

Identifying early warning indicators for real estate-related banking crises

Stijn Ferrari, Mara Pirovano, Wanda Cornacchia



Danmarks Nationalbank workshop on House price bubbles – how to detect, predict and prevent them?
Copenhagen, 20 September 2016

Motivation

- ▶ Systemic risks stemming from excessive developments in real estate markets have significantly contributed to financial instability in the past
 - Financial and economic busts preceded by a real estate boom are particularly harmful from a financial stability perspective since they are longer and costlier than the average downturn
- ▶ Identifying and monitoring real estate market risks as well as designing macroprudential policies targeting such risks is one of the priorities for central banks and supervisory authorities across the globe
 - The operationalisation of risk monitoring frameworks and macroprudential policy strategies requires identifying sound leading indicators and associated thresholds signalling excessive developments in the real estate sector well in advance



Main messages

- ▶ This paper applies a signalling approach to evaluate of the signalling ability of several potential early warning indicators for real estate-related banking crises
 - Non-parametric and parametric (discrete choice) setting
 - Unique dataset of real estate-related banking crises for 25 EU countries

- ▶ Main findings:
 - Important role of both real estate price variables and credit developments
 - Cyclical developments as well as structural dimension of real estate prices and credit
 - Macroeconomic and market variables (notably inflation rate and short-term interest rates)
 - Combining multiple variables in a discrete choice parametric approach in order to deal with issues of dimensionality
 - Country-specific thresholds...



Signalling approach

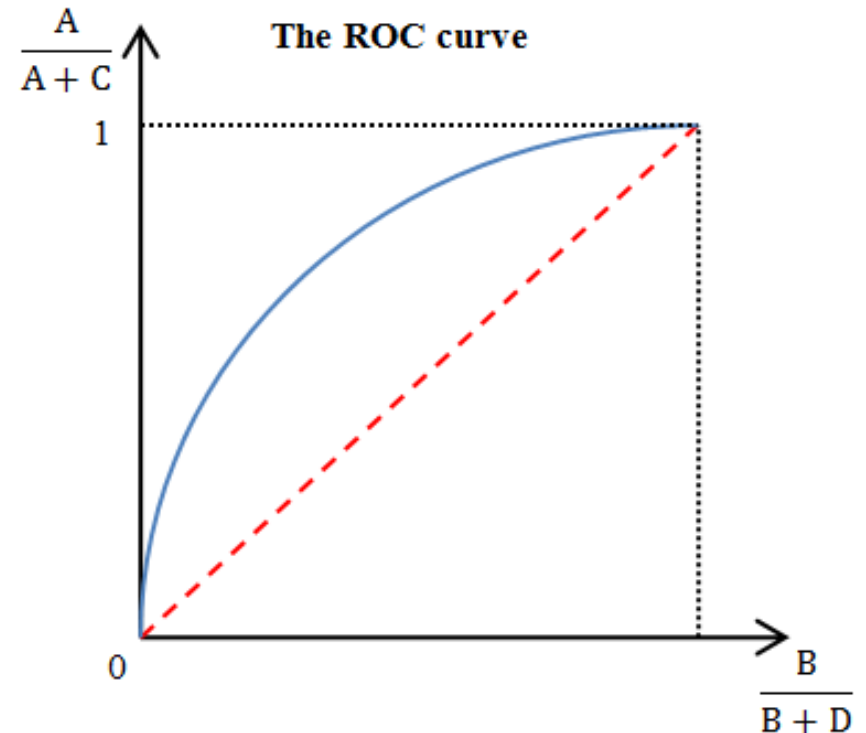
Step 1	Determine relevant crisis event and distinguish pre-crisis and normal observations (drop crisis observations)	Step 4	Determine for each threshold whether signals (not) given are correct (see confusion matrix)
Step 2	Assume prediction horizon	Step 5	Calculate for each threshold the loss function
Step 3	Determine for a grid of thresholds whether a signal (indicator exceeding threshold) is given	Step 6	Select the threshold for which the loss function is minimized

Confusion Matrix

	<i>Crisis</i>	<i>No crisis</i>
Signal is issued	A	B
Signal is not issued	C	D

Loss function

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



Data

- ▶ 25 EU countries, 1970Q1 to 2012Q4

- ▶ 15 real estate-related banking crises: Denmark (1987Q1, 2008Q3), Finland (1991Q3), France (1993Q3), Hungary (2008Q3), Ireland (2008Q3), Latvia (2008Q4), Lithuania (2008Q4), Netherlands (2008Q3), Slovenia (2008Q1), Spain (2009Q2), Sweden (1990Q3, 2008Q3), United Kingdom (1990Q3, 2007Q3)

- ▶ Four categories of potential early warning indicators:
 - Structural credit variables
 - Cyclical credit variables
 - Structural and cyclical real estate variables
 - Other variables (macroeconomic, credit conditions, market, construction sector, banking sector)



Main results: multivariate non-parametric

- ▶ Best ten trivariate indicator combinations:
 - A signal is issued when at least one of the three indicators breaches its threshold
 - Combination of credit (cyclical or structural) and cyclical and structural real estate variables

<i>Indicator 1</i>	<i>Indicator 2</i>	<i>Indicator 3</i>	<i>Threshold 1</i>	<i>Threshold 2</i>	<i>Threshold 3</i>	<i>Type I error</i>	<i>Type II error</i>	<i>Relative usefulness</i>	<i>AUROC</i>	<i>AUROC CI</i>
Real NFC credit growth	Real RRE price gap	Nominal RRE price to rent gap	12.33	14.42	30.08	0.15	0.18	0.66	0.85	[0.80, 0.89]
Real total credit growth	Real RRE price gap	Nominal RRE price to rent gap	11.41	14.42	27.97	0.16	0.20	0.63	0.84	[0.80, 0.89]
Real bank credit growth	Real RRE price gap	Nominal RRE price to rent gap	11.86	13.57	31.06	0.16	0.20	0.63	0.84	[0.79, 0.89]
Real NFC credit growth	Real RRE price gap	Nominal RRE price to income gap	12.70	14.42	31.86	0.19	0.17	0.65	0.83	[0.78, 0.88]
Debt service ratio	Nominal total credit to GDP gap	Nominal RRE price to income gap	0.67	40.73	23.55	0.24	0.10	0.66	0.83	[0.79, 0.88]
Nominal bank credit to GDP gap	Real RRE price gap	Nominal RRE price to rent gap	10.82	14.42	30.08	0.17	0.19	0.63	0.82	[0.78, 0.87]
Real total credit growth	Real RRE price gap	Nominal RRE price to income gap	11.51	13.57	31.86	0.19	0.21	0.61	0.82	[0.78, 0.87]
Nominal bank credit to GDP	Real RRE price gap	Nominal RRE price to rent gap	162.82	13.57	30.08	0.28	0.12	0.60	0.82	[0.77, 0.87]
Nominal total credit to GDP gap	Real RRE price gap	Nominal RRE price to rent gap	13.30	14.42	28.55	0.15	0.23	0.61	0.82	[0.77, 0.87]
Debt service ratio	Real RRE price gap	Nominal RRE price to income gap	0.68	27.24	23.72	0.24	0.10	0.66	0.82	[0.77, 0.87]
Average for all indicator triplets			-	-	-	0.24	0.28	0.48	0.70	[0.65, 0.76]

Main results: multivariate parametric

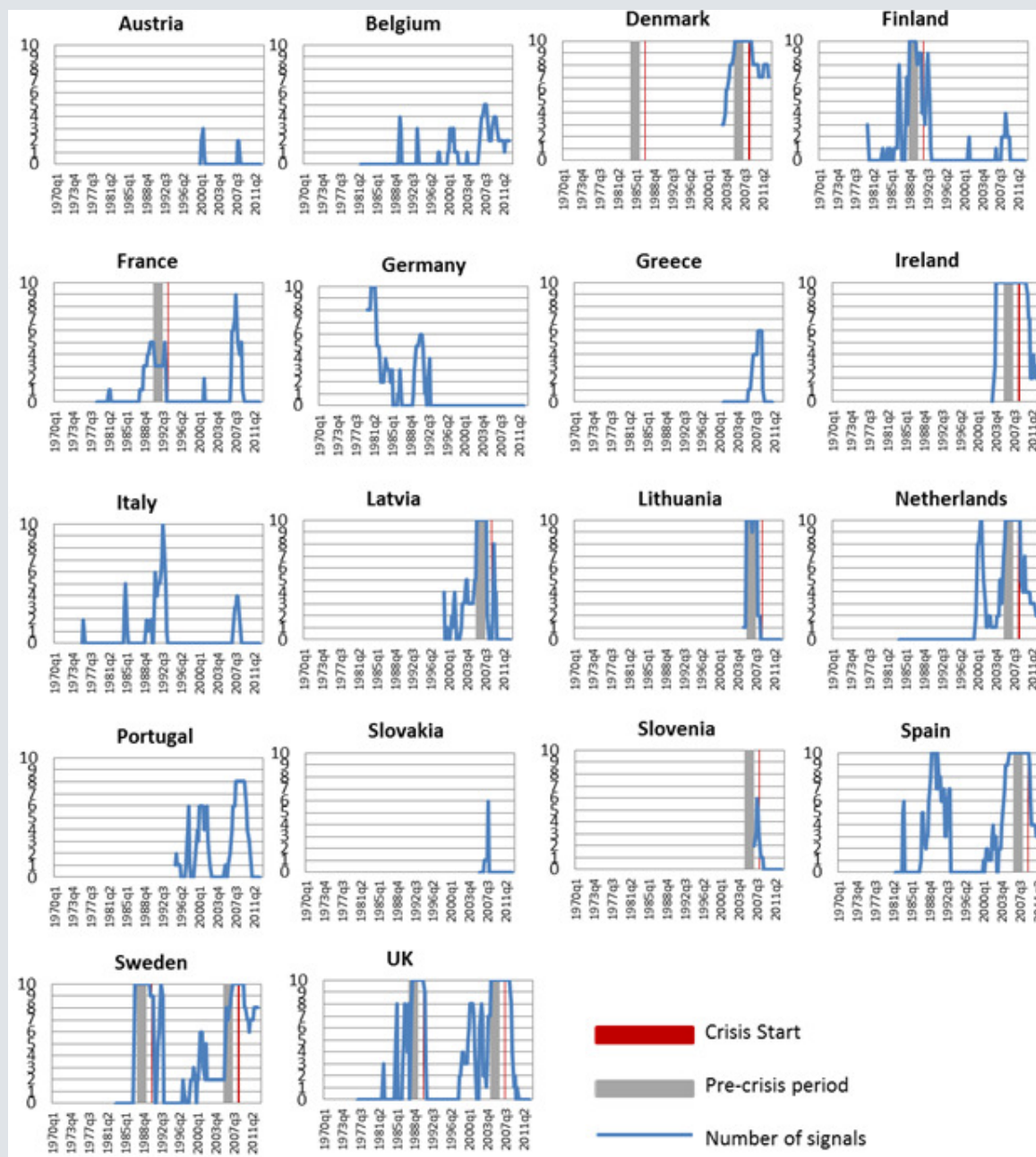
▶ Best ten logit models:

	<i>Model1</i>	<i>Model2</i>	<i>Model3</i>	<i>Model4</i>	<i>Model5</i>	<i>Model6</i>	<i>Model7</i>	<i>Model8</i>	<i>Model9</i>	<i>Model10</i>
Real total credit growth	0.166*** (4.849)	0.242*** (4.616)			0.196*** (3.644)		0.122*** (4.479)			
Nominal bank credit to GDP	0.049*** (6.078)		0.048*** (5.824)			0.035*** (4.518)		0.056*** (5.513)		
RRE price to rent gap	0.037*** (2.787)	0.042*** (2.578)	0.031** (1.974)	0.049*** (3.542)	0.034*** (3.145)	0.051*** (3.651)		0.044*** (2.804)	0.051*** (3.861)	
3-month money mkt rate	0.426*** (5.633)	0.544*** (5.242)	0.401*** (5.728)	0.409*** (4.334)	0.471*** (5.044)	0.390*** (4.336)	0.347*** (2.685)	0.455*** (5.087)	0.445*** (4.892)	0.327*** (2.379)
Inflation	-0.302*** (-2.760)	-0.378*** (-2.971)	-0.284*** (-2.597)	-0.264** (-2.184)	-0.257*** (-2.148)	-0.296*** (-2.646)	-0.333** (-2.434)	-0.324** (-2.499)	-0.287*** (-2.294)	-0.336** (-1.966)
Household credit to GDP		0.085*** (4.211)		0.060*** (3.497)						
Real bank credit growth			0.131*** (4.713)							
Real NFC credit growth				0.218*** (5.619)		0.200*** (5.783)			0.234*** (6.223)	0.159*** (4.780)
Nominal total credit to GDP					0.038*** (5.363)				0.028*** (3.604)	
Debt service ratio							7.216*** (6.207)			6.805*** (6.655)
RRE price to income gap							0.116*** (3.683)			0.116*** (3.841)
Real HH credit growth								0.113*** (7.856)		
Constant	-10.224*** (-14.079)	-12.115*** (-4.906)	-9.543*** (-11.367)	-9.746*** (-6.215)	-11.977*** (-6.626)	-9.100*** (-10.652)	-8.021*** (-5.378)	-10.583*** (-9.638)	-10.683*** (-6.924)	-7.968*** (-5.969)
Type I error	0.02	0.18	0.12	0.18	0.14	0.06	0.17	0.06	0.11	0.13
Type II error	0.20	0.07	0.15	0.11	0.12	0.21	0.08	0.20	0.19	0.12
Relative usefulness	0.78	0.74	0.74	0.71	0.74	0.73	0.75	0.74	0.71	0.75
AUROC	0.95	0.94	0.94	0.94	0.94	0.94	0.94	0.93	0.93	0.93
AUROC CI	[0.92, 0.98]	[0.91, 0.97]	[0.91, 0.97]	[0.91, 0.97]	[0.91, 0.97]	[0.90, 0.97]	[0.90, 0.97]	[0.90, 0.97]	[0.90, 0.97]	[0.90, 0.97]

* Significant at 0.1; ** significant at 0.05; *** significant at 0.01

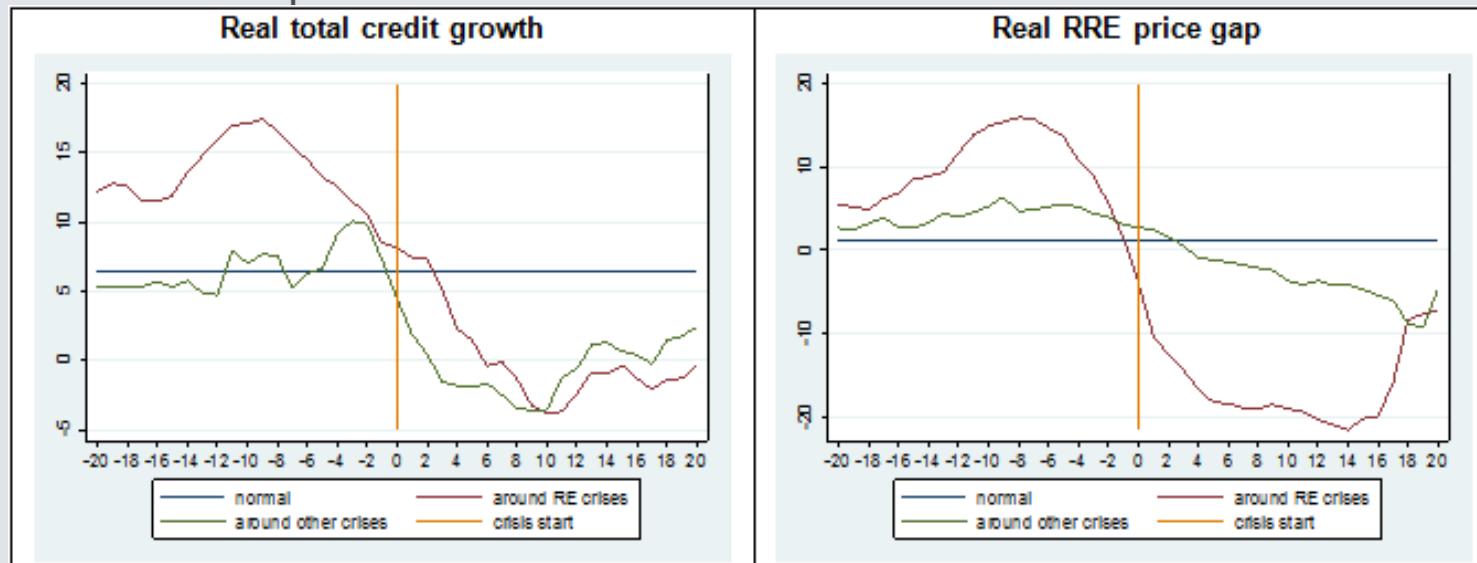
Main results: multivariate parametric

- ▶ Combining signals of the ten best logit models:
 - A large fraction of models issue warnings at the same time
 - For all crisis countries except France and Slovenia, all ten best logit models correctly signal the imminent occurrence of a real estate-related crisis
 - False alarms notably in France, Germany, Italy, the Netherlands, Portugal and Spain



Digging deeper (work in progress): real estate-related vs. other banking crises

- ▶ Do the identified early warning indicators work particularly well for signalling real estate-related banking crises or also for other types of banking crises?
 - Augment real estate-related banking crisis database with Laeven and Valencia (2012) crisis database
 - For example:



- ▶ Including robustness checks on
 - identification of real estate-related banking crises; and
 - how other crises in the sample are dealt with in the evaluation of early warning performance



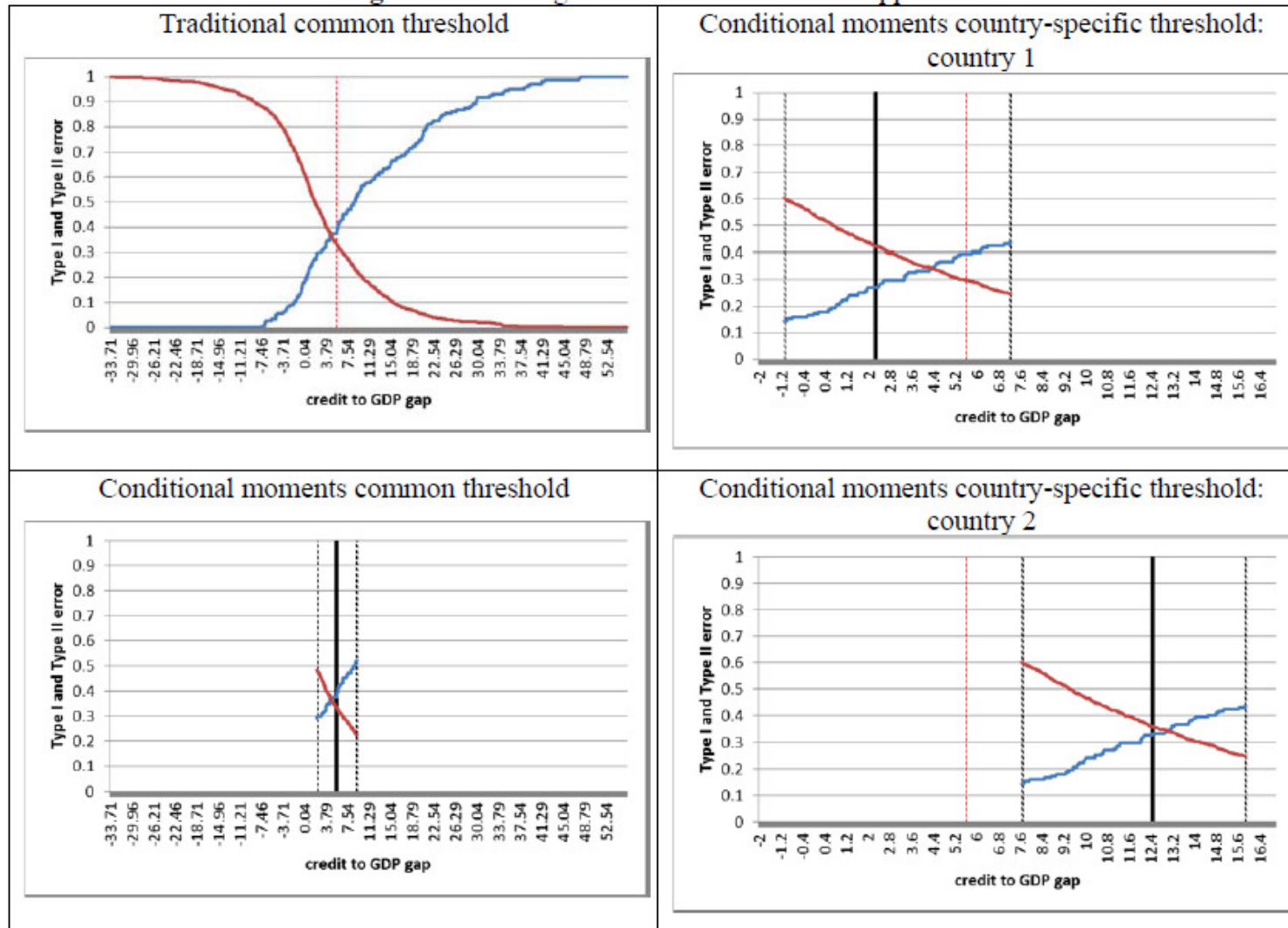
Digging deeper (beyond scope): country-specific thresholds...

- ▶ Need for methods to calculate robust country-specific thresholds, as there is room for improvement compared to pooled thresholds

Country	Optimal pooled threshold	TPR	FPR	Relative usefulness	Optimal country-specific threshold	TPR	FPR	Relative usefulness
Austria	0.061	.	0.02	.	.	.	.	.
Belgium	0.061	.	0.03	.	.	.	.	.
Cyprus	0.061	.	1	.	.	.	.	.
Czech Republic	0.061	.	0	.	.	.	.	.
Denmark	0.061	1	0.46	0.54	0.18	0.81	0.17	0.64
Estonia	0.061	.	.	.	.	.	.	.
Finland	0.061	1	0.04	0.96	0.06	1	0.04	0.96
France	0.061	1	0.13	0.87	0.06	1	0.13	0.87
Germany	0.061	.	0.12	.	.	.	.	.
Greece	0.061	.	0.26	.	.	.	.	.
Hungary	0.061	.	.	.	.	.	.	.
Ireland	0.061	1	0.29	0.71	0.83	1	0.01	0.99
Italy	0.061	.	0.15	.	.	.	.	.
Latvia	0.061	1	0.44	0.56	0.25	1	0	1
Lithuania	0.061	1	0.33	0.67	0.16	0.88	0	0.88
Luxembourg	0.061	.	.	.	.	.	.	.
Malta	0.061	.	.	.	.	.	.	.
Netherlands	0.061	1	0.15	0.86	0.11	1	0.07	0.93
Poland	0.061	.	.	.	.	.	.	.
Portugal	0.061	.	0.44	.	.	.	.	.
Slovakia	0.061	.	0.05	.	.	.	.	.
Slovenia	0.061	.	.	.	.	.	.	.
Spain	0.061	1	0.37	0.63	0.77	1	0	1
Sweden	0.061	0.94	0.08	0.86	0.04	1	0.13	0.88
United Kingdom	0.061	0.94	0.23	0.71	0.16	0.94	0.01	0.93

Country-specific thresholds: conditional moments approach (Ferrari and Pirovano, 2016)

Figure 1: Situating the conditional moments approach



Notes: The ascending blue line plots the Type I error as a function of the credit to GDP gap. The descending red line plots the Type II error as a function of the credit to GDP gap. The red dashed vertical line is the traditional early-warning threshold, whereas the black vertical lines are the optimal country-specific conditional moments-based thresholds. The bounds of the interval over which the latter is searched are indicated by the dashed black vertical lines.



Conclusions

- ▶ Important role of both cyclical and structural developments in real estate price and credit variables in signalling real estate-related banking crises
- ▶ Take into account macroeconomic and market variables (notably inflation rate and short-term interest rates)
- ▶ Work in progress: real estate-related vs. other banking crises
- ▶ Need for methods to calculate robust country-specific thresholds
- ▶ But above all: keep in mind that early warning models are just a starting point for policy discussion



References

- ▶ Ferrari, S., M. Pirovano and W. Cornacchia (2015), “Identifying early warning indicators for real estate-related banking crises”, ESRB Occasional Paper No. 8, 69 p.
- ▶ Ferrari, S. and M. Pirovano (2016), “Does one size fit all at all times? The role of country specificities and state dependencies in predicting banking crises”, NBB Working Paper No 297, 27 p.

