPR						138							