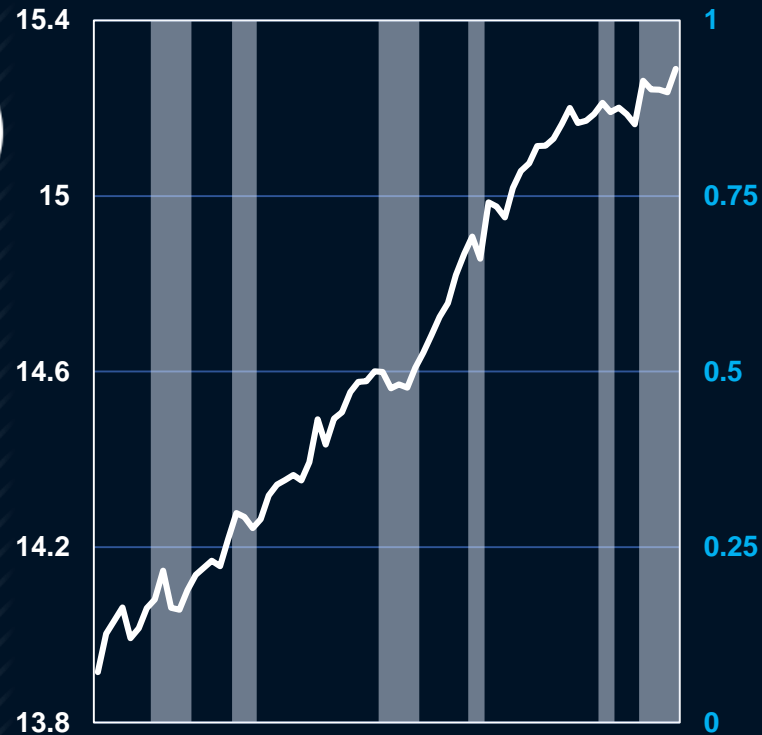




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THE CONNECTEDNESS OF ASIAN COUNTRIES: NETWORK ANALYSIS



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The views in this paper are those of the authors and do not necessarily reflect the views of the Bank of Mongolia.



INTRODUCTION

- Importance
- Literature Review



METHODOLOGY

- Diebold-Yilmaz Index
- Network Connectedness



EMPIRICAL RESULTS

- Data
- Spillover Index



CONCLUDING REMARKS

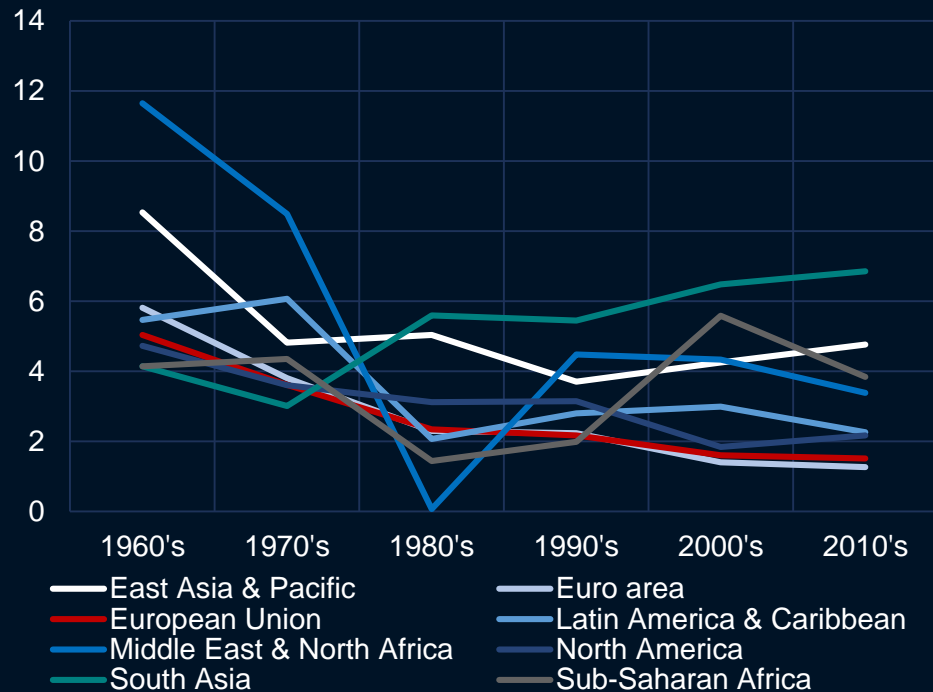


Introduction



Importance

Figure 1. Economic growth by continents, 1960-2017



Literature Review



Understanding how economies are connected and shocks are transmitted is a crucial and modern issue for policymakers and researchers.



Asian countries tend to play fundamental role in Global economy.

- *For instance, shocks from some Asian countries spread complex effects to neighboring economies, and apparently to other economies across the globe during the financial crisis of 1997-98.*



Recent activities in economies also prove that emerging market economies in Asia can become a major source of shocks that transmitted widely, as well as their increasing economic importance.



Therefore, studying the economic connectedness of Asian countries is an important and an early action for policy decisions.



Introduction

Importance

Diebold & Yilmaz (2009) “Measuring financial asset return and volatility spillovers, with application to global equity markets”

- They provide a simple and intuitive measure of interdependence of asset returns and/or volatilities.



Methodology

Diebold & Yilmaz (2015) “Measuring the Dynamics of Global Business Cycle Connectedness”

- Using a connectedness-measurement technology fundamentally grounded in modern network theory, they measure real output connectedness for a set of six developed countries, 1962-2010.



Empirical results

Davaajargal (2018) “Diebold-Yilmaz index”, Eviews add-ins

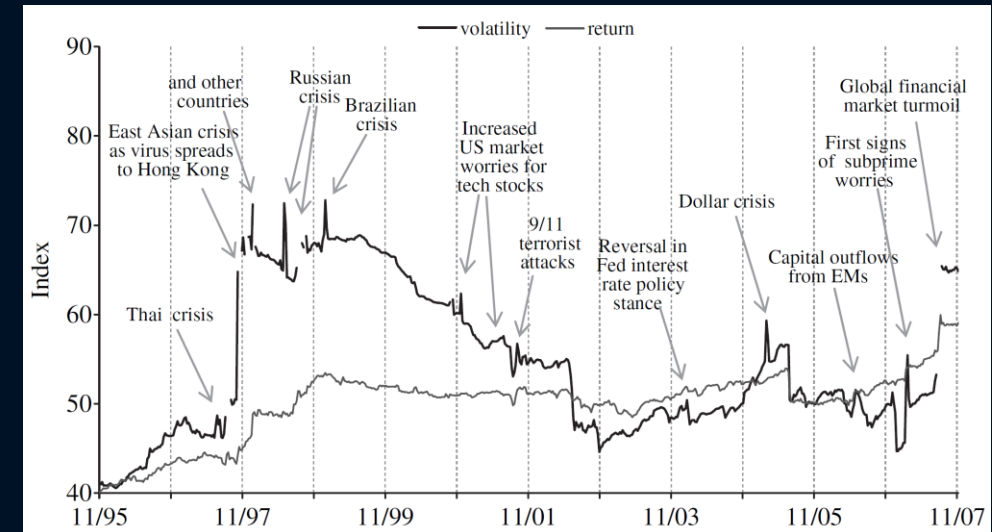
- The add-in estimates the Diebold-Yilmaz index of spillover using forecast error variance decomposition method of VAR model.



Concluding remarks

Literature Review

Spillover Plot, Global Stock Market Returns and Volatility, 11/1995–11/2007





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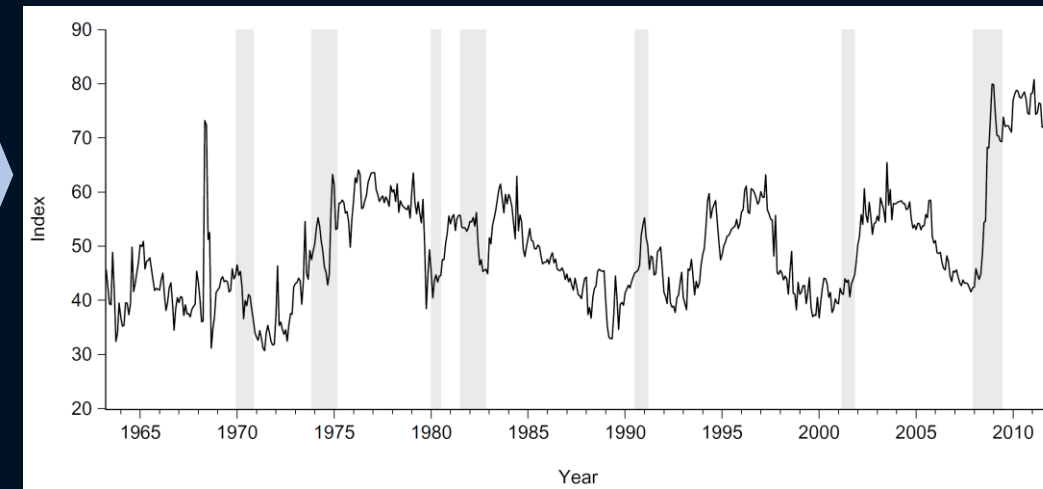
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Concluding remarks

Literature Review

Dynamic Total Connectedness, G-6 Industrial Production, 1958:01- 2011:12





Introduction



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Concluding remarks



Literature Review



DY INDEX

The add-in estimates the Diebold-Yilmaz index of spillover.

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Introduction

Connectedness table

Simple VAR equation

$$y_t = A_0 + A_1 * y_{t-1} + \dots + A_p * y_{t-p} + \epsilon_t \quad (1)$$

- Where: y_t is a vector of length k . There are k equations; p is the order of the VAR; $\{\epsilon_t\}$ is a sequence of serially uncorrelated random vectors with concurrent full rank covariance matrix Σ ; A_0 is a $(k \times 1)$ vector of constants; A_i 's are $(k \times k)$ coefficient matrices.

Connectedness table

where the H-step forecast error variance of variable i accounted for by exogenous shocks to variable j is denoted by d^H_{ij} .

	x_1	x_2	...	x_N	From Others
x_1	d^H_{11}	d^H_{12}	...	d^H_{1N}	$\sum_{j=1}^N d^H_{1j}, j \neq 1$
x_2	d^H_{21}	d^H_{22}	...	d^H_{2N}	$\sum_{j=1}^N d^H_{2j}, j \neq 2$
\vdots	\vdots	\vdots	\ddots	\vdots	\vdots
x_N	d^H_{N1}	d^H_{N2}	...	d^H_{NN}	$\sum_{j=1}^N d^H_{Nj}, j \neq N$
To Others	$\sum_{i=1}^N d^H_{i1}, i \neq 1$	$\sum_{i=1}^N d^H_{i2}, i \neq 2$...	$\sum_{i=1}^N d^H_{iN}, i \neq N$	$\frac{1}{N} \sum_{i,j=1}^N d^H_{ij}, i \neq j$

Spillover index

$$C = \frac{1}{N} \sum_{\substack{i,j=1 \\ i \neq j}}^N d_{ij} \quad (2)$$

- There is just one total connectedness measure, as total connectedness distills a system into a single number





Connectedness index

Network analysis

Introduction

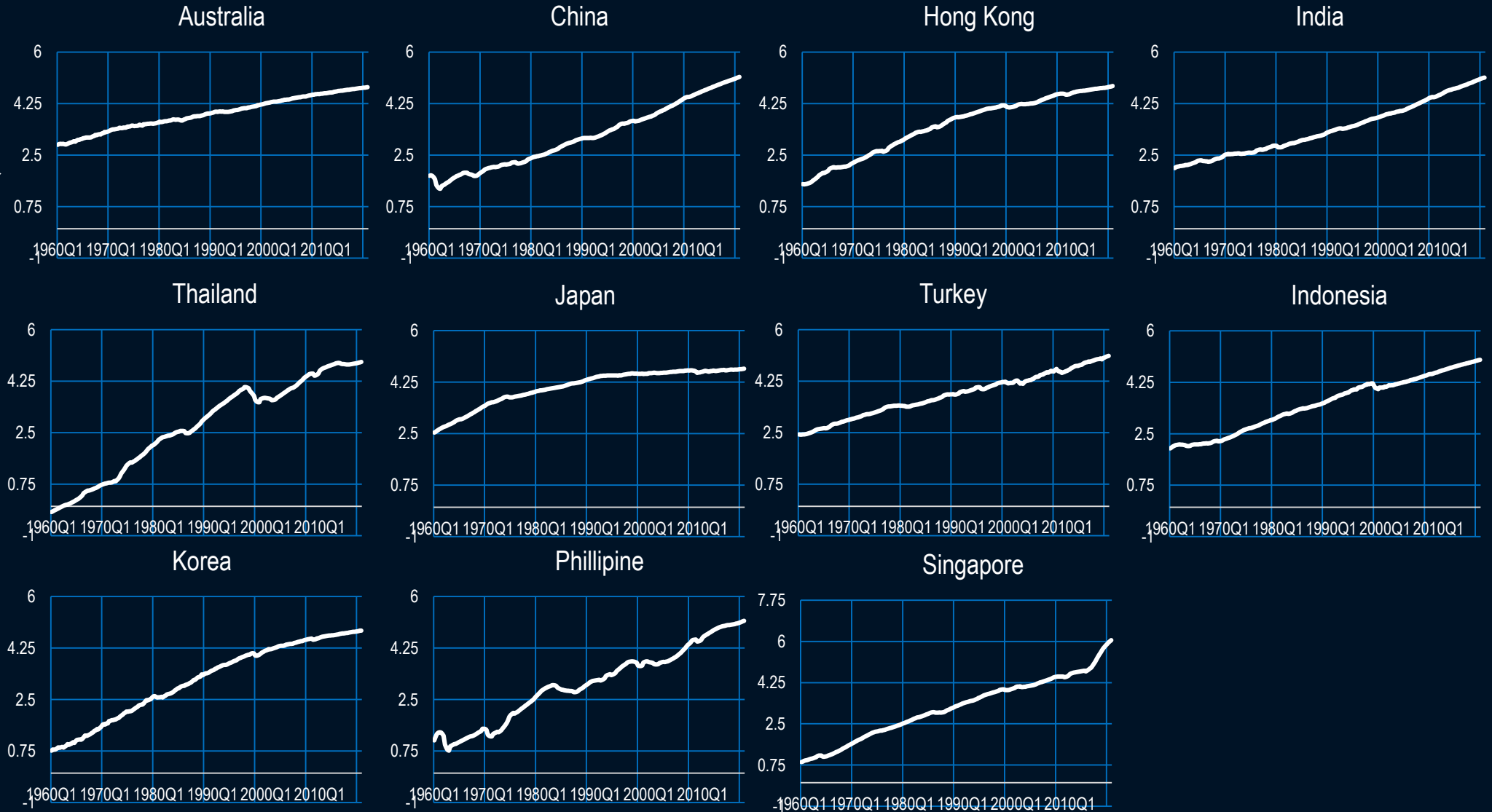


Methodology



Data

First Difference of Logged quarterly real GDP of selected 11 Asian countries, 1960q1-2016q4





Introduction



Methodology



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Concluding remarks

Connectedness index

Dynamic Total Connectedness, Selected Asian countries, 1985-2017



Note: We used Generalized VAR(3) with 120-quarter rolling window and 10 quarter forecast horizons.

Network analysis

Robustness	The estimation is fairly robust.
Fluctuations	Connectedness index fluctuates in the short-term.
Long-term trend	Long-term growth of connectedness index reflects the influence of globalization.
Cycles	Connectedness index might captures the 3 possible cycles. (1985-1996, 1996-2002, 2002-2014)
Crisis	Connectedness index increased significantly during the both crises. /Diebold & Yilmaz (2015)/
Future	The next financial crises is coming soon because of previous patterns of crises and growth of Asian connectedness index.



Introduction



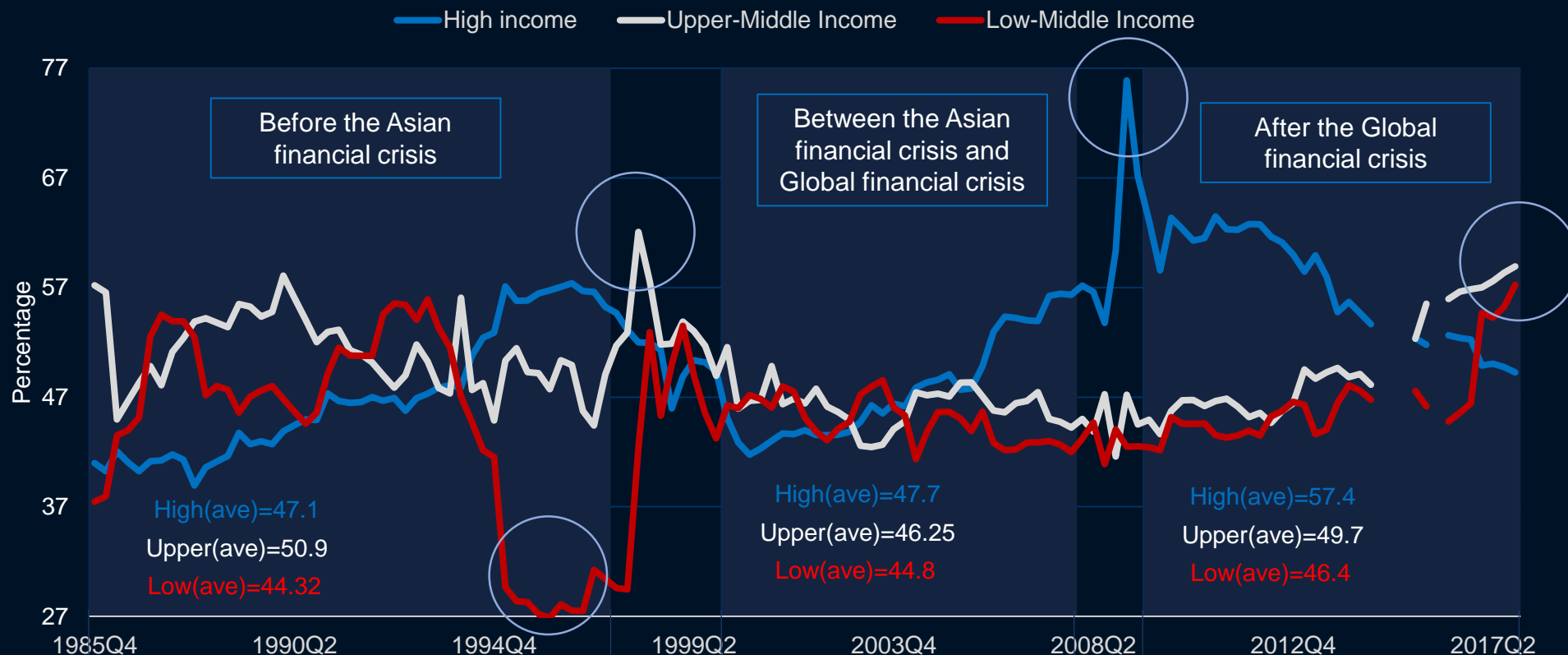
Methodology



Empirical results



Dynamic directional connectedness by income classification, 1985-2017 (To others)



- Upper-Middle income countries tended to contribute more to others.
- Before the crisis, there was huge drop to contribution of low-middle income countries to others.

- Significant growth of contribution of upper-middle income countries to others was one factor for the Asian financial crisis.
- Contributions of three categories to others were nearby to each.

- Notable growth of contribution of high income countries to others was captured during the Global financial crisis.
- High income countries tended to contribute more to others.



Introduction



Methodology

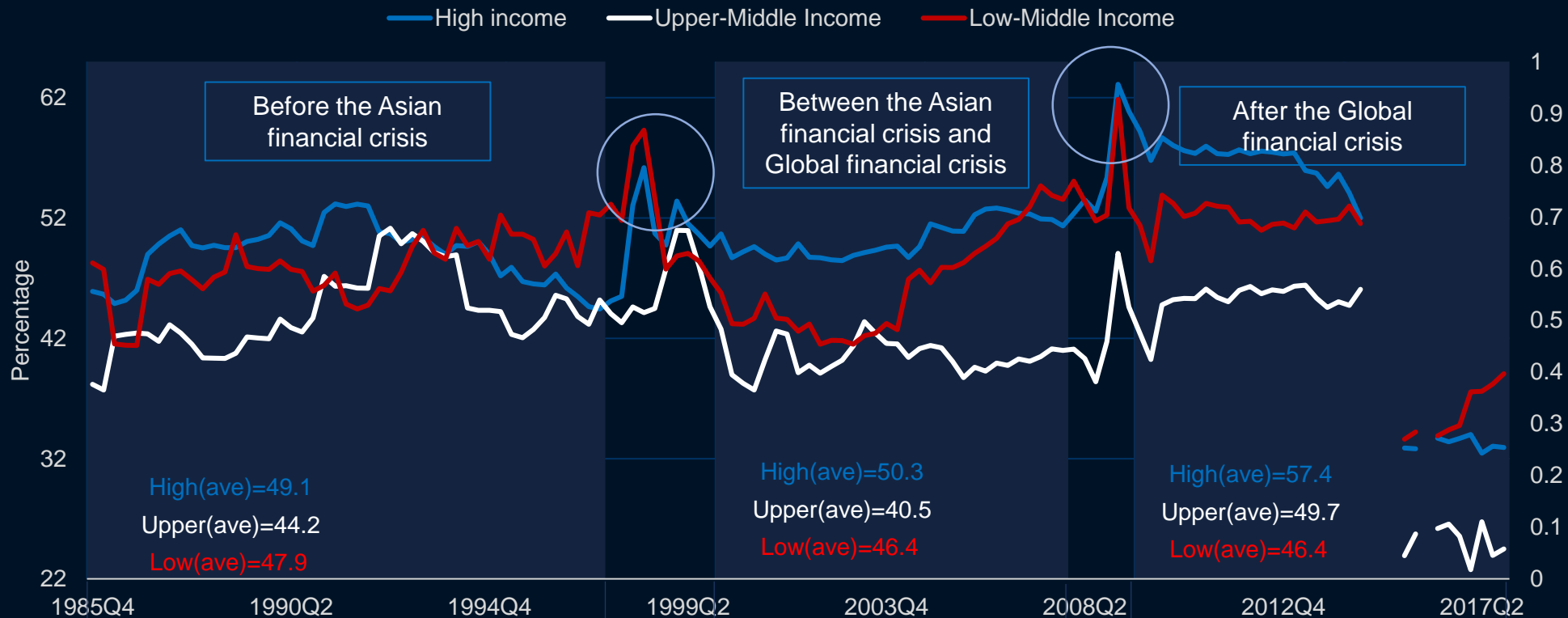


Empirical results



Concluding remarks

Dynamic directional connectedness by income classification, 1985-2017 (From others)



- High and lower-middle income countries tended to receive more contribution from others.

- During the Asian financial crisis, effect from others of all 3 categories increased significantly.

- High and lower-middle income countries tended to receive more contribution from others.



Connectedness index

Network analysis

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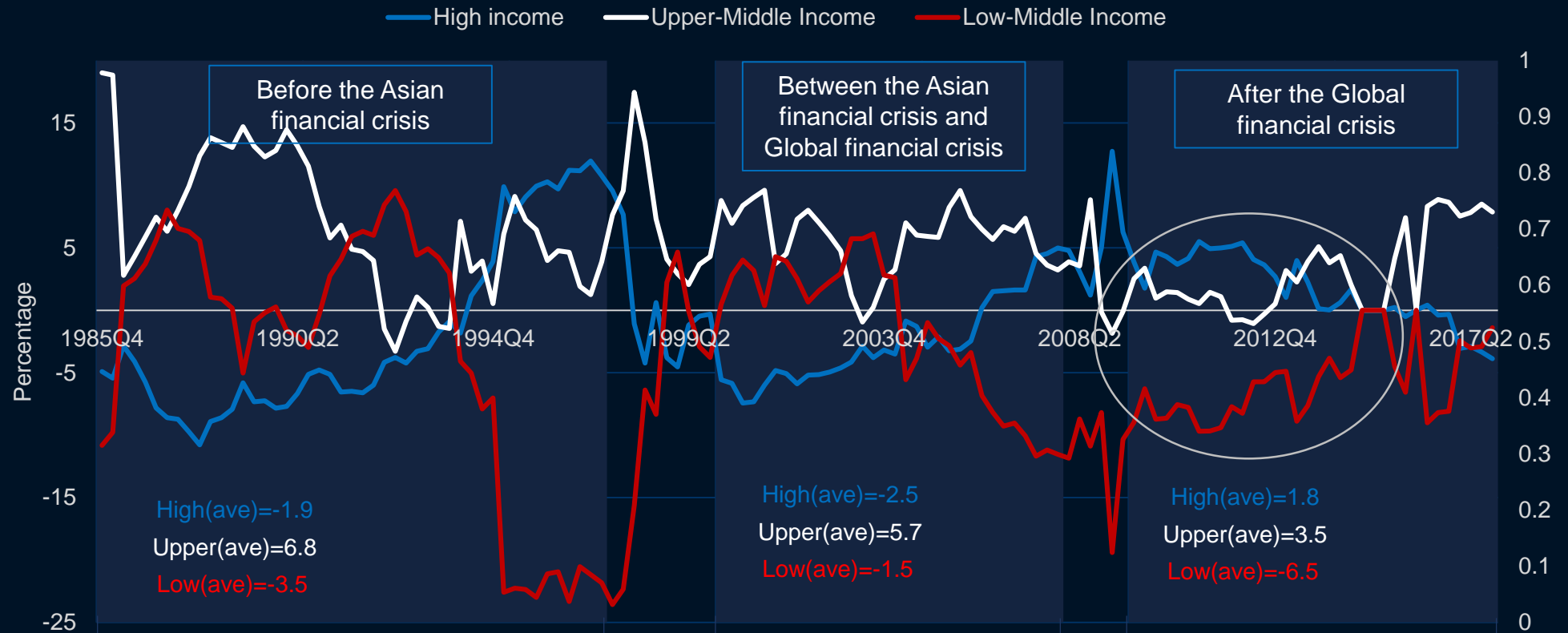
Methodology



Empirical results



Dynamic directional connectedness by income classification, 1985-2017 (Net to)



- Upper-middle income countries tended to contribute more to others.
- High and lower-middle income countries tended to receive more contribution from others.

- Upper-middle income countries tended to contribute more to others.
- High and lower-middle income countries tended to receive more contribution from others.

- Recently, high income countries tend to contribute more to others while lower-middle income countries tend to receive more contribution from others.
- Upper-middle income countries tend to play role of shock transmitter.



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Connectedness index

Network analysis

Static Connectedness, Selected Asian countries GDP, 1960Q1-2017Q4

	Japan	India	Thailand	China	Korea	Hong Kong	Singapore	Indonesia	Philippines	Australia	Turkey	From Others
Japan	78.41	0.12	1.41	3.47	3.01	1.76	1.45	1.64	0.30	0.76	7.67	21.59
India	4.57	78.85	0.55	2.65	7.13	2.30	0.96	0.83	0.27	1.23	0.67	21.15
Thailand	1.98	2.00	56.42	0.73	2.82	8.89	7.16	7.39	11.88	0.23	0.50	43.58
China	4.63	4.69	0.18	77.34	0.93	2.12	1.25	2.23	3.37	3.03	0.23	22.66
Korea	7.14	4.32	5.15	2.54	65.81	2.28	2.21	3.13	5.60	0.74	1.08	34.19
Hong Kong	8.56	2.99	10.54	3.22	1.50	50.85	16.01	0.75	2.97	1.68	0.94	49.15
Singapore	1.31	0.45	6.62	0.16	0.97	13.19	72.20	0.18	3.02	1.12	0.78	27.80
Indonesia	0.39	0.92	22.75	0.43	4.43	3.71	3.19	56.00	5.48	1.94	0.77	44.00
Philippines	1.28	0.42	15.14	14.54	4.41	5.17	5.35	1.71	49.17	2.54	0.27	50.83
Australia	3.20	2.35	2.95	3.91	3.86	3.66	0.51	1.84	4.10	73.18	0.43	26.82
Turkey	6.52	1.67	2.62	0.54	0.91	1.77	3.30	1.12	0.56	0.18	80.83	19.17
Contribution to others	39.58	19.92	67.92	32.17	29.97	44.86	41.39	20.81	37.55	13.44	13.34	32.81%
Net	17.98	-1.22	24.34	9.50	-4.22	-4.30	13.59	-23.19	-13.28	-13.38	-5.83	

Concentration from others

	Australia	Korea	China	Thailand	Turkey	Japan	Hong Kong	India	Phillippines	Singapore	Indonesia
Concentration from others (HHI)	1233.4	1330.3	1478.7	1804.4	1873.8	1941.4	1967.4	1967.6	2038.4	2999.8	3082.2



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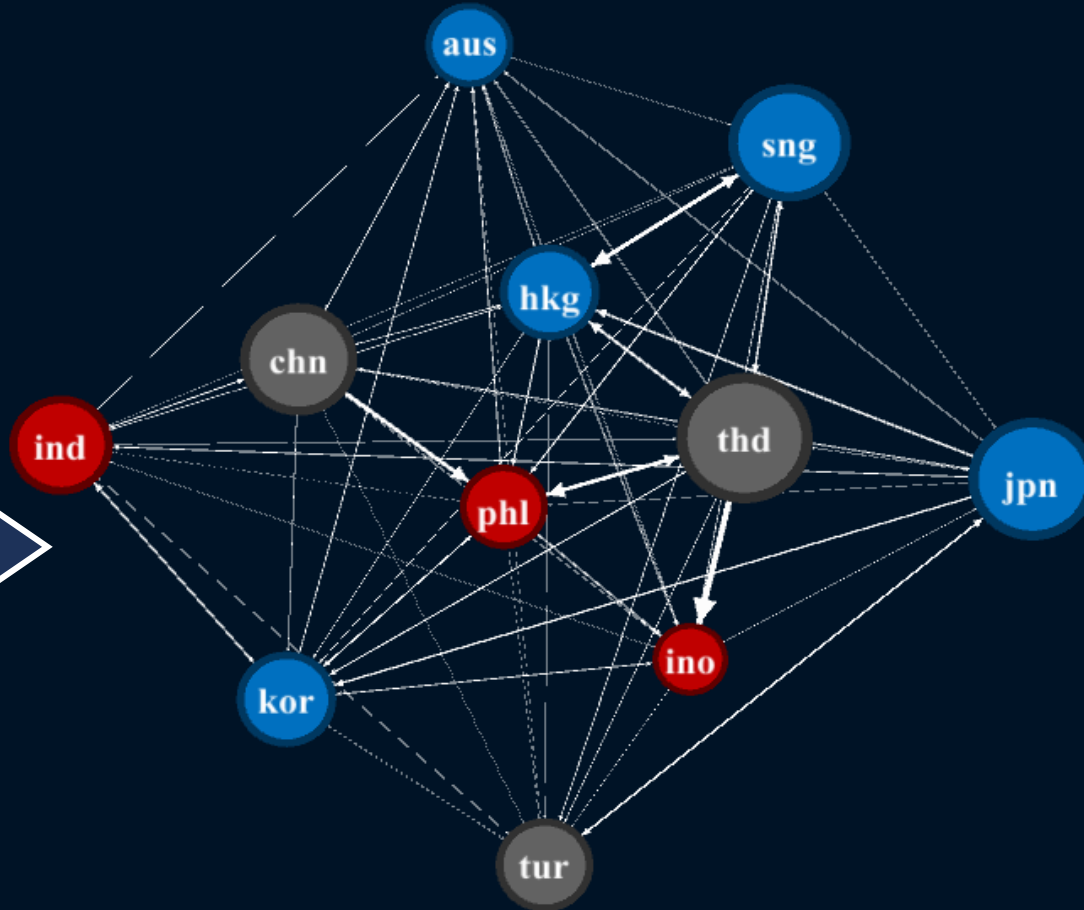
Empirical results



Concluding remarks

Connectedness index

Network connectedness of Asian economy, from 1960 to 2017



Network analysis

Visualization	ForceAtlas2 algorithm of Jacomy et al. (2014) of the Gephi software.
Attributes	Node, node size, node color, edge, edge thickness.
System	A country that is located at the center of network plays the more important role in a system.
Clustering	Upside tends to contain high-income countries, center side tends to contain upper middle-income countries, and downside tends to contain low-middle income countries
Role	China, Thailand, Hong Kong, and Philippine play an important role in the Asian economy.
Linkage	Upper middle-income countries serve as the linkage between high and lower-middle income countries.
Contribution to own	Thailand, Singapore, Japan, and China highly tend to contribute their GDP growth to themselves comparing to other countries.



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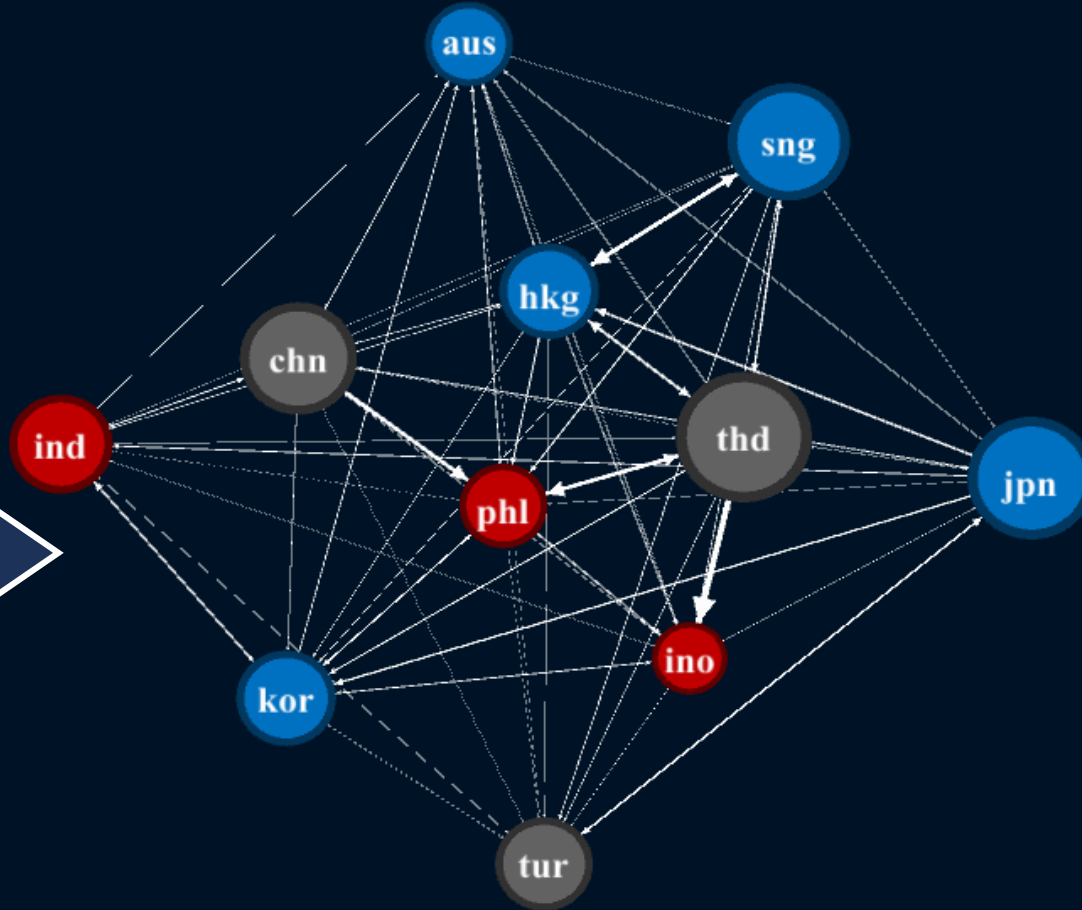
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Network connectedness of Asian economy, from 1960 to 2017



Network analysis

Asian map



Geographical Aspects

Network visualization clearly shows the geographical aspects of the countries.



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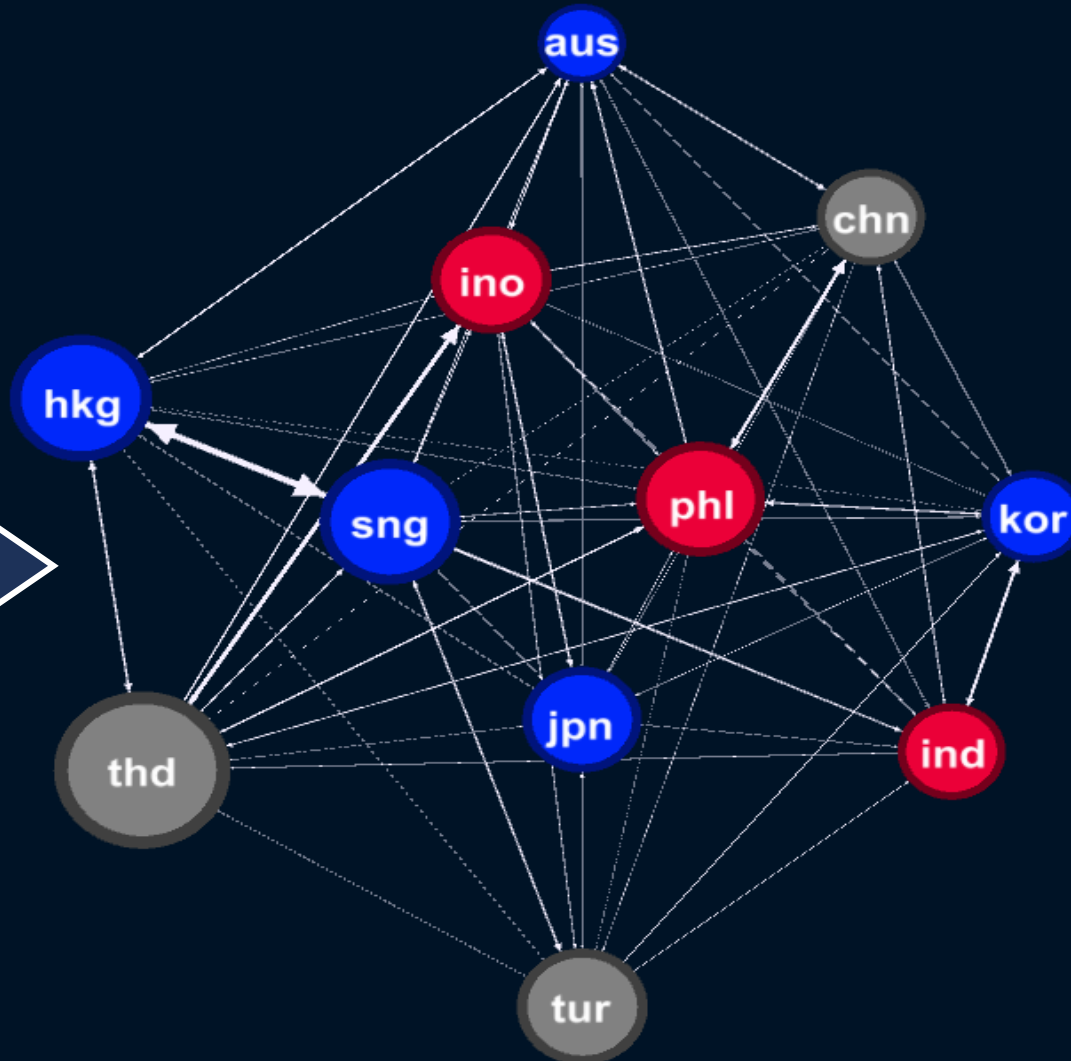
Empirical results



Concluding remarks

Connectedness index

Network connectedness of Asian economy,
Before Asian financial crisis: from 1960 to 1997



Network analysis

Role

Singapore, Indonesia and Philippine played important role in terms of connectedness.

Contribution to own

China, Korea, and Australia were less connected with other countries and their contribution of GDP growth to themselves was relatively low comparing to other countries.



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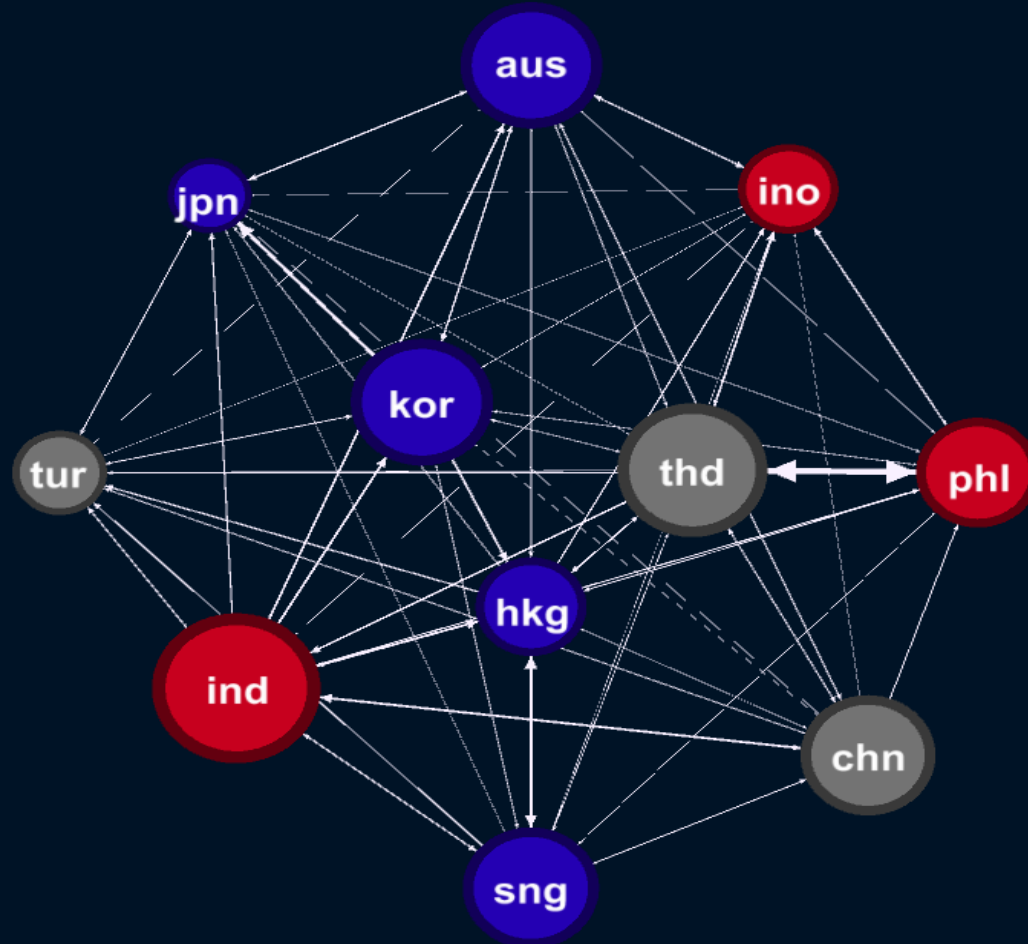


Concluding remarks

Connectedness index

Network analysis

Network connectedness of Asian economy,
After Asian financial crisis: from 1998 to 2017



Role	Korea, Thailand and Hong Kong played important role in terms of connectedness in the Asian economy
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Contribution to own	China, Korea, Australia, India and Singapore's contribution of GDP growth to themselves were relatively high comparing to other countries
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Introduction



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Empirical results



Concluding remarks

- **Diebold-Yilmaz index can be applied to both macro and micro datasets of Mongolia.**
 - **For example, the connectedness of financial sectors (Commercial banks, Non-bank financial corporations, ets.....)**
 - **The connectedness of economic activities in Mongolia (Mining sector, Industrial sector, ets....)**
- **Diebold-Yilmaz index can be easily estimated with the Eviews add-ins created by Davaajargal Luvsannyam.**
- **Upper middle-income countries serve as the linkage between high and lower-middle income countries.**
- **Connectedness index is one of the appropriate measure for the event of Financial crisis.**