Risk Management using Real-Time Financial and Business Conditions Indicators

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Outline

- Estimating real time business conditions indicators
- Relationship between business conditions indicator and equity indices
- Creating a systemic risk index
- Conclusions

Estimating a business conditions index for Australia

- Use a linear dynamic factor model in daily state-space form
- Handle mixed-frequency and stock/flow data for Australia from 1986-2013
- Construct an (unobservable) domestic business conditions index and an external conditions index for Australia that summarizes large amount of information
- Decompose the contributions of 9 observable variables to the indices over time
- Construct impulse responses for both states and observable variables
- Focus on the 2008 crisis and its aftermath

Related Literature

- Dynamic factor models with mixed frequency, US: Aruoba, Diebold and Scotti (2009, JBES), Mariano and Murasawa (2003, JAE)
- Leading and coincident indicators: Stock and Watson (1989)
- Dynamic factor model for macro, US: Bernanke et al (2005, QJE)
- Coincident indicator for euro area: Altissimo, F., et al. (2001, CEPR), Angelini et al (2011, Ecmts J)
- Real-time estimates for macroeconomy, US: Evans (2005, IJCB); Giannone et al (2008, JME)

Considered Variables

Nine observable series available at different frequencies (most from 01/01/1986 to 31/07/2013)

Internal-related variables:

- ys_t - Yield Slope (daily) | (10yr - 3m TB)
- hrs_t - Total hours worked (monthly)
- bc_t - NAB Business confidence (quarterly) – from 30/09/1989
- gdp_t - Real GDP (quarterly)
- vac_t - Job vacancies (quarterly)

Considered Variables

External-related variables:

- tot_t - Terms of trade (quarterly)
- twi_t - Export-weighted real exchange rate (quarterly)
- $wgdp_t$ - Export-weighted real world GDP (quarterly) - from 15/02/1988
- ted_t - TED spread (daily) | (3m LIBOR - US TB)

- Flow data: hrs_t , gdp_t , $wgdp_t$
- Stock data: ys_t , bc_t , vac_t , tot_t , twi_t , ted_t
- Financial Data: ys_t , ted_t

Model Setup (State Variables)

Model for daily (unobservable) domestic business conditions index X^d and (unobservable) external conditions index X^f

$$\begin{bmatrix} X_t^d \\ C_t^{dM} \\ C_t^{dQ} \\ X_t^f \\ C_t^{fQ} \end{bmatrix} = \begin{bmatrix} \rho_d & 0 & 0 & \phi & 0 \\ \rho_d & \theta_d^M & 0 & 0 & 0 \\ \rho_d & 0 & \theta_d^Q & 0 & 0 \\ 0 & 0 & 0 & \rho_f & 0 \\ 0 & 0 & 0 & \rho_f & \theta_f^Q \end{bmatrix} \begin{bmatrix} X_{t-1}^d \\ C_{t-1}^{dM} \\ C_{t-1}^{dQ} \\ X_{t-1}^f \\ C_{t-1}^{fQ} \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 1 & 0 \\ 1 & 0 \\ 0 & 1 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \epsilon_t^d \\ \epsilon_t^f \end{bmatrix}$$

Model Setup (Observable Variables)

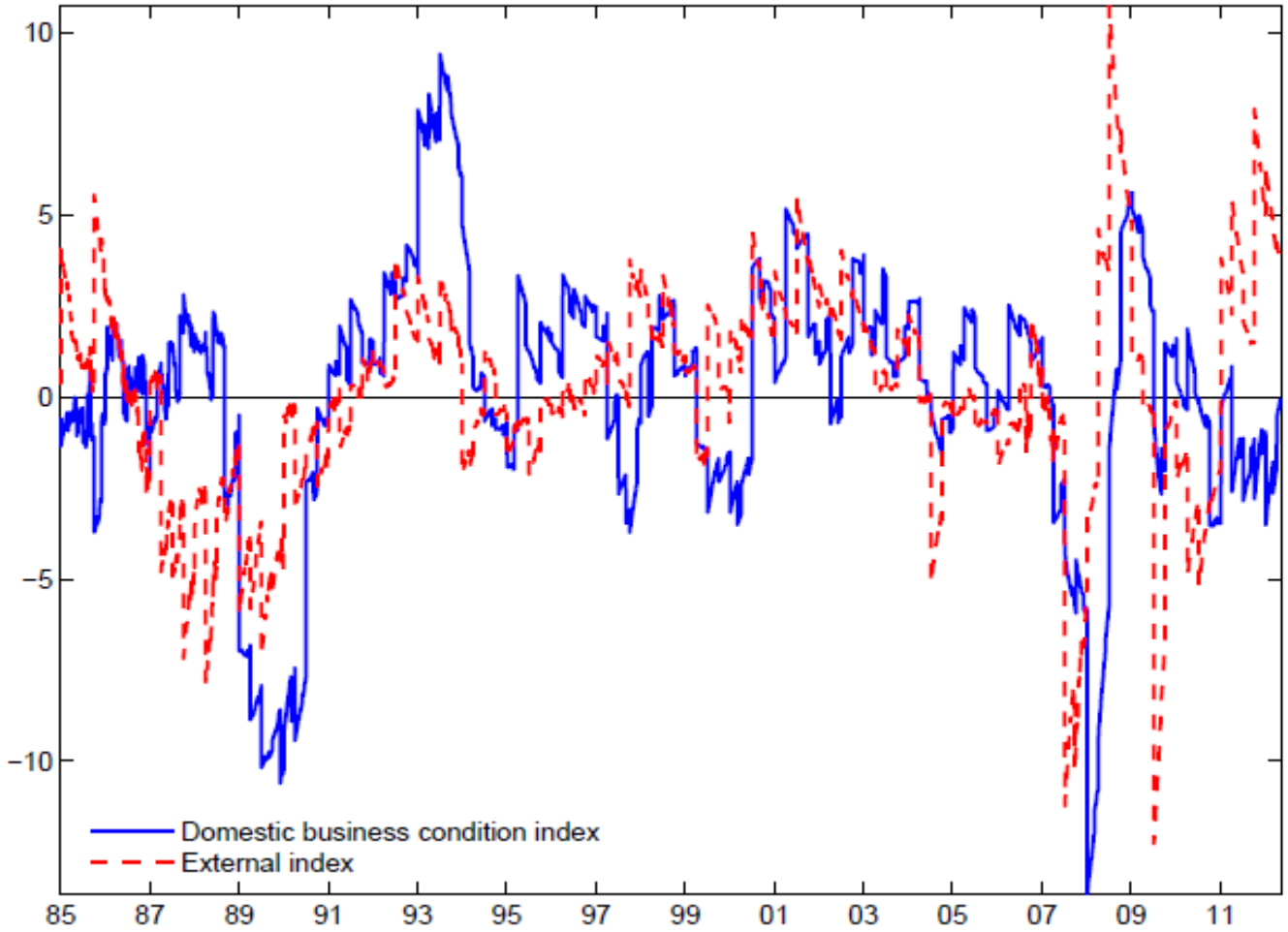
$$
\begin{bmatrix} ys_t \\ hrs_t \\ bc_t \\ vac_t \\ gdp_t \\ twi_t \\ tot_t \\ wgdp_t \\ ted_t \end{bmatrix} = \begin{bmatrix} \gamma_{ys} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \gamma_{hrs} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \gamma_{bc} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \gamma_{vac} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \gamma_{gdp} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \gamma_{twi} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \gamma_{tot} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \gamma_{wgdp} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \gamma_{ted} \end{bmatrix} \begin{bmatrix} ys_{t-1} \\ hrs_{t-1} \\ bc_{t-1} \\ vac_{t-1} \\ gdp_{t-1} \\ twi_{t-1} \\ tot_{t-1} \\ wgdp_{t-1} \\ ted_{t-1} \end{bmatrix}
$$

$$
+ \begin{bmatrix} \beta_{ys} & 0 & 0 & 0 & 0 \\ 0 & \beta_{hrs} & 0 & 0 & 0 \\ \beta_{bc} & 0 & 0 & 0 & 0 \\ \beta_{vac} & 0 & 0 & 0 & 0 \\ 0 & 0 & \beta_{gdp} & 0 & 0 \\ \beta^d_{twi} & 0 & 0 & \beta^f_{twi} & 0 \\ \beta^d_{tot} & 0 & 0 & \beta^f_{tot} & 0 \\ 0 & 0 & 0 & 0 & \beta_{wgdp} \\ 0 & 0 & 0 & \beta_{ted} & 0 \end{bmatrix} \begin{bmatrix} X^d_t \\ C^{dM}_t \\ C^{dQ}_t \\ X^f_t \\ C^{fQ}_t \end{bmatrix} + \begin{bmatrix} \eta^{ys}_t \\ \eta^{hrs}_t \\ \eta^{bc}_t \\ \eta^{vac}_t \\ \eta^{gdp}_t \\ \eta^{twi}_t \\ \eta^{tot}_t \\ \eta^{wgdp}_t \\ \eta^{ted}_t \end{bmatrix}
$$

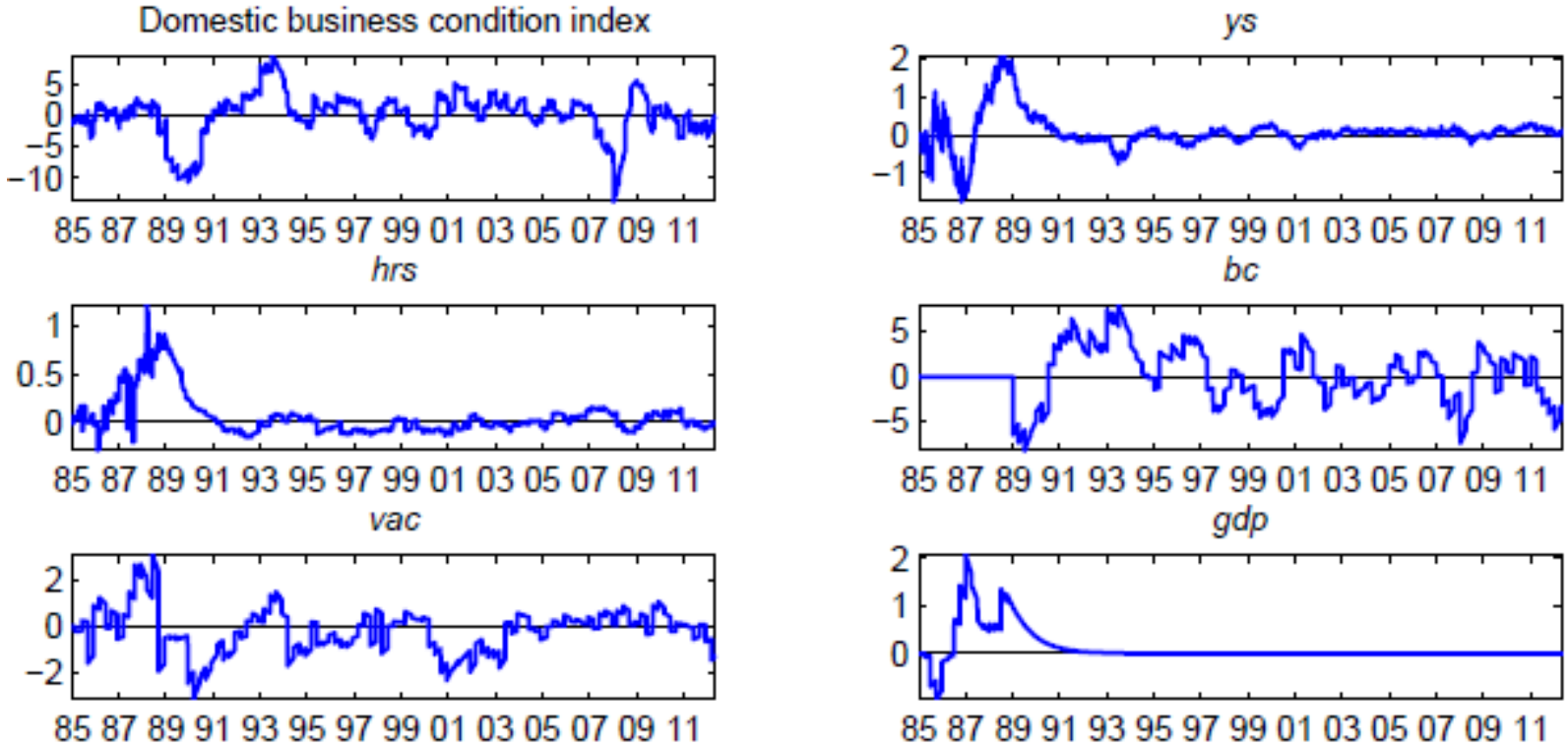
Model Estimation

- Implementation of Kalman filter by minimizing prediction errors
- Challenge lies in the nature of the data:
  - not every series has data available in every daily period *t*
  - combination of stock and flow data
- Simplex method to find starting vales for parameters
- Use quasi-Newton method for estimation

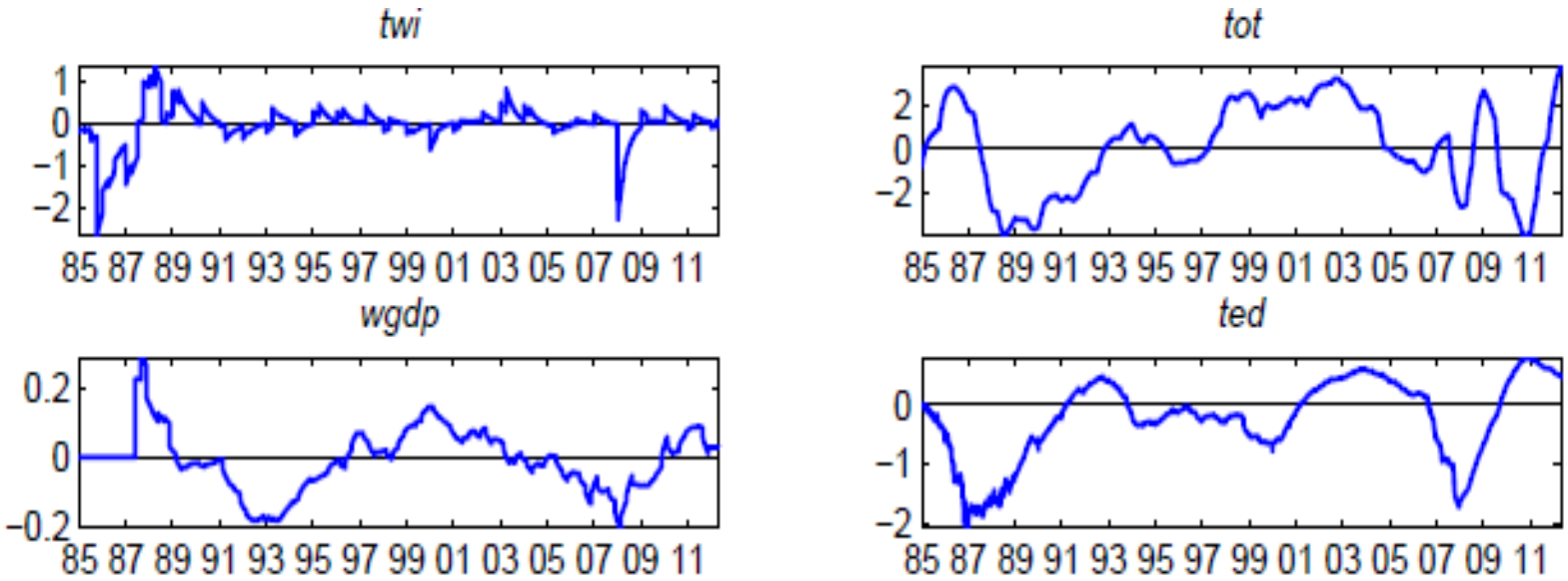
Estimated Domestic and External Index



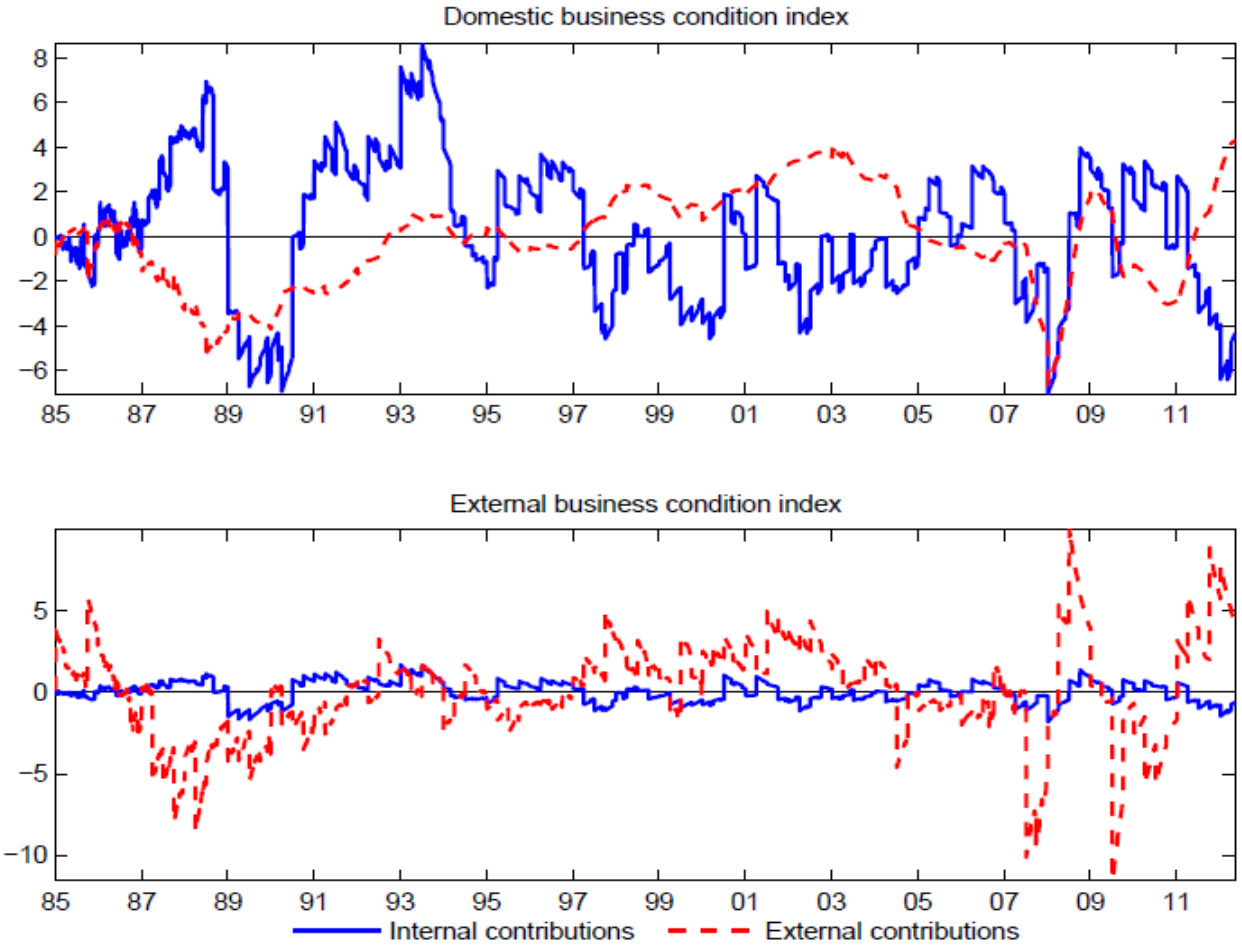
Individual Contributions of Observables



Individual Contributions of Observables



Contributions of internal and external variables



Key Results for Derived Index

- The NAB business confidence measure plays a vital role in the estimated domestic business conditions index (leading indicator).
- Terms of trade plays a vital role in the external conditions index.
- Financial variables (the domestic yield spread and the external TED spread) only appear to play an important role in crisis episodes.
- Australia's mild experience of the global financial crisis of 2008 mainly driven by the external index, which then fed into deteriorating business confidence.
- In 2013, the external index was positive and improving, yet the domestic index was languishing, which may be because of pessimism in business confidence.

Relationship of Business Condition Index with Equity Returns

- We investigate the relationship of the index with weekly and monthly returns of the AOI
- We examine contemporaneous relationship but also predictive relationship between changes in the derived BCI and AOI returns
- To examine contribution of index to risk management, we also consider possible non-linear relationship between changes in the index and equity returns using copula analysis
- Copulas allow for a more general specification of the dependence structure than correlation that can only measure linear dependence

Copulas (Definition)

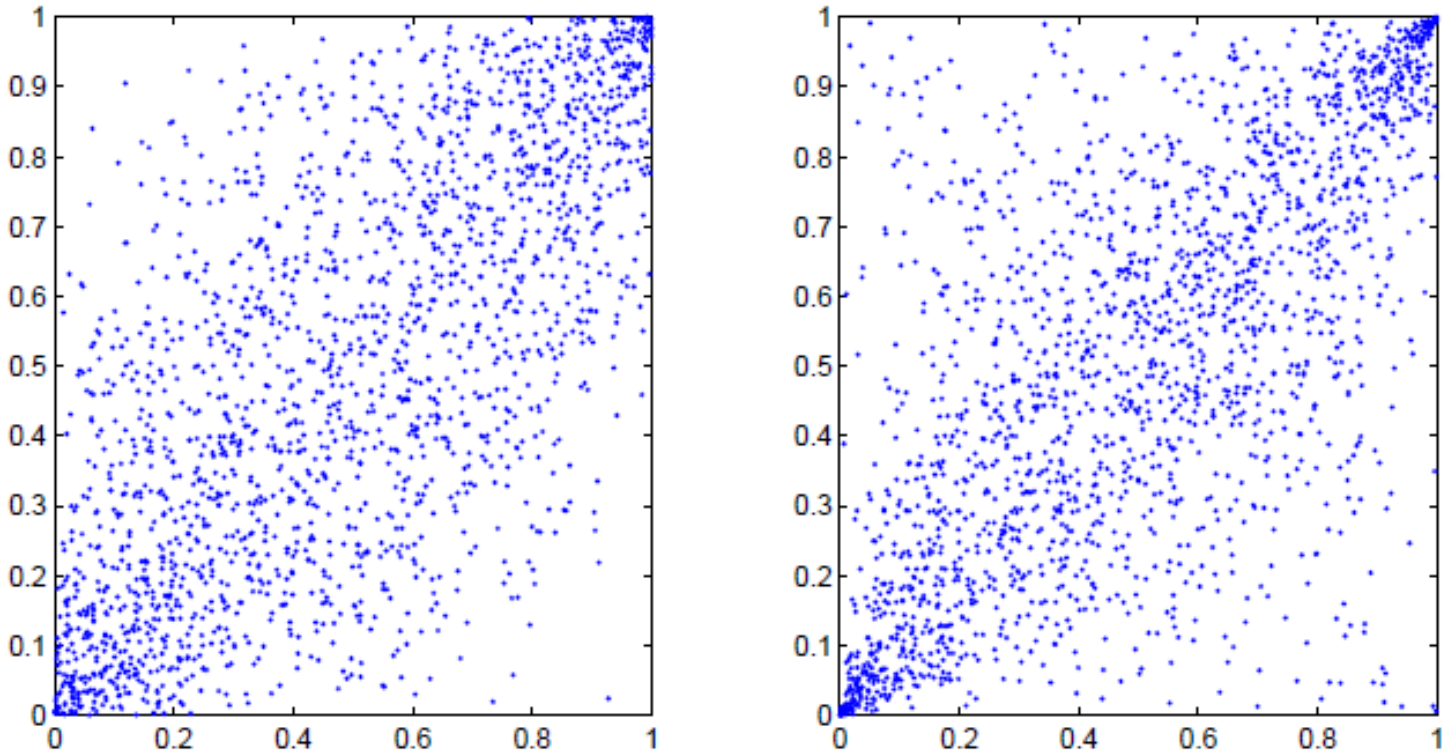
Let $X = (X_1, \ldots, X_n)'$ be a random vector of real-valued random variables whose dependence structure is completely described by the joint distribution function.

Each random variable X_i has a marginal distribution of F_i that is assumed to be continuous for simplicity.

Then the function C can be identified as a joint distribution function with standard uniform marginals — the copula of the random vector X:

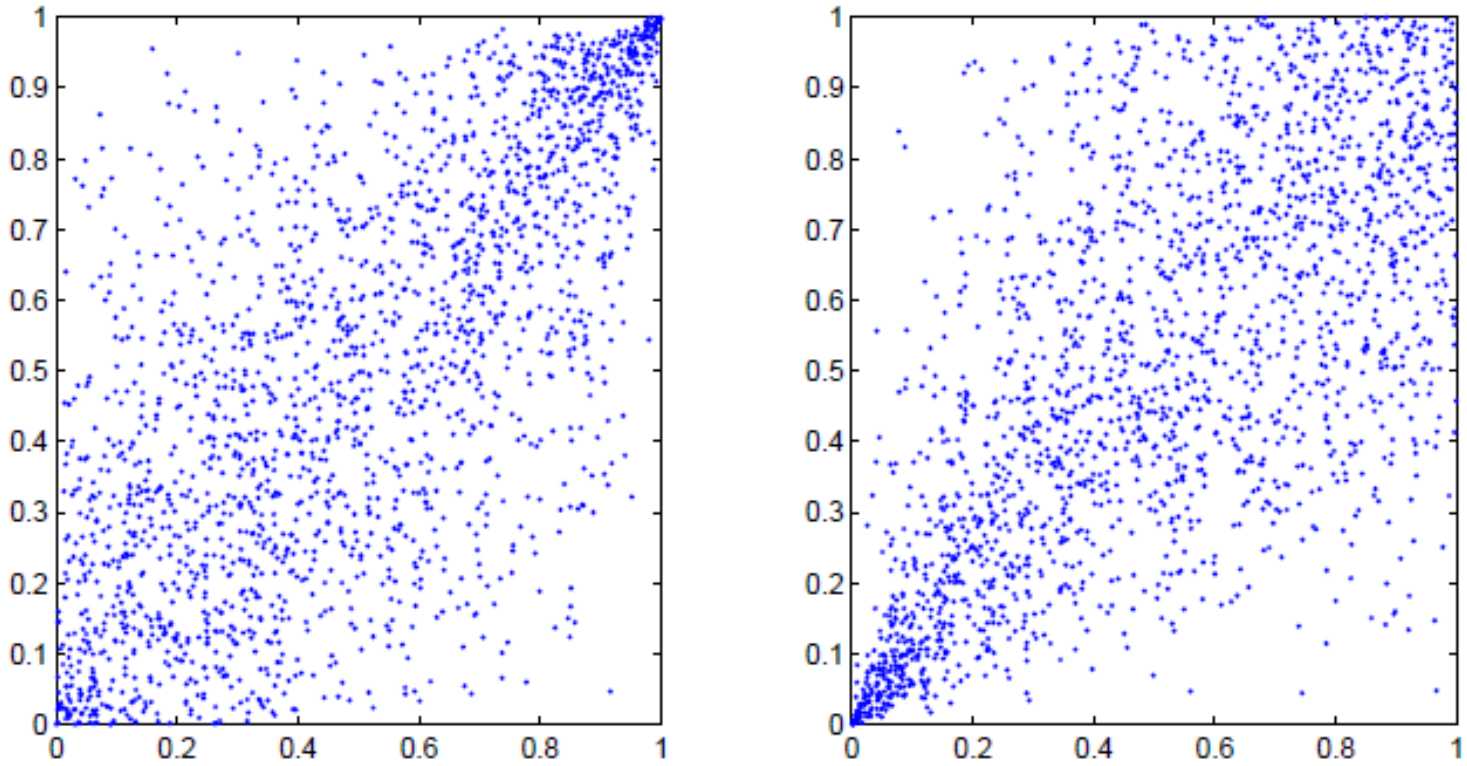
$$\begin{aligned} F(x_1, \ldots, x_n) &= P(X_1 < x_1, \ldots, X_n < x_n) \\ &= P[F_1(X_1) < F_1(x_1), \ldots, F_n(X_n) < F_n(x_n)] \\ &= C(F_1(x_1), \ldots, F_n(x_n)), \end{aligned}$$

Dependence Structure for Gaussian and Student-t Copula



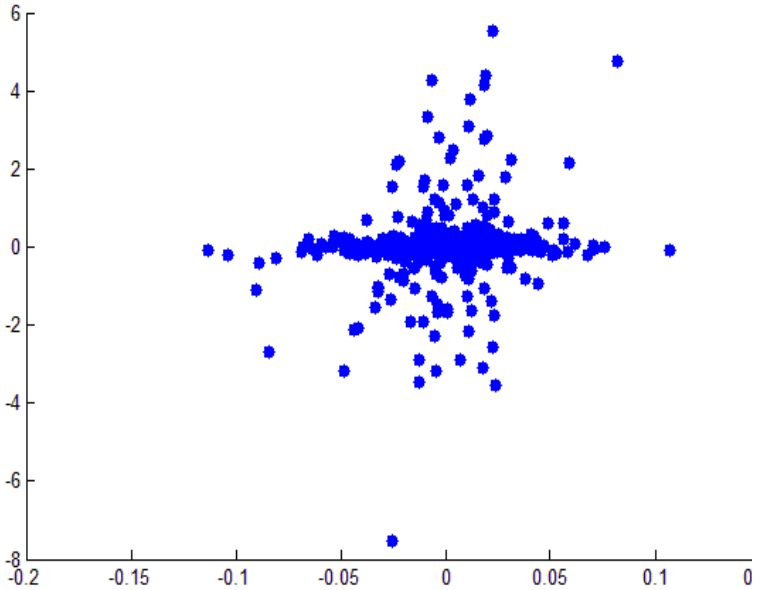
Scatterplot of simulated dependence structure for Gaussian copula (left panel) and Student t copula with df=2 (right panel), τ=0.6.

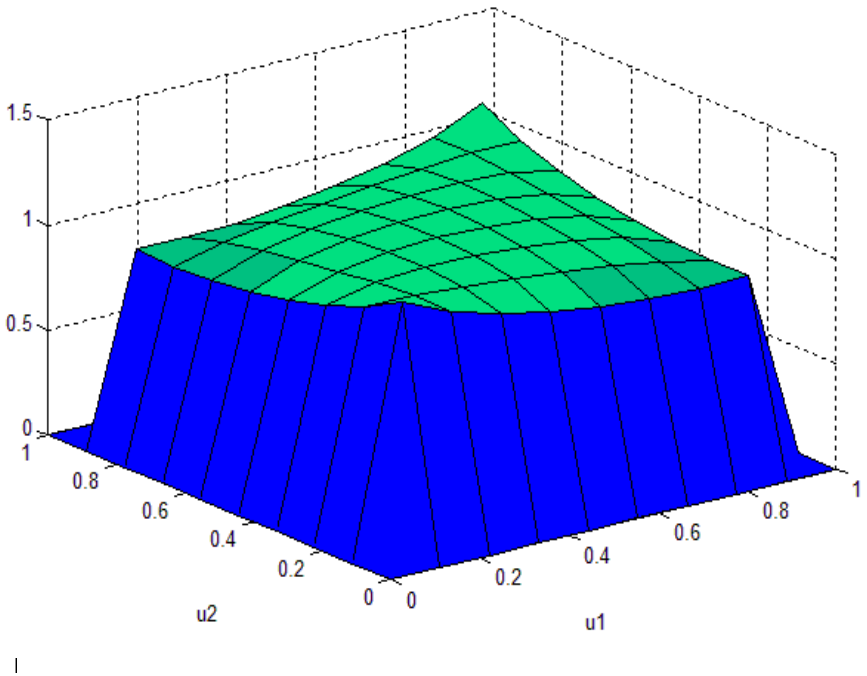
Dependence Structure for Clayton and Gumbel Copula



Scatterplot of simulated dependence structure for Clayton (left panel) and Gumbel copula, τ=0.6.

BCI changes and AOI Returns





Scatterplot of AOI weekly returns in t+2 vs. weekly changes in BCI in t (*left panel*) and estimated Student t-copula (df=7) for dependence structure

Relationship of Business Condition Index with Equity Returns

- Student-t copula provides best fit to dependence structure between changes in BCI and AOI returns
- For weekly data contemporaneous correlations are close to zero but lagged BCI (t → t+2, t→ t+3) has some predictive power on AOI index returns ($\rho>0.1$)
- For monthly data, correlations for contemporaneous and t→t+1 relationship are significant ($\rho>0.1$)
- Indicates some symmetric tail dependence between changes and returns that cannot be modelled by linear correlation
- Substantial changes in index have some predictive power on forthcoming large AOI returns

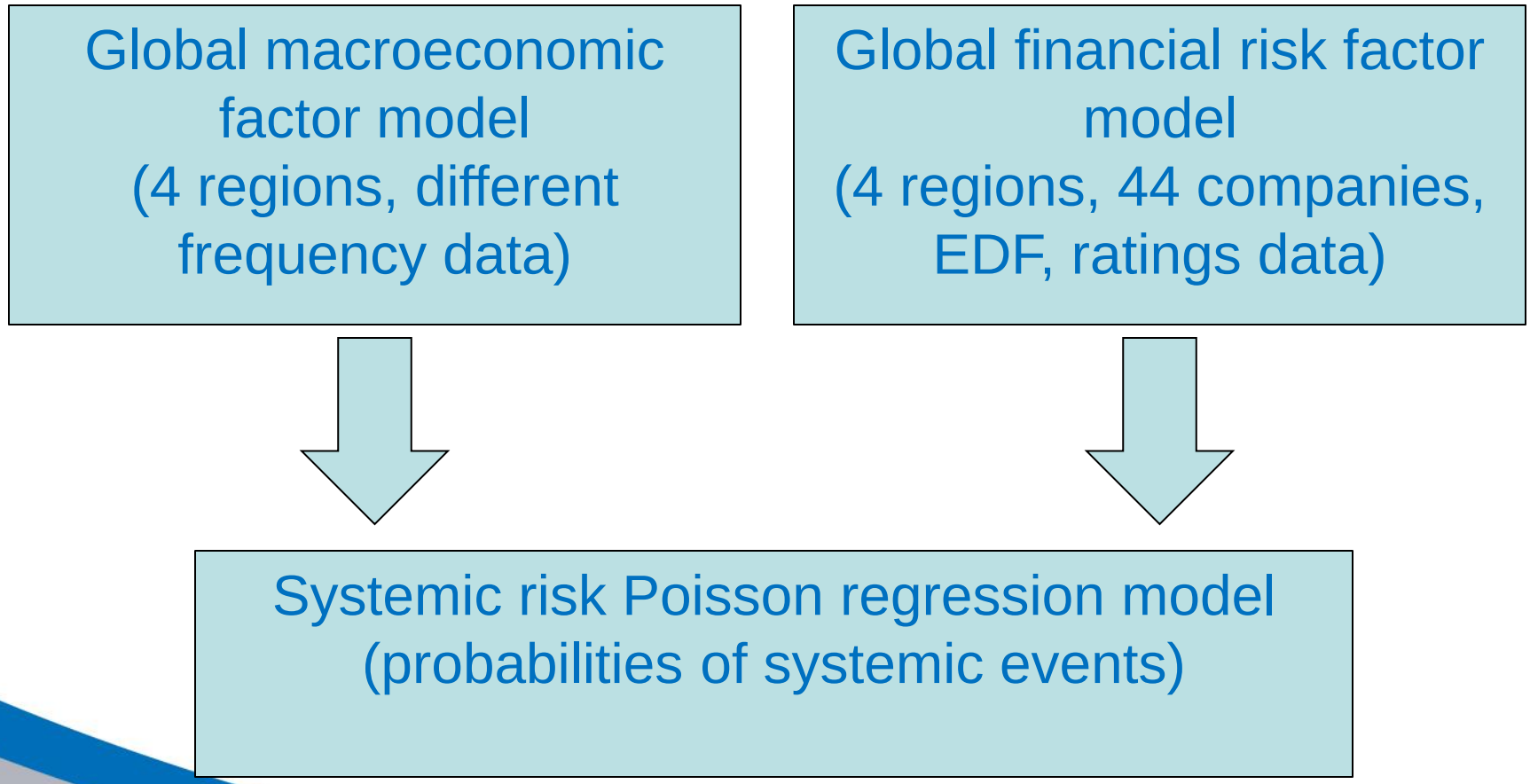
Developing a Systemic Risk Indicator for Australia

- Aim: To develop a systemic index with early warning features that can be used for macro-prudential policy in Australia
- Systemic risk index can depend on estimated unobserved states for macroeconomic conditions index, financial conditions index, and other explanatory variables such as, e.g., volatility in the equity market
- Financial conditions index is derived using Moody's EDF and ratings from 01/01/2000 – 31/12/2012
- A systemic index can be constructed for a region where no (or very few) systemic events have occurred.

Related Literature

- Bottom-up approaches measure the contribution of individual institutions to the systemic risk of the entire financial market in a region
  - CoVaR (Adrian and Brunnermeier, 2009); SRISK (Brownlees and Engle, 2010); VAR for VaR (White, Kim and Manganelli, 2010); Contribution to total capital shortfall (Acharya, 2010)
- Top-down approaches identify systemic risk by inferring factors relating to the whole financial system, potentially including macroeconomic variables
  - Principal Component Analysis (Billio et al, 2010); Network Analysis (Allen et al, 2010)
  - Systemic risk diagnostics and early warning indicators derived from macro and credit risk data (Schwaab et al, 2011)

Research Design



Macroeconomic Factor Model

- Macroeconomic condition in each region is decomposed into a global component that is common to all regions f_0 and a regional specific component f_i
- Global factor follows the dynamics:

$$f_{0,t+1} = \phi_0 \, f_{0,t} + \eta_{0,t}$$

- Transition of factor for region i (i=1,…,4):

$$f_{i,t+1} = \phi_i \, f_{i,t} + \theta_i \, f_{0,t} + \eta_{i,t}$$

- Observation equation:

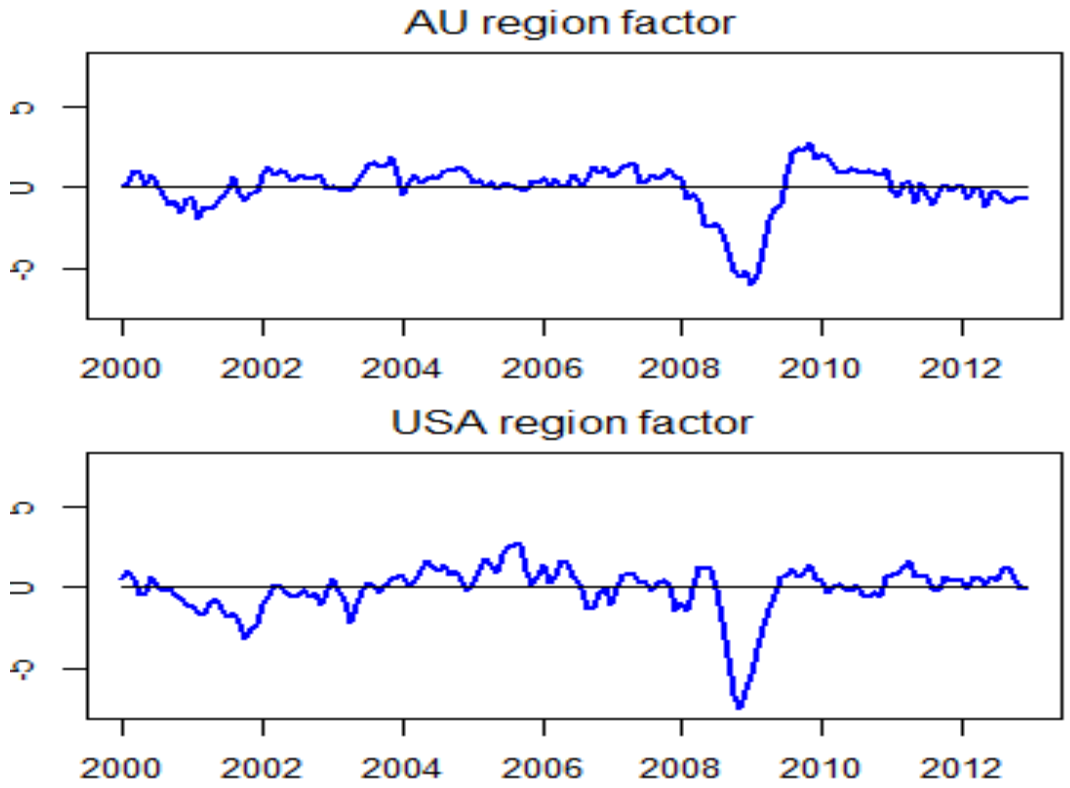
$$y_t = \gamma y_{t-1} + Z f_t + \varepsilon_t$$

Macroeconomic Variables

Variables	Monthly	Quarterly	Annual	Stock/Flow
GDP		AU, EU, US	ROW	Flow
Inflation rate	EU, US, ROW	AU		Flow
Unemployment rate	AU, EU, US		ROW	Stock
Confidence index	EU, US	AU, ROW		Stock
Property price	EU, US, ROW	AU		Stock
Stock market return	AU, EU, US, ROW			Flow
Job vacancy	AU, US	EU, ROW		Stock
Term of trade	US, ROW	AU	EU	Stock
Term premium	AU, EU, US, ROW			Stock

Table 1: Variables used in macroeconomic model

Macroeconomic Factors



Financial Risk Model

Parsimonious groupings

- The largest 11 financial companies in each region (i=1,..11)
- 4 regions: US, EU, AU, ROW (r=1,..4)

Expected default freq:
(from Moodys EDF)

$$z_{i,r}(t) = \text{prob(value <debt)}$$

Rating level:

$$A_{i,t} = 1, \ldots, 20$$

Unobserved factors:

$$S(t) = \{S_a(t), S_r(t)\}$$

{Ratings, and region factors}

Rating frequency

Rating	Frequency Count	Percent of Total Frequency	Cumulative Frequency Count	Cumulative Percent
Aaa	780	3.26	780	3.26
Aa1	2654	11.10	3434	14.37
Aa2	3437	14.38	6871	28.75
Aa3	4227	17.69	11098	46.43
A1	2186	9.15	13284	55.58
A2	3125	13.07	16409	68.65
A3	2498	10.45	18907	79.11
Baa1	1249	5.23	20156	84.33
Baa2	1092	4.57	21248	88.90
Baa3	780	3.26	22028	92.16
Ba1	468	1.96	22496	94.12
Ba2	624	2.61	23120	96.73
Ba3	468	1.96	23588	98.69
B1	156	0.65	23744	99.34
B3	157	0.66	23901	100.00

Table 3: Observations across ratings

Model for Financial Risk Factors

$$\log \frac{z_{i,t}}{1-z_{i,t}} = a + A_{i,t} S_{a,t} + dS_{r,t} + v_{i,t}$$

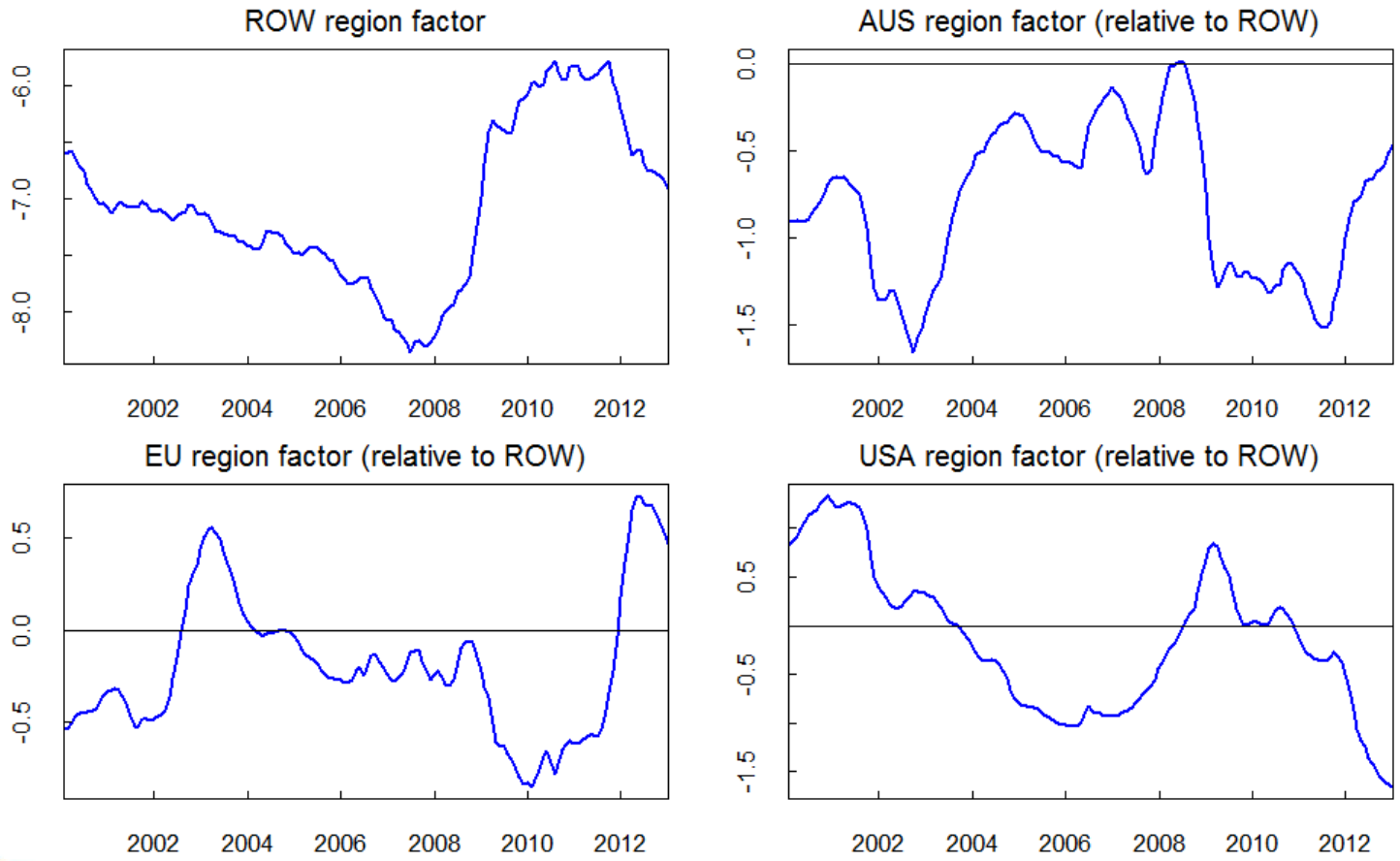
$$S_{t+1} = \rho S_t + \eta_t$$

$$\eta_t \sim N(0, Q), \quad \rho, Q \text{ are diagonal.}$$

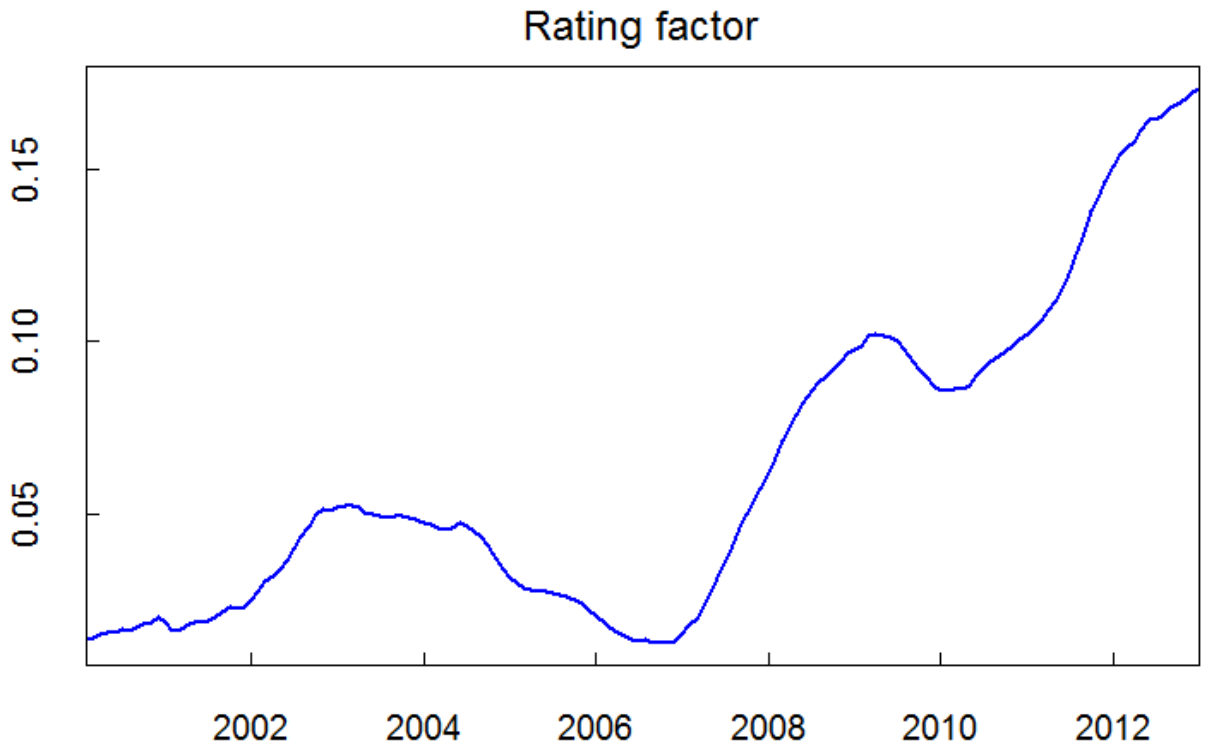
Companies: $i = 1, \ldots, 11$

Regions: $r = 1, \ldots, 4$

Financial Risk Factors



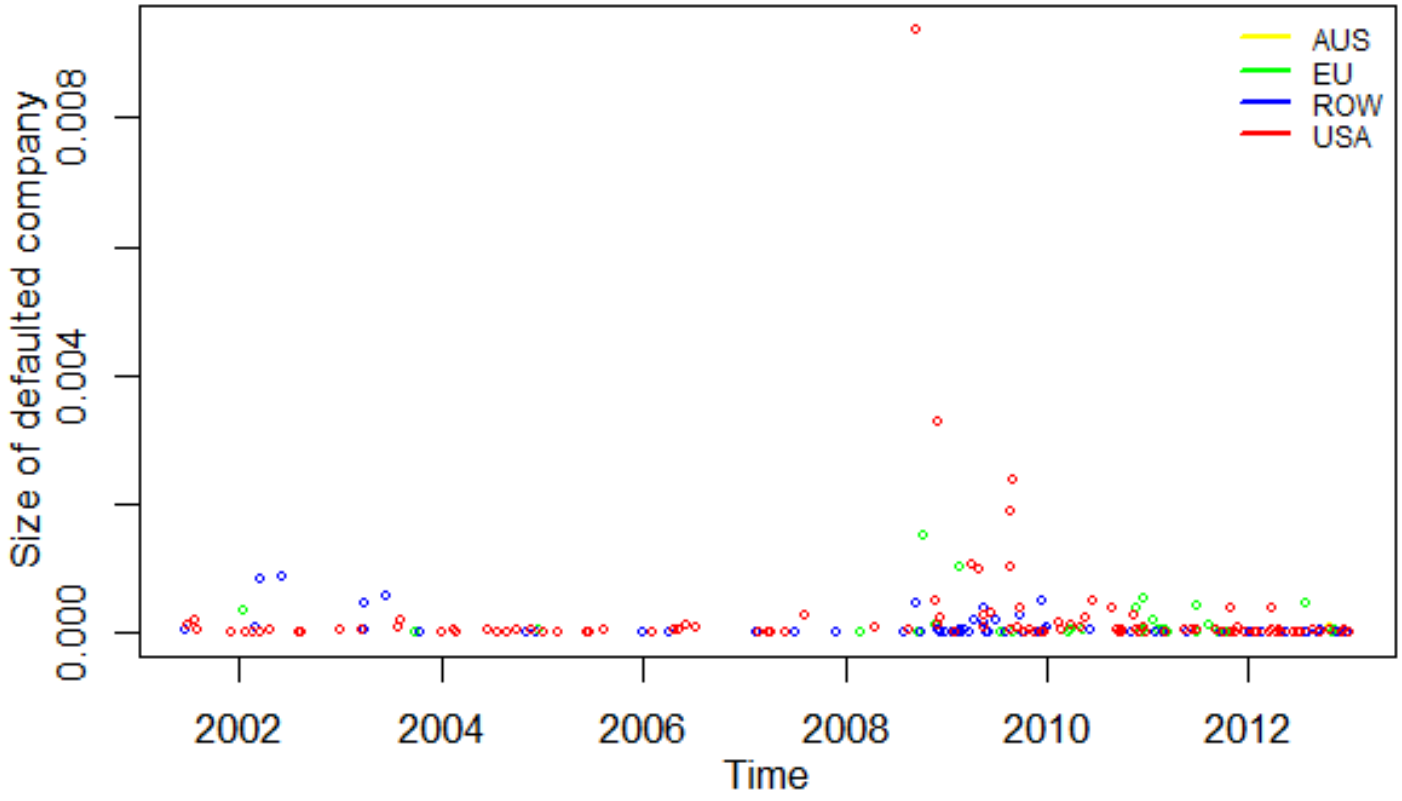
Rating Factor



Systemically Relevant Events

- Default events of financial corporations are sourced from COMPUSTAT and Moody's Corporate Default Risk Service
- We define a systemically relevant event as the default of a financial institution whose market capitalization is greater than (i) 0.01%; (ii) 0.002% of the total regional market capitalization of all financial institutions
- Based on this definition we obtain (i) 42; (ii) 82 events for all regions

Defaults in the Financial Sector and Systemically Relevant Events



Defaults in the Financial Sector and Systemically Relevant Events

- Largest company defaulted is: LEHMAN BROTHERS HOLDINGS INC
- Australian companies defaulted:

  AU000000RRT1,RECORD REALTY

  AU000000BAO2,BROOKFIELD AUSTR OPP FUND

Explaining Systemically Relevant Events

We create a simple model for explaining the number of systemically relevant events:

- Number of systemic events : y_t^s
- Common financial risk factor: $f_{0,t}^f$
- Regional financial risk factor: $f_{r,t}^f$
- Macroeconomic factor: f_t^m
- Stock market index volatility, estimated using an EWMA approach X_t

Poisson Regression Model

Poisson regression assumes the response variable *y* follows a Poisson distribution, and the logarithm of its expected value can be modelled by a linear combination of unknown parameters:

$$y_t^s \sim Poisson(\lambda_t^s)$$

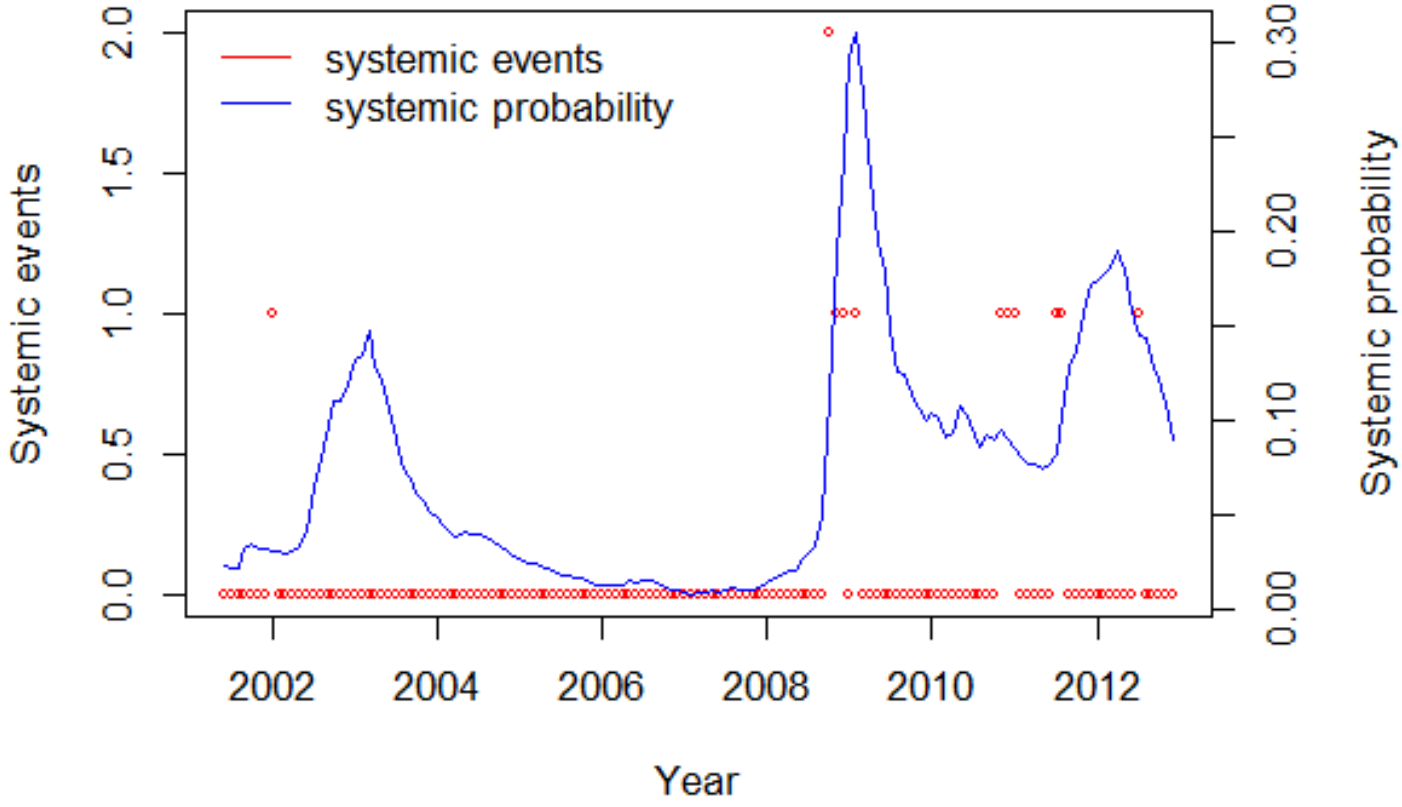
$$\log \lambda_t^s = \gamma_0 + f_{0,t}^{f}\gamma_1 + f_{r,t}^{f}\gamma_2 + X_t\,\gamma_3 + f_t^{m}\gamma_4$$

Results for Poisson Regression (k=0.01%)

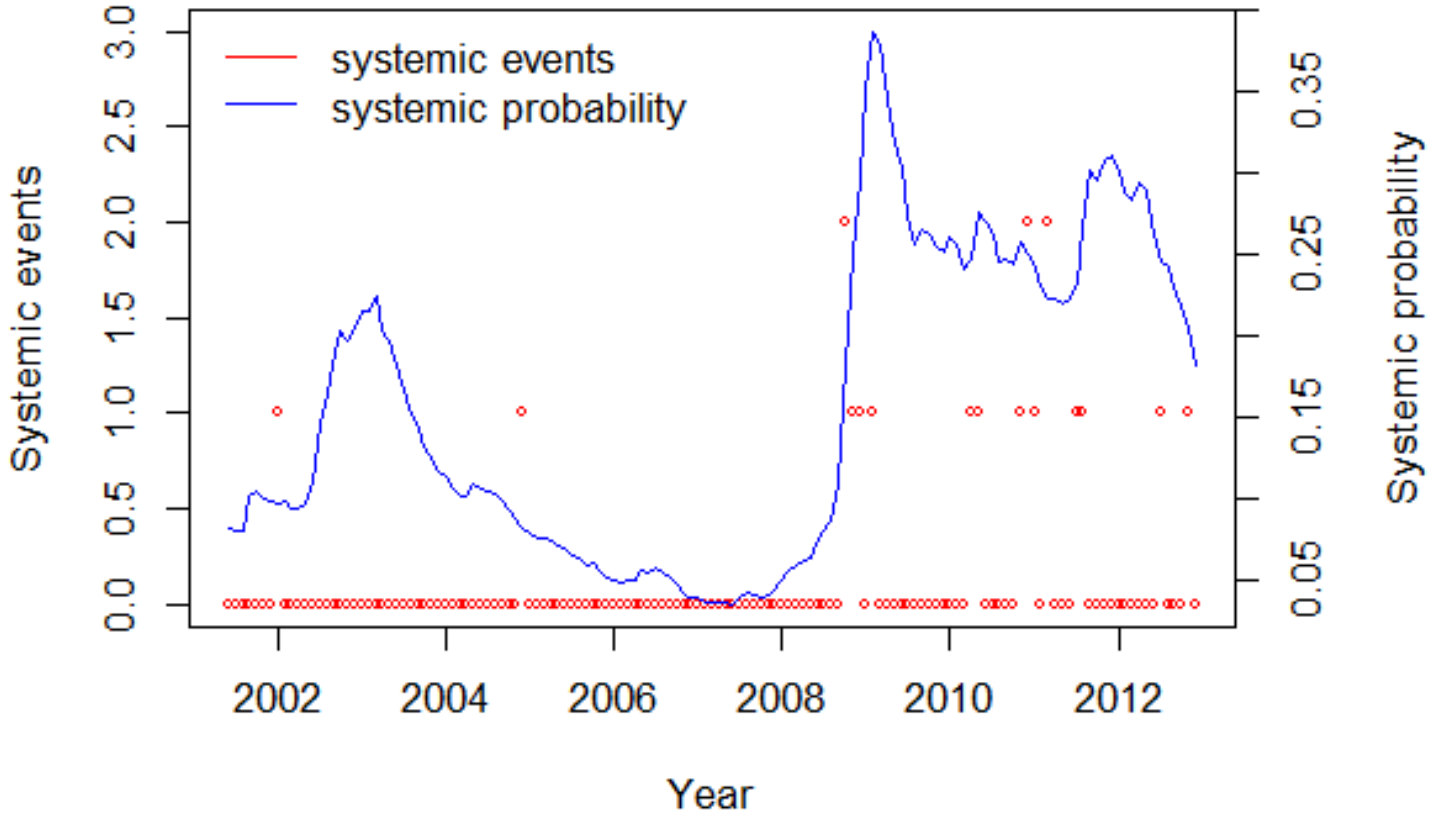
	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	1.3234	1.5734	0.84	0.4003
f0	0.7880	0.2219	3.55	0.0004
fr	1.0168	0.3521	2.89	0.0039
vol	119.5016	25.0235	4.78	0.0000
fm	0.1047	0.0756	1.38	0.1661

Table 7: Poisson regression estimates, R-squared = 0.1941

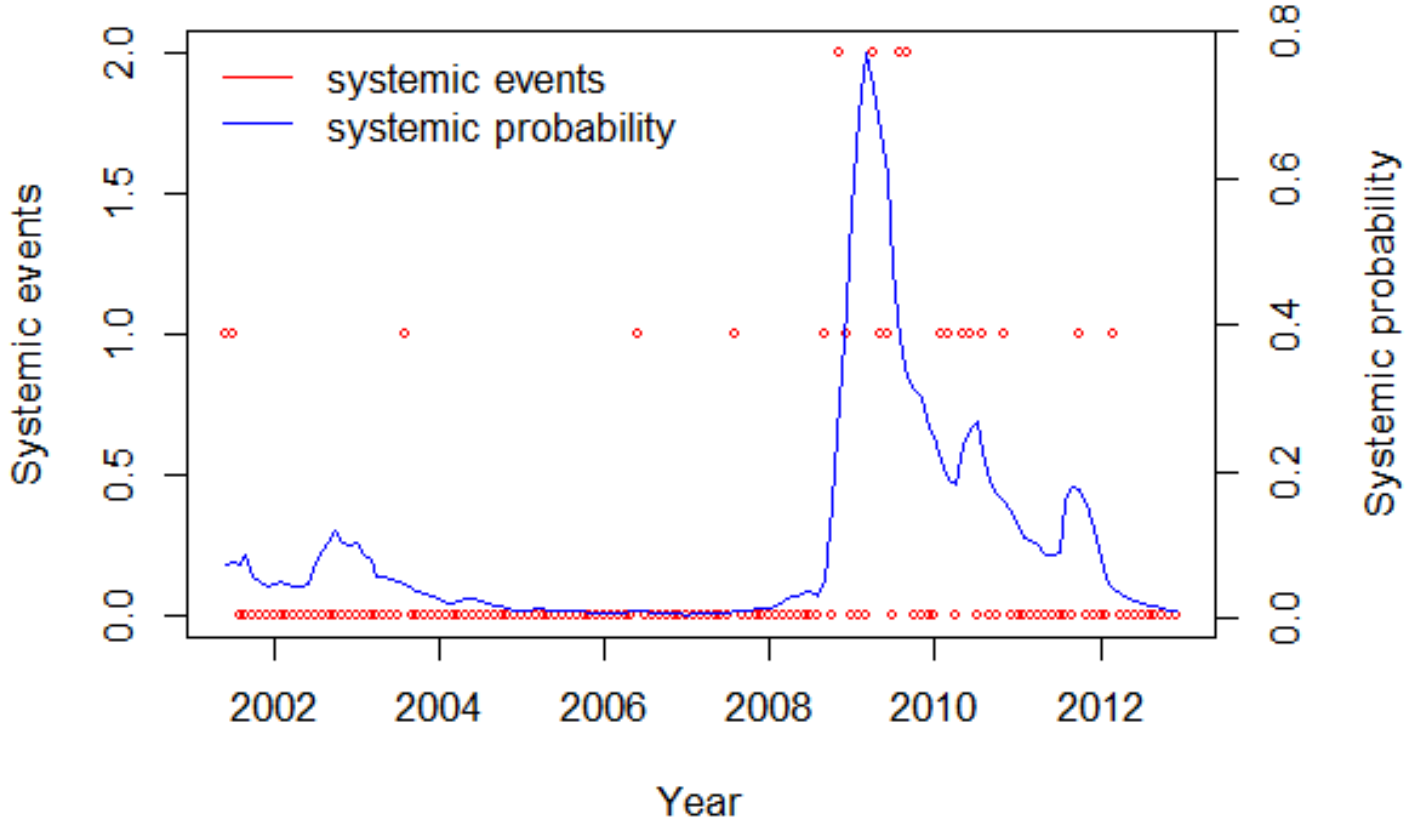
Systemic Index – Europe (k=0.01%)



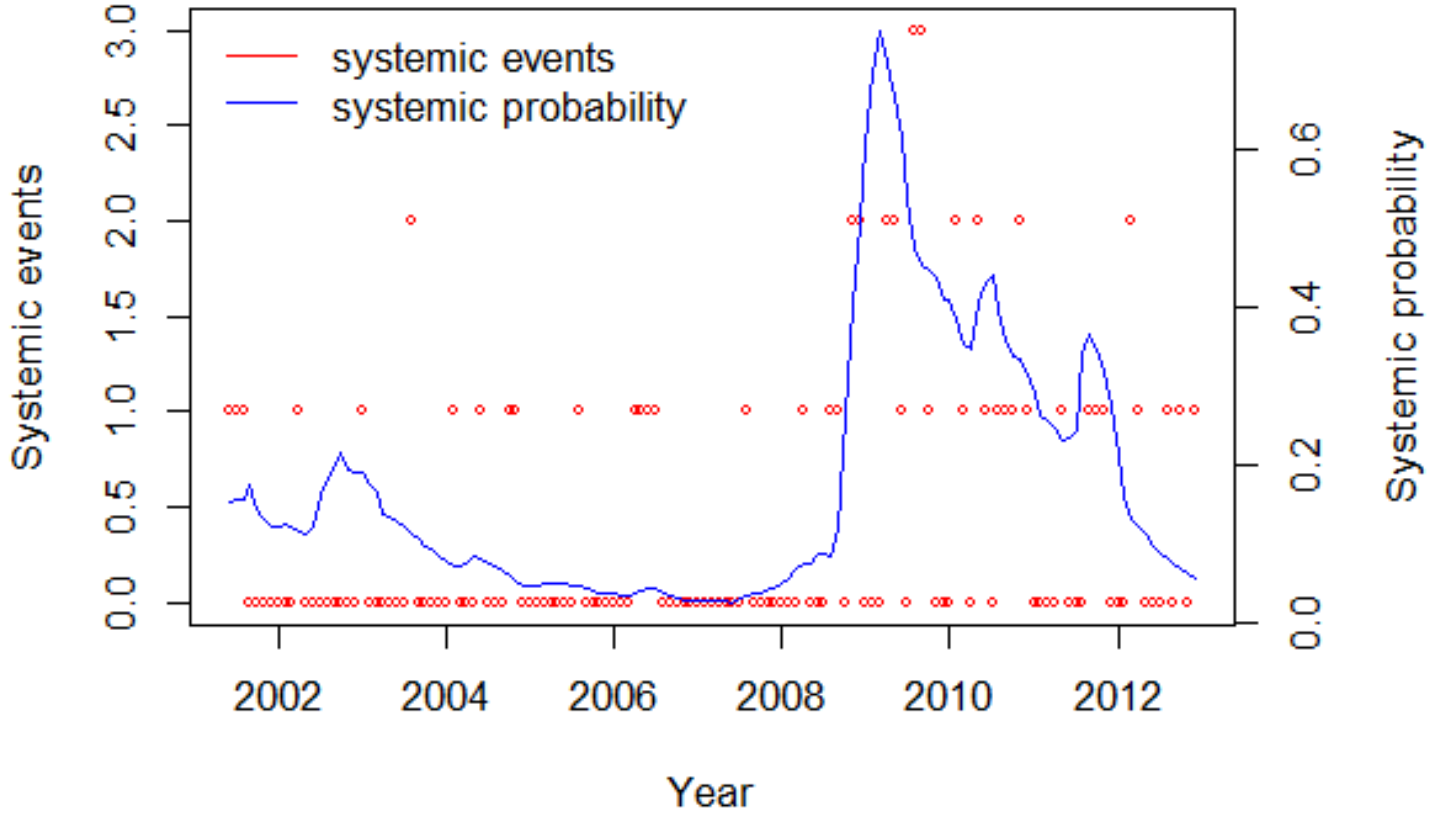
Systemic Index – Europe (k=0.002%)



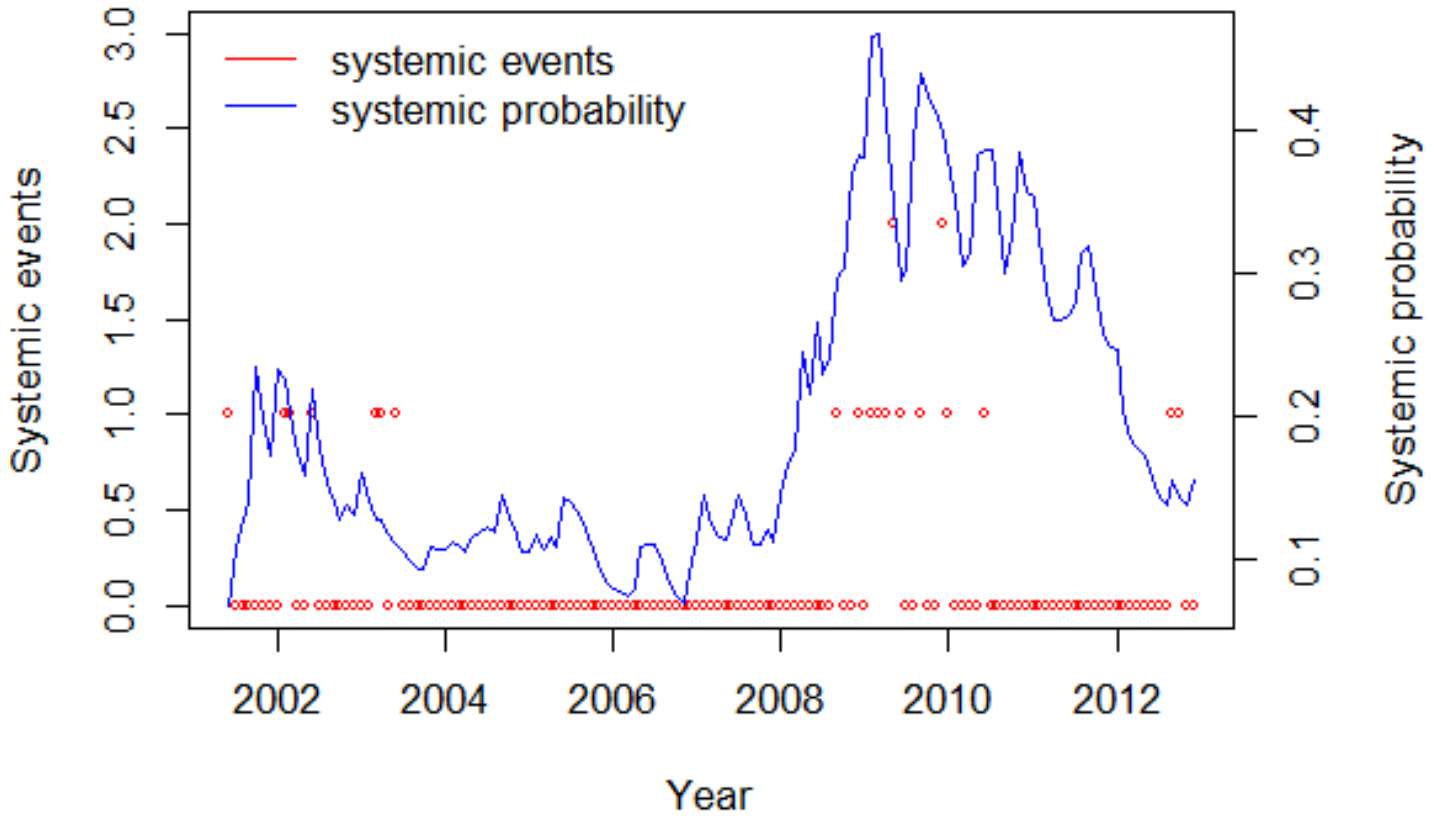
Systemic Index – US (k=0.01%)



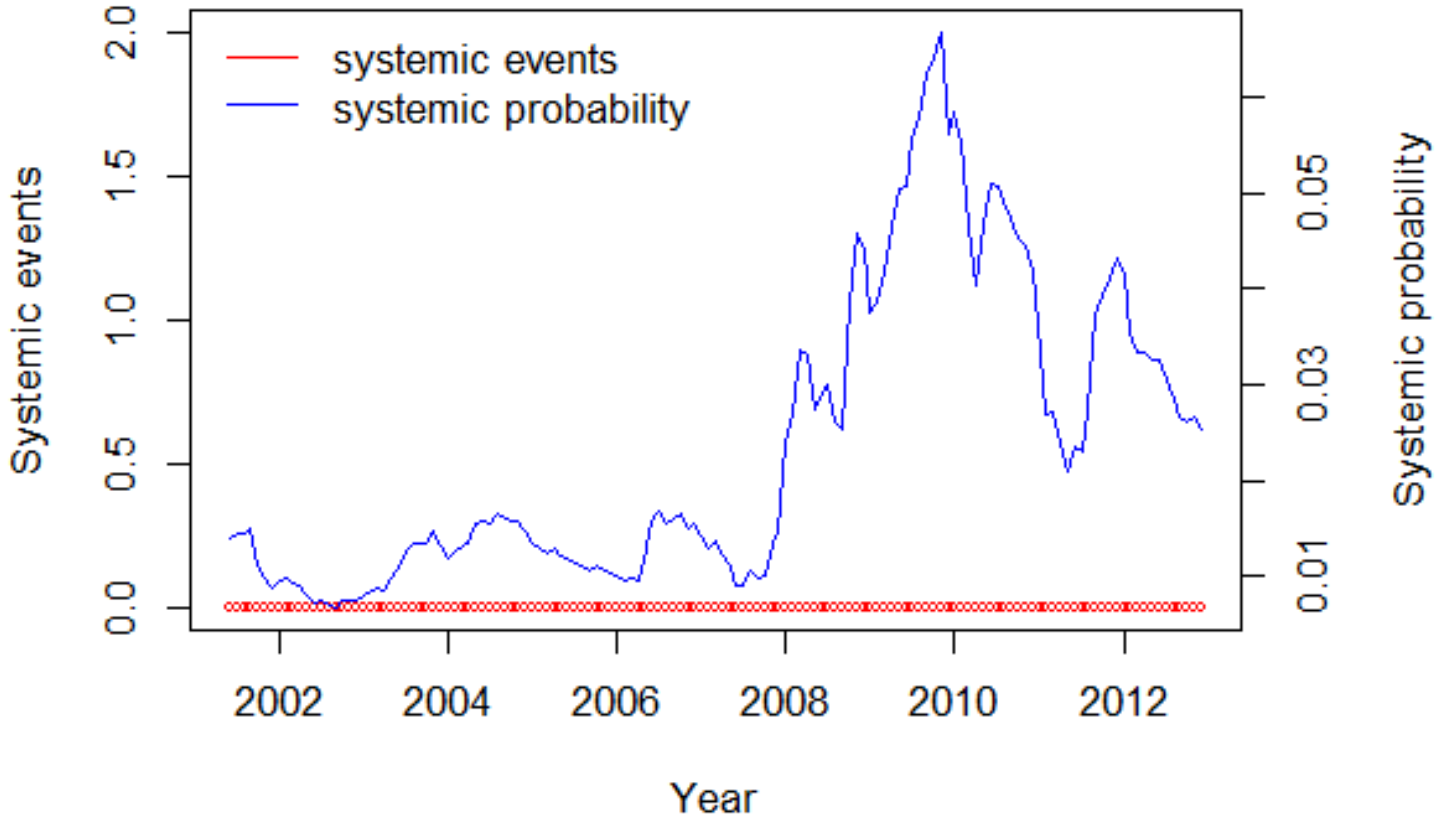
Systemic Index – US (k=0.002%)



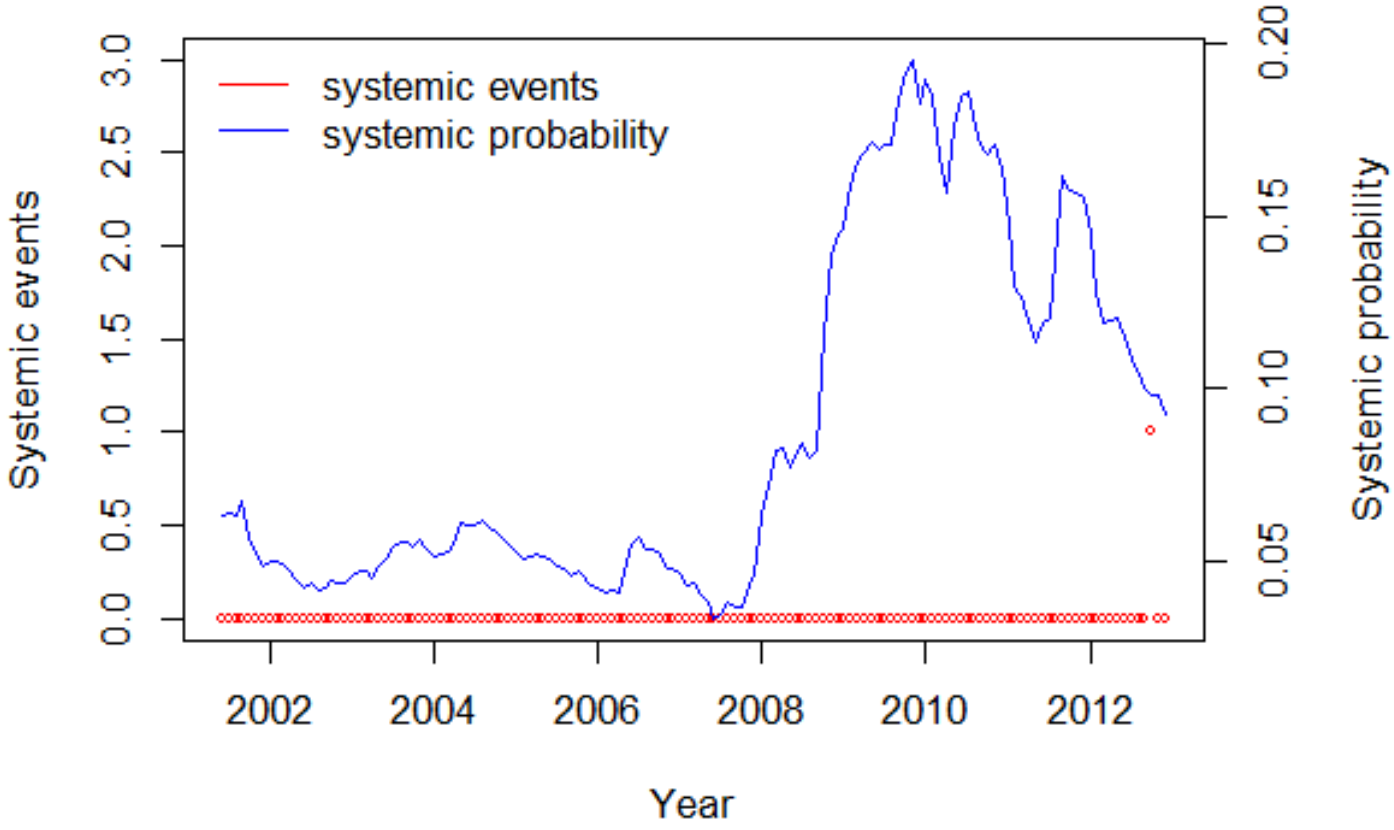
Systemic Index – ROW (k=0.01%)



Systemic Index – Australia (k=0.01%)



Systemic Index – Australia (k=0.002%)



Concluding Comments

- We construct an unobservable domestic business conditions index and an external conditions index for Australia that summarizes large amount of information
- Addresses lack of parsimonious indicators for national or regional financial and business conditions in real-time
- Provides the first real-time business and systemic risk indicators for Australia summarizing large amount of information
- Identifies driving factors of risk in Australia's economy financial markets including possible spill-over effects
- Derived index seems to have some predictive power on equity returns in financial markets (mainly for tail risks)

Concluding Comments

- We have used macroeconomic, financial risk and financial institutions' default data to construct a systemic index
- The method incorporates the probability of defaults of financial institutions as well as the size of financial institutions.
- A systemic index can be constructed for a region where no (or very few) systemic events have occurred.
- The index is consistent with observed systemic data, but number of systemically relevant events in Australia is lower than what is suggested by the created systemic risk indicator

Concluding Comments

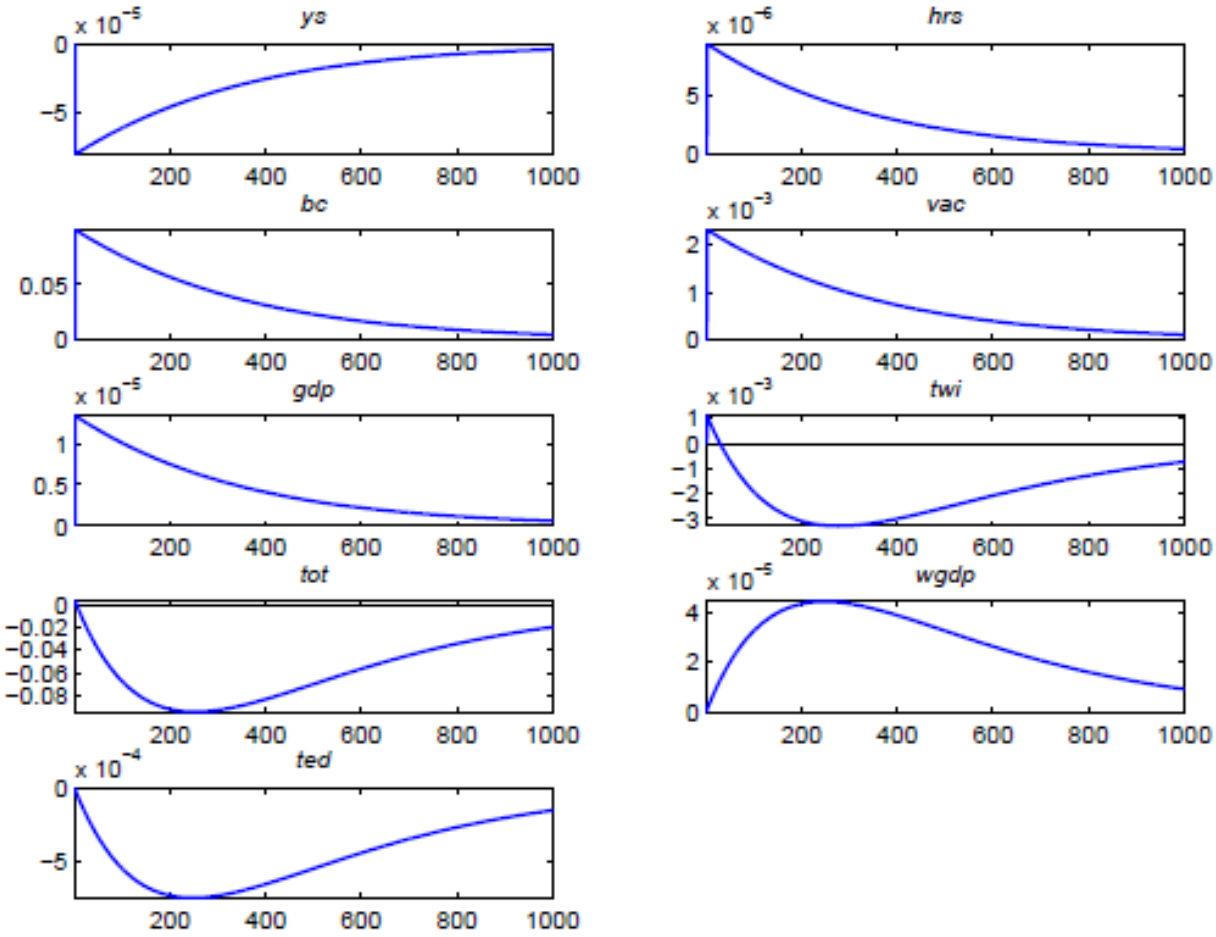
- Derived common and regional financial factors provide significant contributions to explaining systemic risk
- Volatility in regional markets is a significant factor for derived systemic risk indicators
- Derived macroeconomic condition index does not provide a significant contribution in the current model

Concluding Comments

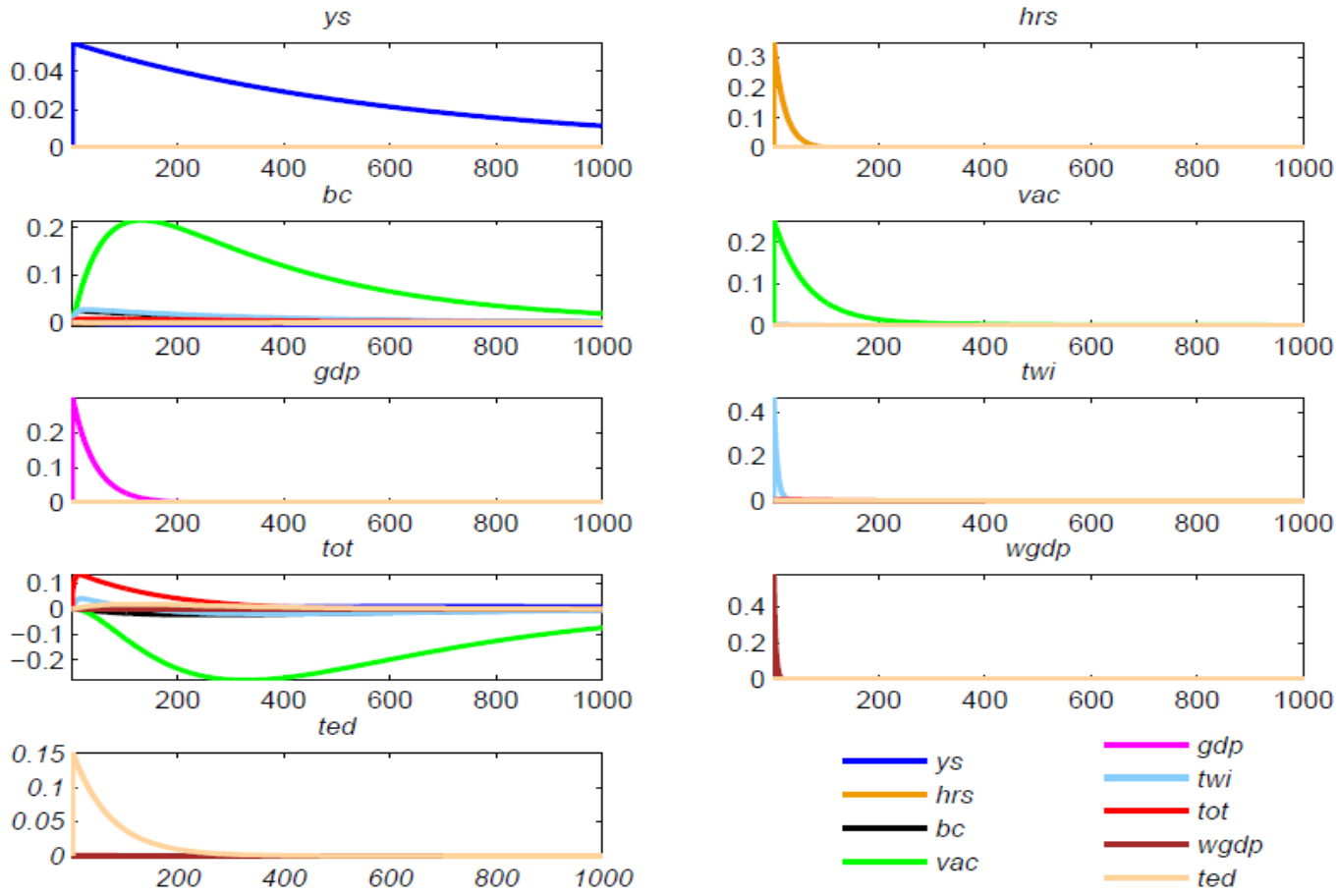
- Forward-looking indicators for business conditions, financial and systemic risks will provide an efficient, low cost summary of information
- Availability of this information in real-time is expected to provide economic benefits to policymakers and market participants
- Indicators as result of this project will reduce the dimensionality of the information problem, and make it easier for market participants to better manage and hedge the many risks they face
- Project will hopefully contribute to policy efforts to sustain financial stability in Australia and the region

Thank you very much!

Impulse responses of domestic index



Impulse responses of each observable on others and itself



Appendix List of financial institutions

No	Name	ISIN	Region	Country	Mcap	Rank
1	COMMONWEALTH BANK AUSTRALIA	AU000000CBA7	AUS	AUS	5.59E+10	1
2	WESTPAC BANKING	AU000000WBC1	AUS	AUS	4.58E+10	2
3	ANZ-AUSTRALIA & NEW ZEALD BK	AU000000ANZ3	AUS	AUS	4.08E+10	3
4	NATIONAL AUSTRALIA BK	AU000000NAB4	AUS	AUS	3.60E+10	4
5	QBE INSURANCE GROUP LTD	AU000000QBE9	AUS	AUS	9.72E+09	6
6	SUNCORP GROUP LTD	AU000000SUN6	AUS	AUS	7.29E+09	8
7	MACQUARIE GROUP LTD	AU000000MQG1	AUS	AUS	6.27E+09	9
8	DEXUS PROPERTY GROUP	AU000000DXS1	AUS	AUS	2.97E+09	19
9	BENDIGO AND ADELAIDE BANK	AU000000BEN6	AUS	AUS	2.03E+09	23
10	COMMONWEALTH PPTY OFFICE FD	AU000000CPA7	AUS	AUS	1.60E+09	24
11	BANK OF QUEENSLAND LTD	AU000000BOQ8	AUS	AUS	1.35E+09	28
12	HSBC HLDGS PLC	GB0005405286	EU	GBR	1.03E+11	1
13	BANCO SANTANDER SA	ES0113900J37	EU	ESP	4.32E+10	2
14	STANDARD CHARTERED PLC	GB0004082847	EU	GBR	3.53E+10	3
15	BNP PARIBAS	FR0000131104	EU	FRA	3.47E+10	4
16	ALLIANZ SE	DE0008404005	EU	DEU	3.21E+10	5
17	ALLIED IRISH BANKS	IE0000197834	EU	IRL	2.91E+10	6
18	BBVA	ES0113211835	EU	ESP	2.53E+10	8
19	LLOYDS BANKING GROUP PLC	GB0008706128	EU	GBR	2.46E+10	9
20	DEUTSCHE BANK AG	DE0005140008	EU	DEU	2.37E+10	10
21	NORDEA BANK AB	SE0000427361	EU	SWE	2.28E+10	11
22	AXA	FR0000120628	EU	FRA	2.18E+10	12

Appendix List of financial institutions

No	Name	ISIN	Region	Country	Mcap	Rank
23	BANK OF CHINA LTD	CNE1000001Z5	ROW	CHN	7.41E+10	4
24	ROYAL BANK OF CANADA	CA7800871021	ROW	CAN	5.00E+10	5
25	TORONTO DOMINION BANK	CA8911605092	ROW	CAN	4.63E+10	7
26	SBERBANK OF RUSSIA OJSC	RU0009029540	ROW	RUS	4.00E+10	10
27	BANK OF NOVA SCOTIA	CA0641491075	ROW	CAN	3.84E+10	11
28	STATE BANK OF INDIA	INE062A01012	ROW	IND	3.18E+10	14
29	UBS AG	CH0024899483	ROW	CHE	3.13E+10	15
30	BANK OF MONTREAL	CA0636711016	ROW	CAN	2.36E+10	20
31	BOC HONG KONG HOLDINGS LTD	HK2388011192	ROW	HKG	1.97E+10	26
32	CANADIAN IMPERIAL BANK	CA1360691010	ROW	CAN	1.93E+10	28
33	CREDIT SUISSE GROUP	CH0012138530	ROW	CHE	1.82E+10	30
34	WELLS FARGO & CO	US9497461015	USA	USA	1.10E+11	1
35	JPMORGAN CHASE & CO	US46625H1005	USA	USA	9.40E+10	2
36	CITIGROUP INC	US1729674242	USA	USA	5.94E+10	3
37	BANK OF AMERICA CORP	US0605051046	USA	USA	5.67E+10	4
38	AMERICAN EXPRESS CO	US0258161092	USA	USA	4.05E+10	6
39	U S BANCORP	US9029733048	USA	USA	3.79E+10	7
40	UNITEDHEALTH GROUP INC	US91324P1021	USA	USA	3.61E+10	8
41	AMERICAN INTERNATIONAL GROUP	US0268747849	USA	USA	3.40E+10	9
42	GOLDMAN SACHS GROUP INC	US38141G1040	USA	USA	3.39E+10	10
43	EXPRESS SCRIPTS HOLDING CO	US30219G1085	USA	USA	2.58E+10	13
44	METLIFE INC	US59156R1086	USA	USA	2.29E+10	14