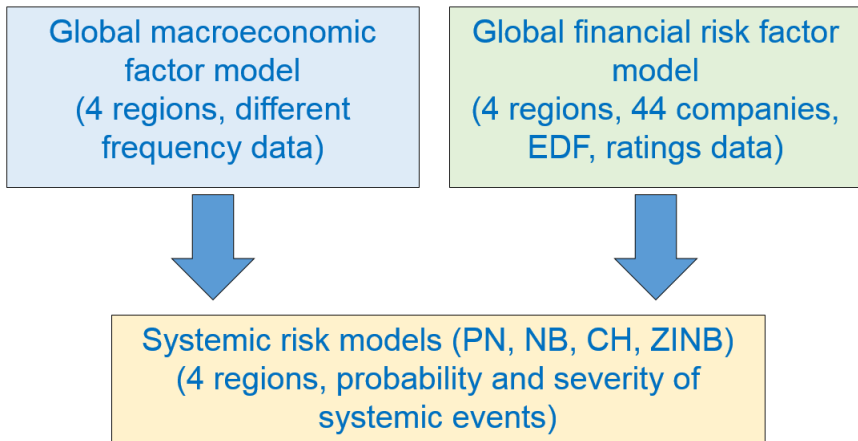# Early Warning Indicators of Systemic Financial Stress

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- A new top-down approach to infer occurrence and severity of systemic events in 4 representative regions of the 'world' since 1990s (US, EU, AU, CH)
- Estimate occurrence probabilities and severities of systemic events from hurdle models using derived macroeconomic, financial risk and ratings factors:
  1. Unobserved macroeconomic factors for the 'world' and each region are estimated using observed stock and flow variables arriving at mixed frequencies.
  2. Unobserved regional financial risk factors (beyond ratings) are derived from Moody's/KMV expected default frequencies for 11 major financial institutions in each region
- Infer regional systemic risks, yielding local predictions from global information even though some regions have few default experiences.

- The occurrence and the severity of systemic events are driven by different factors
- Occurrence is driven by lag of regional macroeconomic factors and the financial risk factor
- Severity is driven by lags of the world macroeconomic factor.

Modelling Framework

Global macroeconomic factor model (4 regions, different frequency data)	Global financial risk factor model (4 regions, 44 companies, EDF, ratings data)

Systemic risk models (PN, NB, CH, ZINB) (4 regions, probability and severity of systemic events)

1. We use Moody's and COMPUSTAT data for all actual defaults in 4 regions - 257 from 1990.1-2012.12.

2. A systemically relevant event occurs where the total market cap of the defaulting companies in a month accounts for $k\%$ or more of a region's market cap.

3. Low threshold $k = 0.0012\%$ gives 83 events, and high threshold $k = 0.005\%$ gives 47 events.

Table: Number of observed defaults per geographical region for the sample period January 1990 - December 2012. Information on defaulted financial institutions is extracted from both Compustat and Moody's Default Risk Service (DRS) with a total number of 257 defaults.

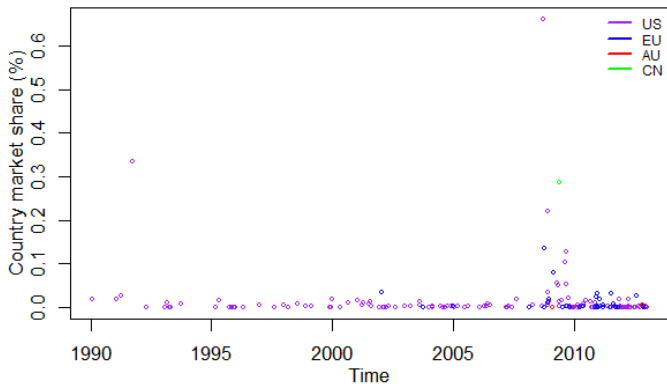| | Default number | Default percent | Loss (%) | |
			Low threshold	High threshold
US	215	83.66	70.99	70.52
EU	39	15.18	19.23	19.43
AU	2	0.78	0.20	0.21
CN	1	0.39	9.58	9.84

Figure: Severity of default events measured by the percentage regional market capitalization of the defaulted financial institution.

4 statistical models for realized systemic risk events, s_t^r

1. PN: Poisson
2. NB: Negative Binomial
3. CH: Conditional Hurdle [FAVOURED BY DATA]
4. ZINB: Zero-inflated Negative Binomial

In favoured statistical model, CH

..

λ_t^r – severity parameter for systemic events.

π_t^r – occurrence probability of a systemic event.

$$Severity \quad parameter: \quad \lambda_t^r = X_t^r \delta + errors \tag{1}$$

$$Occurrence \quad probability: \quad \pi_t^r = Z_t^r \alpha + errors \tag{2}$$

where Z_t^r and X_t^r are (perhaps different) covariates for the 2 components, including $M_t^r, M_t^W, F_t^r, F_t^A, cds, tedspread, tpm, dm3, epp, sr, vol$

We use a dynamic factor model to extract unobserved macroeconomic indicators for each region and the world using observed variables arriving at different frequencies

Table: Variables used in the macroeconomic models

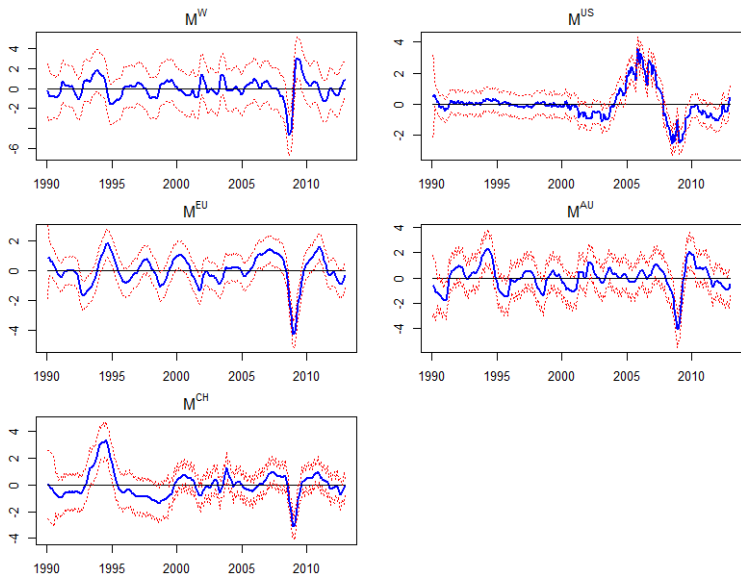| Variables	Monthly	Quarterly	Annual
Output (*gdp*)		*US, EU, AU, CH*	
Inflation (*inf*)	*US, EU, CH*	*AU*	
Unemployment rate (*unr*)	*US, EU, AU*		*CH*
Confidence index (*ci*)	*US, EU*	*AU, CH*	
Residential property price (*pp*)	*US, EU, CH*	*AU*	
Stock market return (*sr*)	*US, EU, AU, CH*		
Job vacancies (*vac*)	*US*	*EU, AU, CH*	
Term of trade (*tot*)	*US, CH*	*AU*	*EU*
Credit/GDP (*crd*)			*US, EU, AU, CH*
Term premium (*tpm*)	*US, EU, AU, CH*		

Figure: Estimates of smoothed macroeconomic factors

We use a dynamic factor model to extract unobserved financial risk and ratings indicators for each region using observed expected default frequencies produced by Moodys for 11 of the largest financial companies in each of 4 regions, $EDF_{i,t}^r$, and their observed ratings.
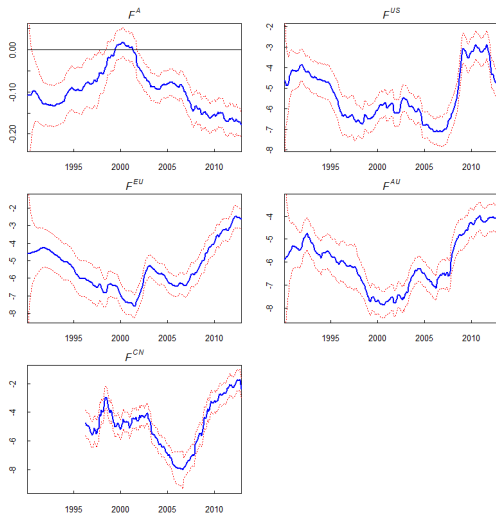
Figure: Estimates of smoothed rating and financial factors

Table: Systemic risk estimation results

	Low threshold events								High threshold events							
	PN		NB		**CH**		ZINB		PN		NB		**CH**		ZINB	
Severity count component																
δ_0					1.78	***	1.81	***					0.82		0.28	
$\delta^{M^W_{t-1}}$					-0.33	***	-0.33	***					-0.34	***	-0.36	***
$\delta^{M^W_{t-9}}$					-0.88	***	-0.79	***					-0.93	***	-0.85	***
Zero component																
α_0	-0.32		0.42	*	-2.01	***	-0.99	***	-1.62	***	-1.13	***	-2.73	***	-0.84	
$\alpha^{D^{AU}}$	-5.77	***	-5.88	***	-3.87	***	-4.08	***	-5.99	***	-6.04	***	-3.16	***	-4.37	***
$\alpha^{D^{CN}}$	-1.10		-5.18	***	-3.84	***	-4.12	***	-0.92		-4.02	***	-3.09	***	-4.43	***
$\alpha^{F^A_{t-1}}$			-0.83	***												
$\alpha^{F^I_{t-1}}$	0.62	***			0.52	***	0.66	***	0.69	***	1.05	***	0.57	***	1.06	***
$\alpha^{M^I_{t-2}}$	-0.35		-0.39						-0.55	*	-0.52		-0.52	***		
$\alpha^{M^I_{t-7}}$	-0.30								-0.32							
$\alpha^{M^W_{t-1}}$	-0.67	***							-0.61	***						
$\alpha^{M^W_{t-7}}$					-0.25	**	-0.22				-0.79	***			-0.65	*
$\alpha^{M^W_{t-8}}$			-1.32	***												
$\alpha^{M^W_{t-9}}$	-1.29															
$\alpha^{M^W_{t-10}}$	1.14								-0.62	***						
$\alpha^{M^W_{t-12}}$	-0.90															
$\alpha^{S^{US}_{t-1}\times D^{-US}}$	0.00	*			0.01	*			0.01	**	0.08	***				
Pseudo R^2	0.50		0.11		0.13		0.13		0.49		0.12		0.15		0.15	
Vuong test result matrix																
Base model																
PN			-3.50	***	**-3.52**	***	-3.51	***			-2.97	***	**-3.00**	***	-2.99	***
NB					**-2.00**	**	-1.85	**					**-1.58**	*	-2.45	***
CH							**0.95**								**-0.59**	

Note: Significance at the 1%, 5% and 10% level is denoted by ***, ** and *, respectively.

For the Vuong test, a significantly negative value indicates that the alternative model is better than the base model and vice versa.

Table: Out of sample test for period 2008 - 2012

| | Low threshold events | | | | | | High threshold events | | | | | |
	PN	NB	**CH**	ZINB		PN	NB	**CH**	ZINB	
Logscore										
US	12706.59	3307.58	351.90	497.38		4763.91	492.38	231.54	246.34	
EU	16093.30	1275.52	175.55	247.33		4666.66	362.10	125.66	122.03	
AU	145.77	131.02	43.46	42.40		36.86	33.66	41.66	59.34	
CN	9056.35	4505.35	60.13	67.08		2742.10	1204.85	61.20	58.22	
Total	38002.02	9219.47	631.04	854.20		12209.53	2092.99	460.06	485.93	
Vuong test result matrix										
Base model										
PN		-1.72 **	**-2.04** **	-2.03 **			-1.92 **	**-2.07** **	-2.06 **	
NB			**-1.91** **	-1.86 **				**-1.43** *	-1.41 *	
CH				1.77 **					**1.20**	

Note: Significance at the 1%, 5% and 10% level is denoted by ***, ** and *, respectively.

For the Vuong test, a significantly negative value indicates that the alternative model is better than the base model.
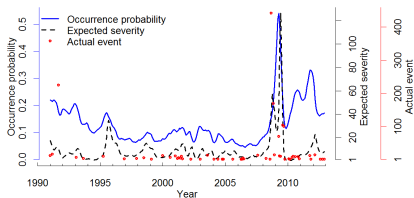
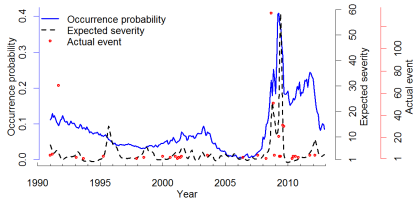Figure: US systemic index—LOW hurdle.
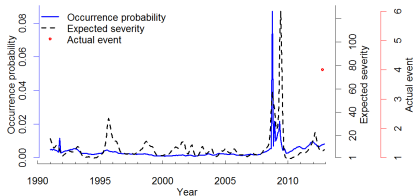

Figure: US systemic index—HIGH hurdle.
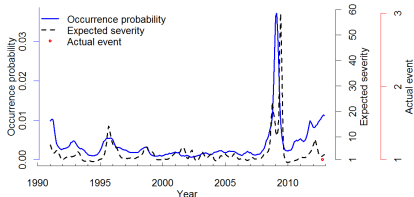
Figure: Australia systemic index—LOW hurdle.

Figure: Australia systemic index—HIGH hurdle.

1. Stronger regional macroeconomic conditions will reduce the probability of a future systemic event, but given that it occurs, the expected severity will be lessened if world macroeconomic conditions are more benign. Policymakers need to ensure macroeconomic stability over the longer term to avoid systemic crises and to coordinate their policies across countries to reduce their expected severity.

2. Regional financial risk arising from EDFs is an important predictor of the probability of a systemic event. Therefore, financial regulators and supervisors need to ensure that these financial risk factors are not escalating.