Global and Regional Linkages Across Market Cycles: Evidence from Partial Correlations in a Network Framework

Presented by: Vikkram Singh
Ph.D. Candidate
Griffith University
Griffith Business School
Email: vikkram.singh@griffithuni.edu.au
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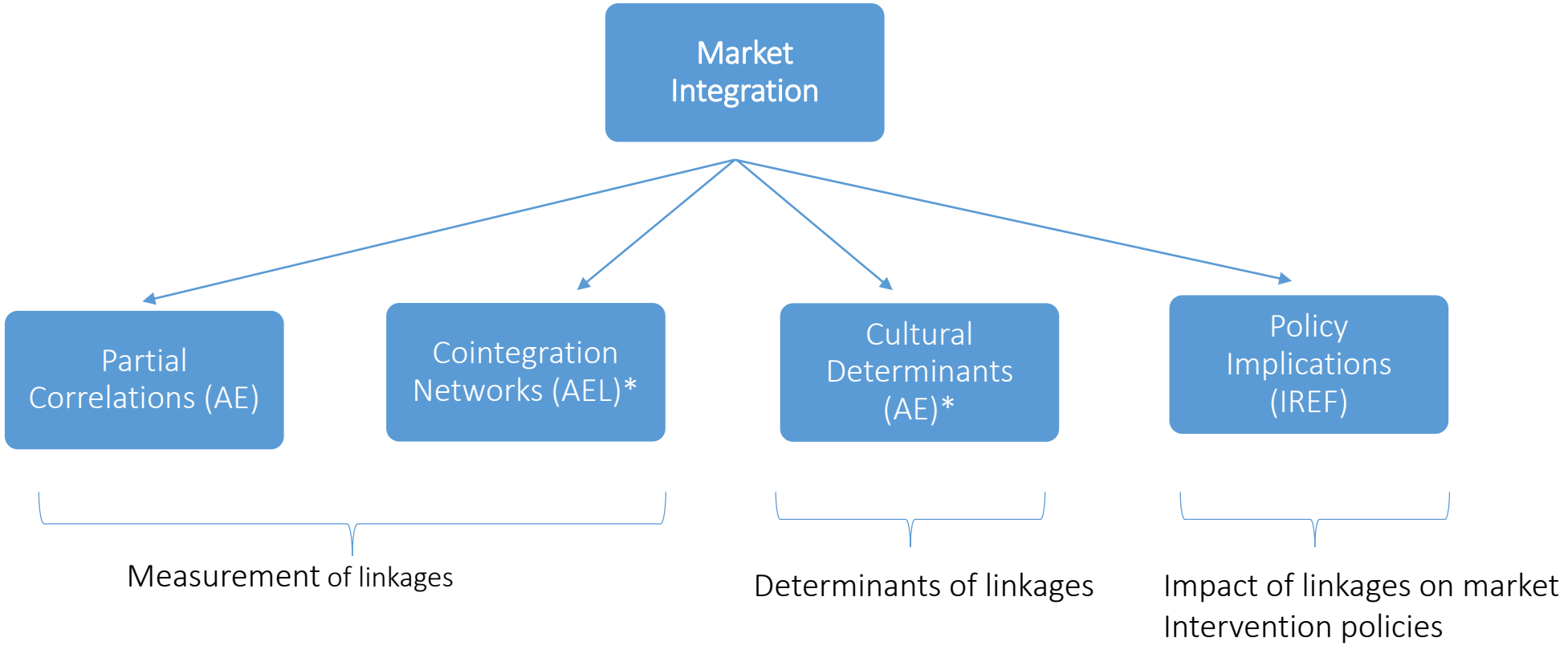
* Authors: Vikkram Singh, Professor Eduardo Roca and Dr. Bin Li

Overview



* Note: Papers Published

Abstract

Using a novel approach, partial correlations within a complex network framework, we examine the degree of globalization and regionalization of stock market linkages and how these linkages vary across different economic or market cycles. Our results show that geography influences network linkages differently across economic cycles. During normal times, regional factors shape market linkages; however, during periods of turbulence, global rather than regional factors drive the linkages. The network traffic also increases during times of turmoil, but contrary to previous results, we do not find a consistent or overwhelming increase in positive linkages between markets. These findings have implications for asset pricing and policy decision-making.

Introduction

- A large body of work offers a range of time-series methods to study the dynamics of market linkages with the most popular being total correlations (e.g., Kenett *et al.,* 2012; Krishnan *et al.,* 2009).
- Limitations: impact of the third variable
- We construct financial networks, a collection of nodes and linkages, between various global equity markets based on partial correlations.

Contribution

- Attempts to estimate global networks between market indices using partial correlations are limited in the current literature.
- Few studies use partial correlation but limit their focus on the relationships between individual or a group of stocks (Kenett *et al.,* 2015, 2010; Shapira *et al.,* 2009).
- Also, allow for the use of various visualization techniques, which can be used to map the changes in networks and identify the formation of clusters over time and across geographic regions.

Introduction

- Changes in market linkages over time – general increase in market linkages or contagion?
  - General increase in linkages (Bekaert and Harvey, 1995; Kizys and Pierdzioch, 2009) or contagion (Lee and Jeong, 2014; Bartram and Wang, 2015)
  - Conduct a time-variant analysis to assess how the linkages in financial networks evolve during periods of distress. In particular, the exclusion of the third market(s) in evaluating the market linkages can differentiate between market interdependence and contagion.
  - Such insights can help finance practitioners in risk optimizing their portfolios and in identifying predictable patterns for trading opportunities (Esmalifalak *et al.,* 2015).
  - The complex financial networks highlight the inability of local monetary and regulatory institutions in preventing volatility spillover effects and the ensuing market crisis. Understanding about the functioning of complex financial networks and the transmission of volatility can assist in preventing such occurrences (IMF, 2008).

Introduction

- Are market linkages global or regional?
  - The available research in the area of market integration does not examine whether regional or global factors impact market linkages (Zhang *et al.,* 2013; Toyoshima and Hamori, 2013). Most delve into EU (Bartram and Wang, 2015), NAFTA (Bayoumi and Swiston, 2008), role of the US (Mishkin, 2011) and recently China (Arsalanalp, 2016).
  - Being able to differentiate between global and regional factors empirically can assist policy makers in devising strategies to prevent the market crisis from spilling over to their markets especially those originating from unrelated global markets.

Introduction

- Investigate clusters
  - Use cluster analysis to explore complex financial networks by organizing them into partitioned, hierarchical and model-based clustering algorithms.
  - Also, identify the “robustness” of the markets in withstanding regional or global shocks – for e.g., a higher network density can lead to a wider propagation of such shocks.
  - Unlike the pairwise or binary association, networks can provide a useful representation of the evolving financial systems. For instance, due to increasing complexity in financial networks, a failure in a particular node can transfer the systematic risk to other nodes, which is hard to visualize using traditional methods of detecting linkages (Vodenska *et al.,* 2016).
  - Also do not require the creation of global and regional market indices when comparing the global and regional impacts on linkages (Heaney and Hooper, 2001).

Literature Review

- Dynamic nature of global financial markets -> globalization, interlinked balance sheets, capital mobility, global portfolio management, cross-listing, information technology (Beck *et al.,* 2013).
- The earliest study to construct networks is Mantegna (1999), who finds a hierarchical distribution of equities in the correlation network. Kenett *et al.* (2012) use complex network approach to determine that higher coupling between equities increases volatility during market crisis.
- An area of literature gap in the field of market integration is the lack of use of partial correlations in estimating financial networks. None explore interaction between indices (Kenett *et al,* 2012, Shapira *et al.,* 2009).

Data

- Log returns of stock market indices of 25 countries from July 1997 to April 2015 based on the weekly MSCI country market indices obtained from the Thomson Reuters DataStream database (weekly data in local currency)

$$R_t = \ln P_t - \ln P_{t-1} \qquad (1)$$

- For a time-variant analysis, we use four sample periods as follows:

  Period 1: Pre-2000 recession period (January 1997 to February 2001)

  Period 2: Early 2000 recession period (March 2001 to November 2001) – dot-com bubble burst; 9/11

  Period 3: Pre-2008 recession period (December 2001 to November 2007)

  Period 4: 2008 recession period (December 2007 to June 2009) – GFC

  Period 5: Post-2008 recession period (July 2009 to April 2015)

AMERICAS	Argentina(AR), Brazil(BR), Canada(CA), Mexico(MX), United States of America(US)
ASIA-PACIFIC	Australia(AU), China (CN), Hong Kong(HK), India(IN), Japan(JP), New Zealand (NZ), Singapore(SG), Indonesia (ID), Malaysia(MY), South Korea(KR)
EUROPE	Denmark(DN), France(FN), Germany(GM), Greece(GR), Italy(IT), Norway(NO), Russia(RU), Switzerland(SZ), Sweden(SW), United Kingdom(UK)

Methodology

Partial Correlation

The partial correlation $\rho(x, y: m)$, between variables x and y conditioned on variable m, is the Pearson correlation coefficient between the residuals of x and y that is uncorrelated with m:

$$\rho(x, y: m) = \frac{\rho(x,y) - \rho(x,y)\rho(x,y)}{\sqrt{[(1-\rho^2(x,m)][(1-\rho^2(y,m)]}} \qquad (2)$$

Log LR-test used to test the significance

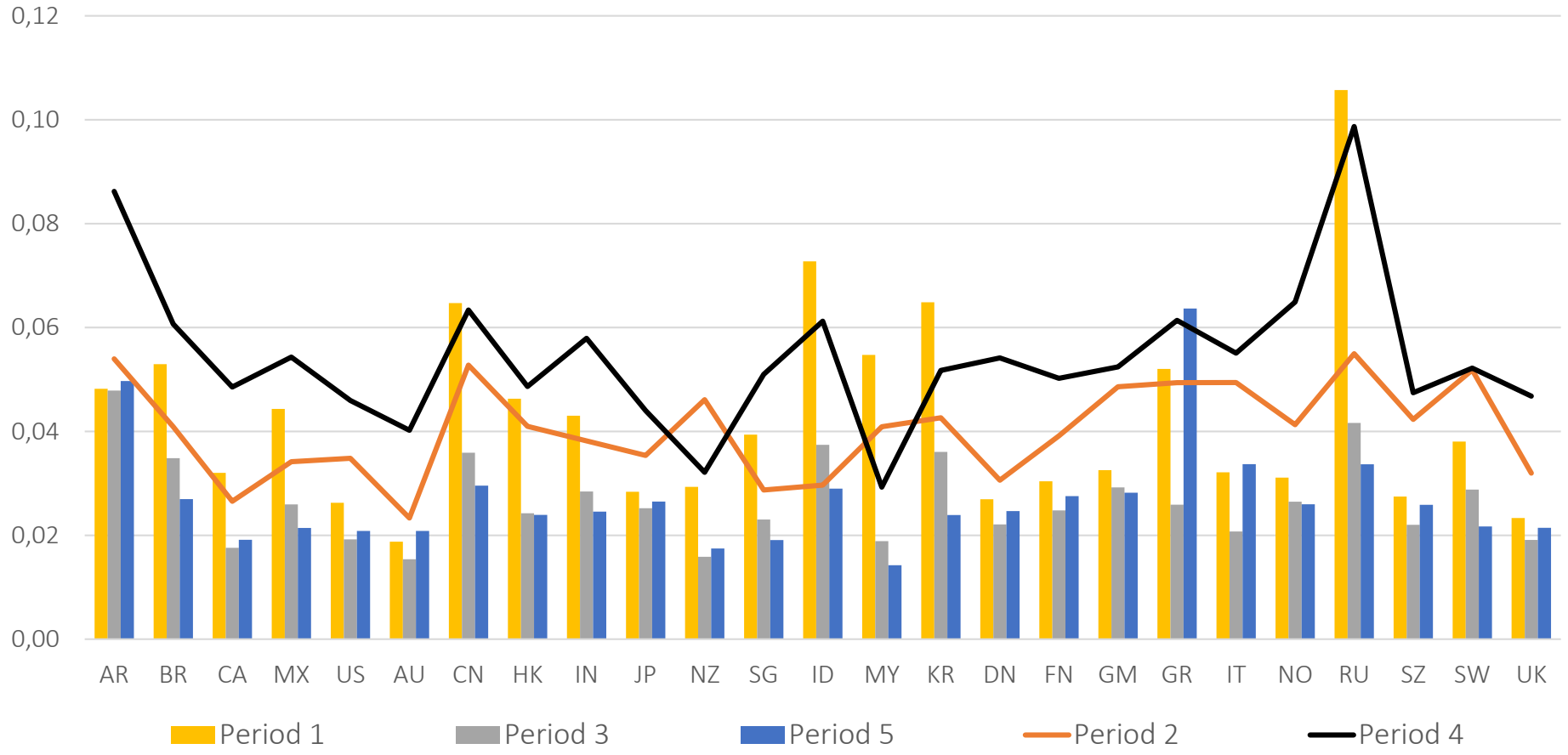
Network Clusters

Use the hierarchical filtering or the agglomerative clustering method based on Ward's minimum variance (Ward, 1963) to construct the networks using partial correlation coefficients. Based on this approach, the ANOVA sum of squares between the two clusters is used to determine the distance between them as follows:

$$D_{kl} = \frac{\|\overline{x_k} - \bar{x}_l\|\|\overline{x_k} - \bar{x}_l\|}{\frac{1}{N_k}+\frac{1}{N_l}} \qquad (3)$$

where $\|x\|$ is the Euclidean length of the vector x or the square root of the sum of the squares of x. The advantage of using the hierarchical clustering method over alternative methods such as the *K*-means clustering is that it does not require a predetermined cluster and provides a better representation of the network structure.

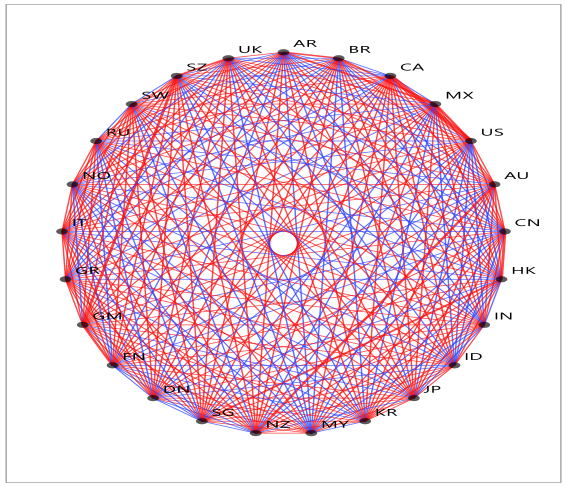
Empirical Results – volatility trends



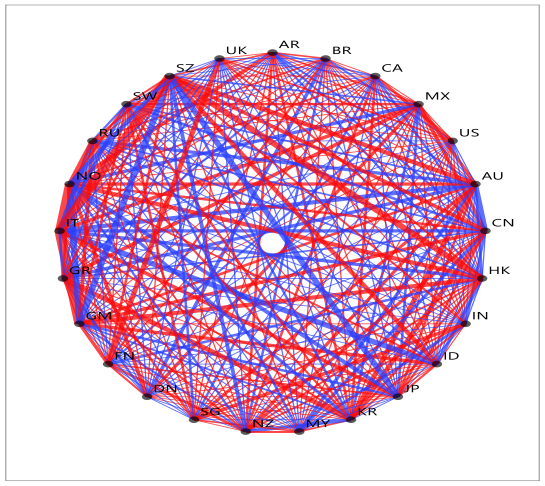
- The volatility, depicted by the standard deviation of the market returns, shows elevated levels during the periods of market crisis, with higher levels reported for the GFC.
- The markets in Europe report the biggest increase in volatility, followed by those in the Americas and Asia-Pacific.

Empirical Results – Time variant Partial Correlation Network

Period 1



Period 2



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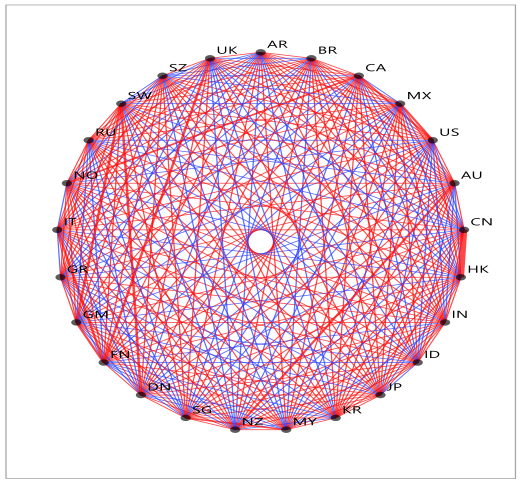
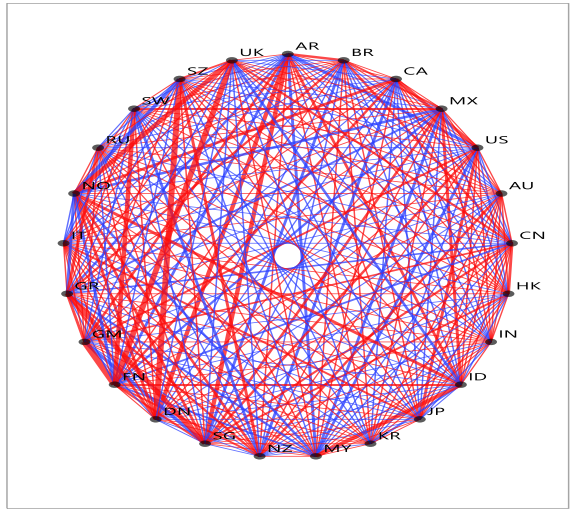
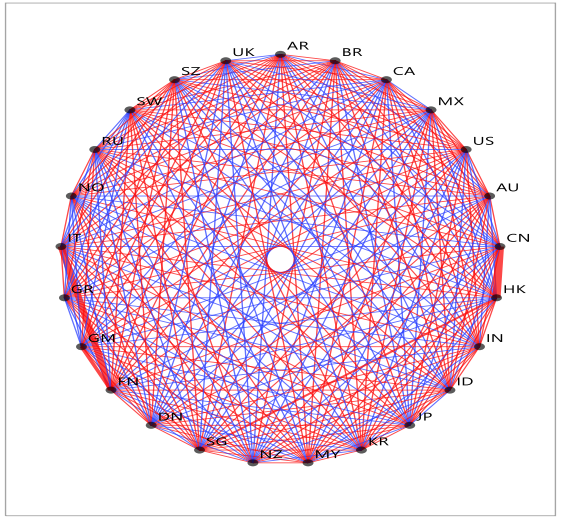


Period 4



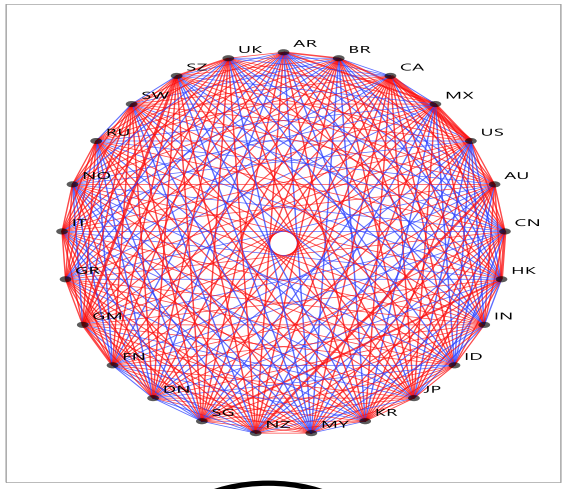
Period 5



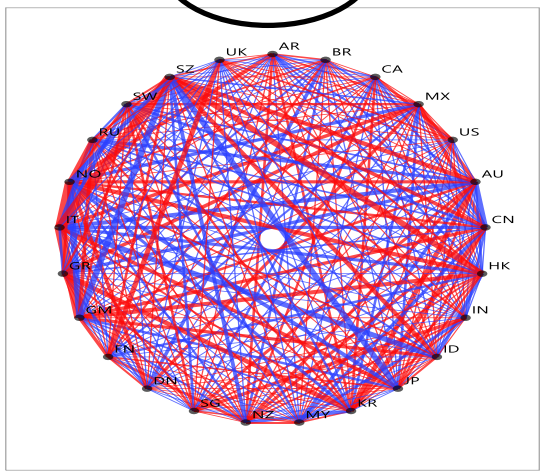
- Nodes=equity markets
- Edges=the partial correlations of log returns
- Red=positive; Blue=negative correlations
- The thickness of linkages determined by the absolute value of the partial correlations.

Empirical Results – Time variant Partial Correlation Network

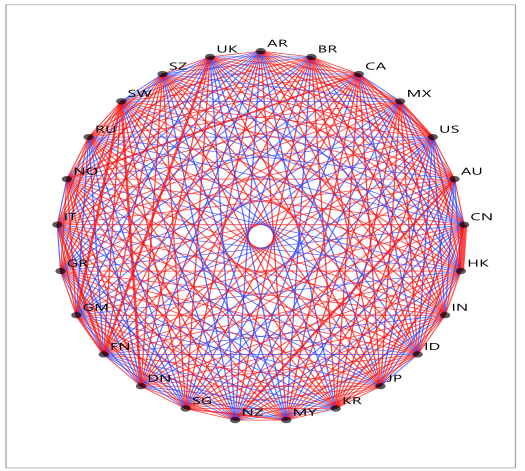
Period 1



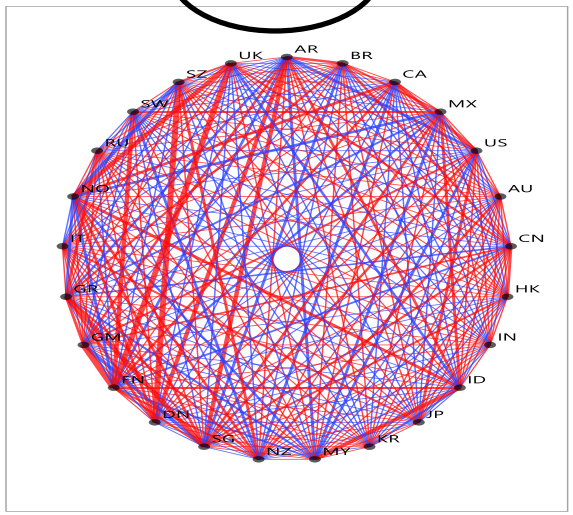
Period 2



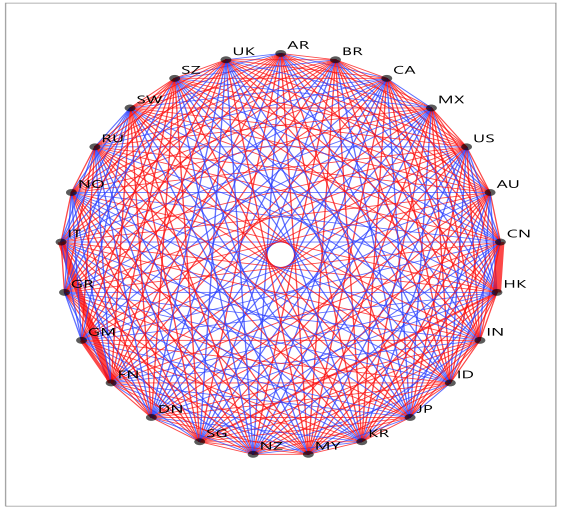
Period 3



Period 4



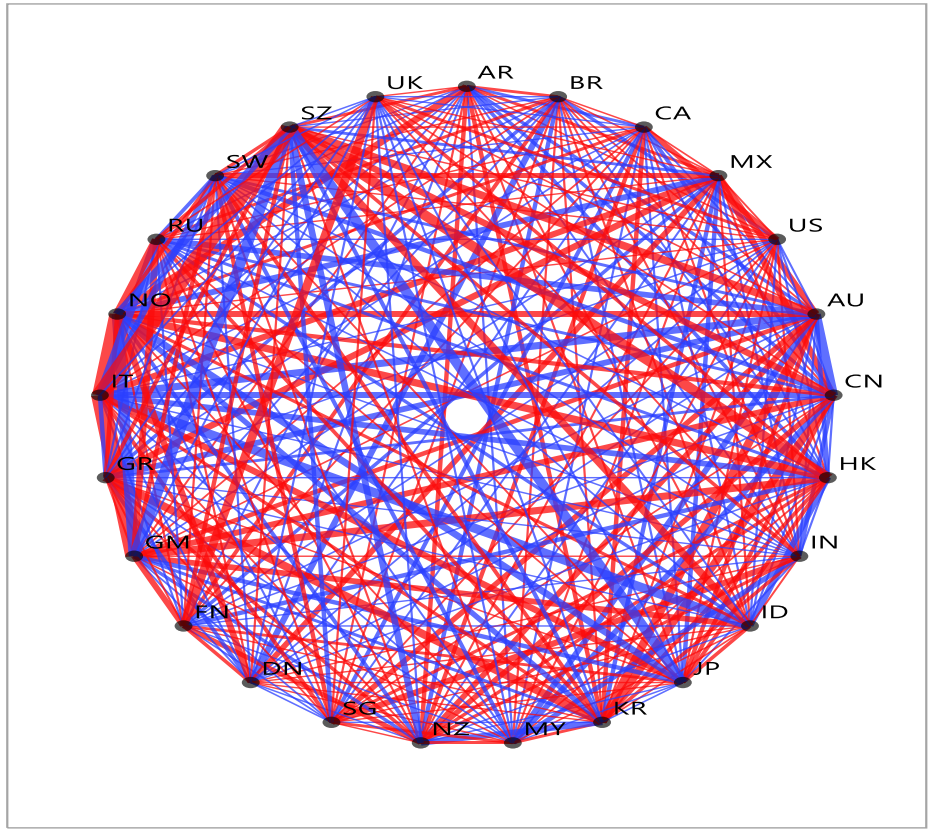
Period 5



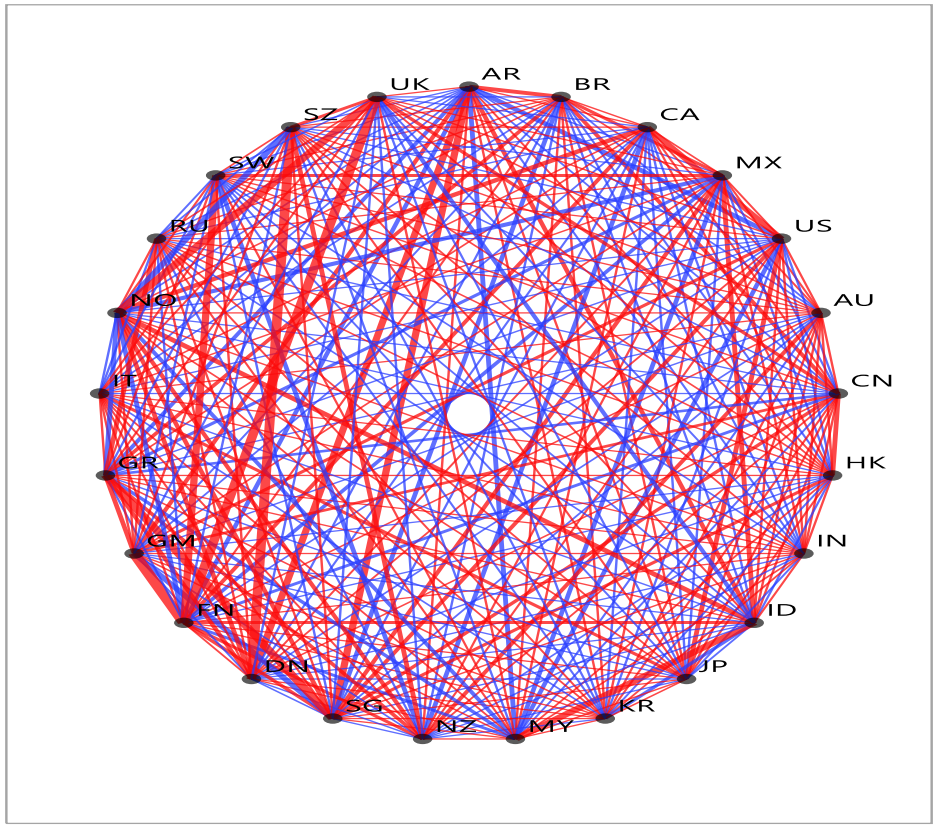
- Network traffic increases during both the crisis periods.
- Not all markets move in the same direction signifying opportunities for portfolio diversification.
- Most market pairs with (-) corr are inter-regional; most with (+) are regional.
- Higher local traffic in Americas and Europe.
- Networks in the Americas and Europe are regional in all periods
- Networks in Asia-Pacific are global during the market crisis and regional otherwise.

Empirical Results – Time variant Partial Correlation Network

Period 2



Period 4



- Inter-regional ties increases during market crisis
- Tighter linkages between US-Europe during GFC

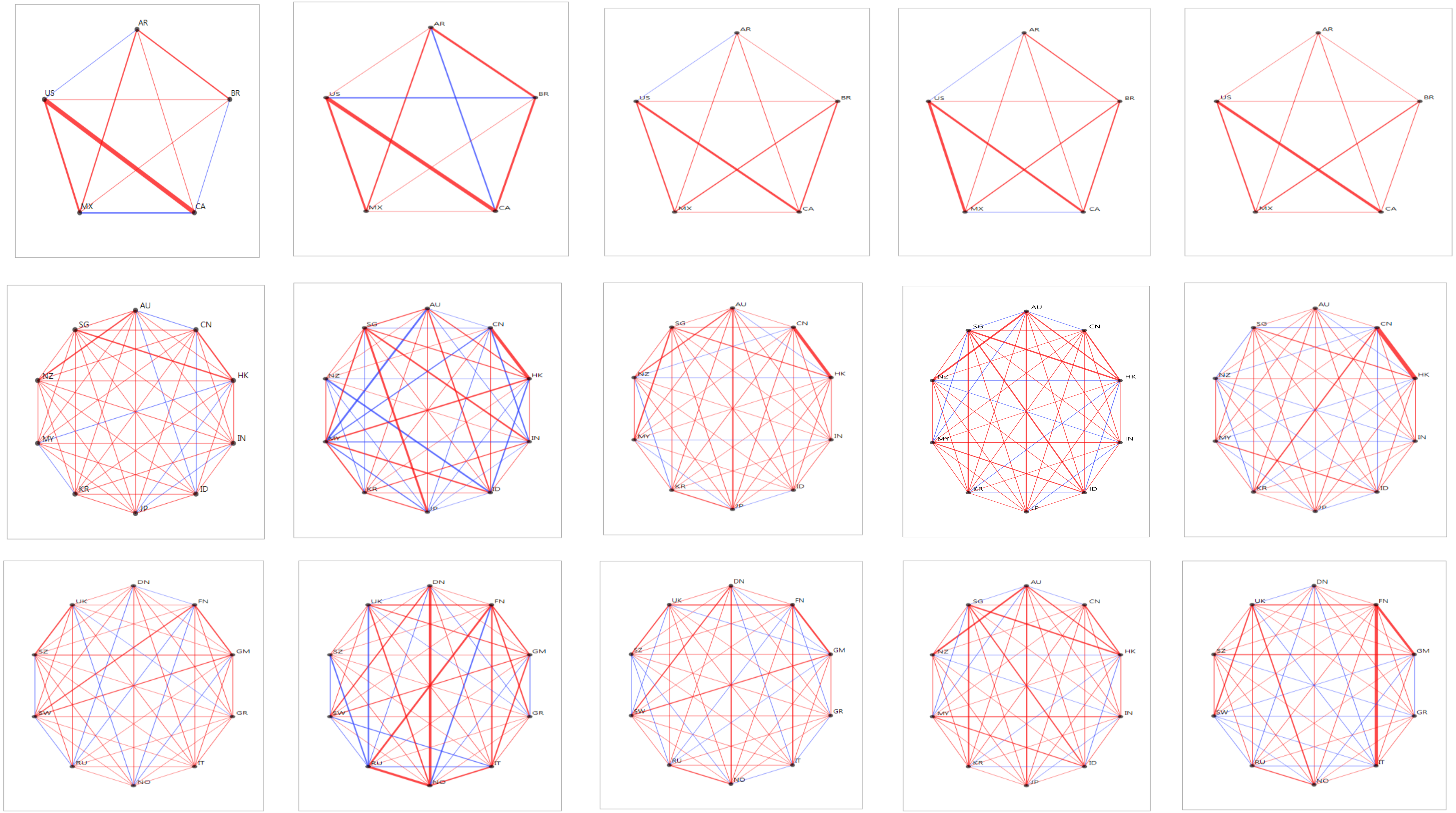
Empirical Results – Regional Networks

Period 1 | Period 2 | Period 3 | Period 4 | Period 5

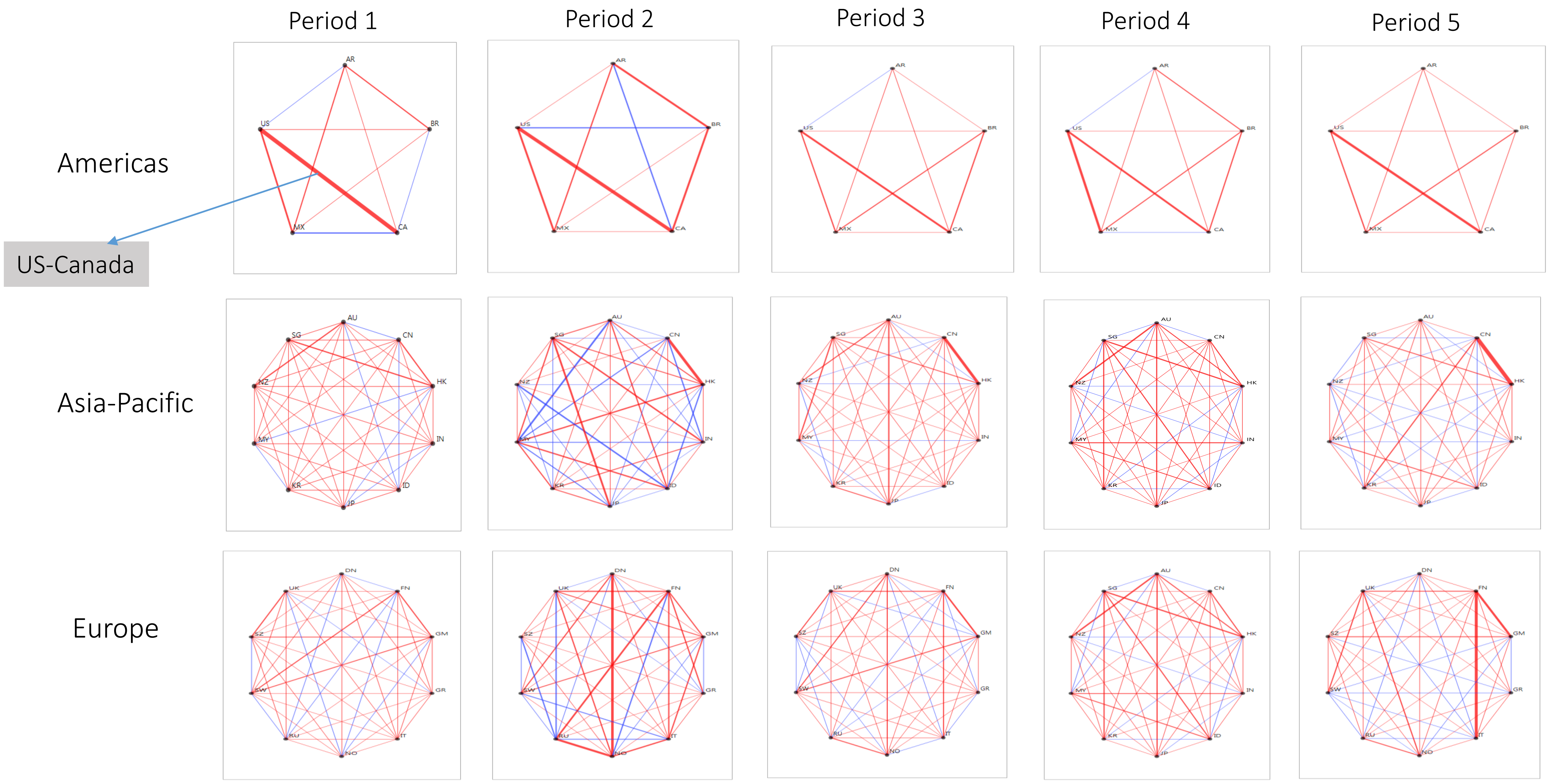
Americas

Asia-Pacific

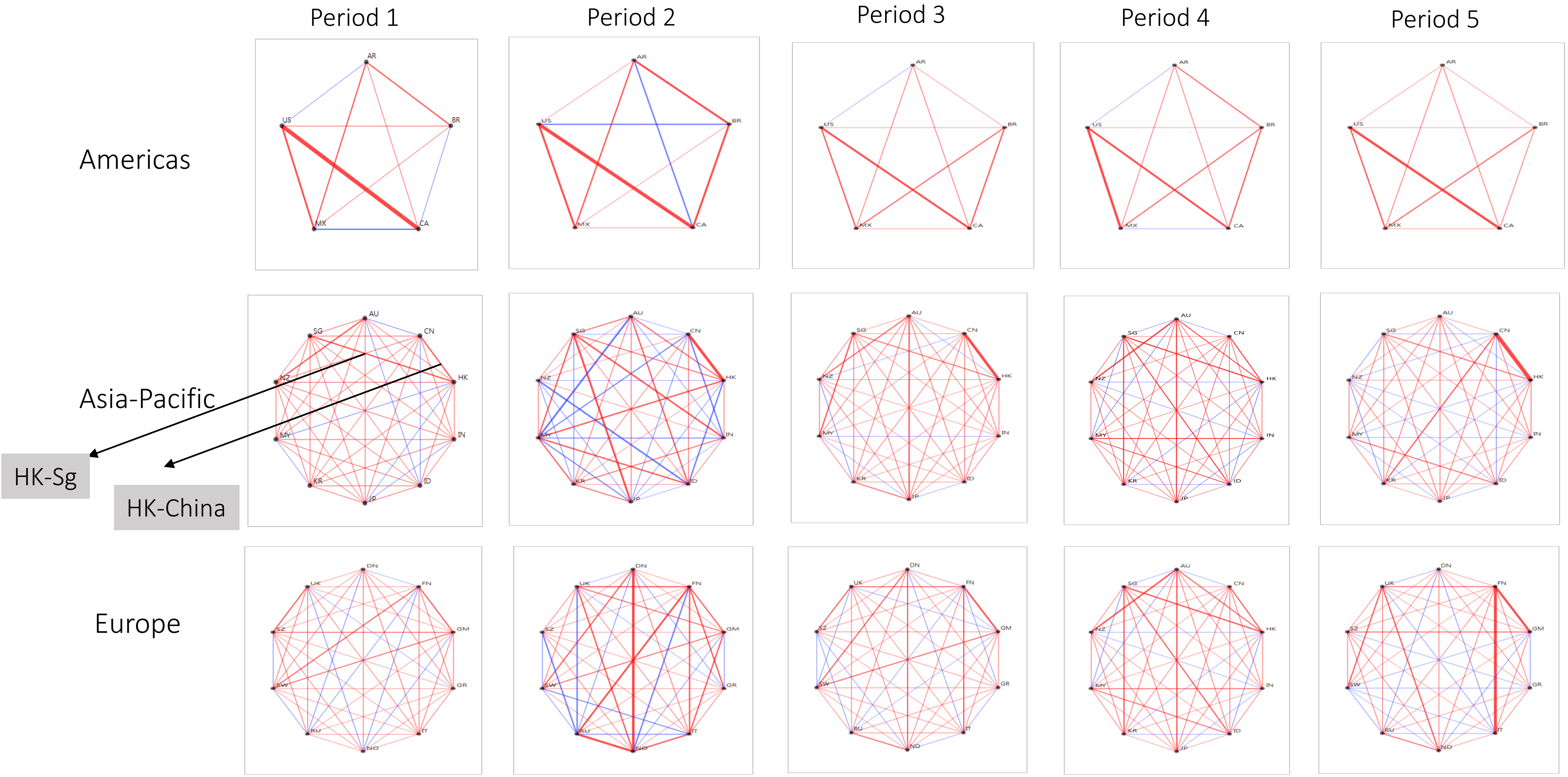
Europe



Empirical Results – Regional Networks



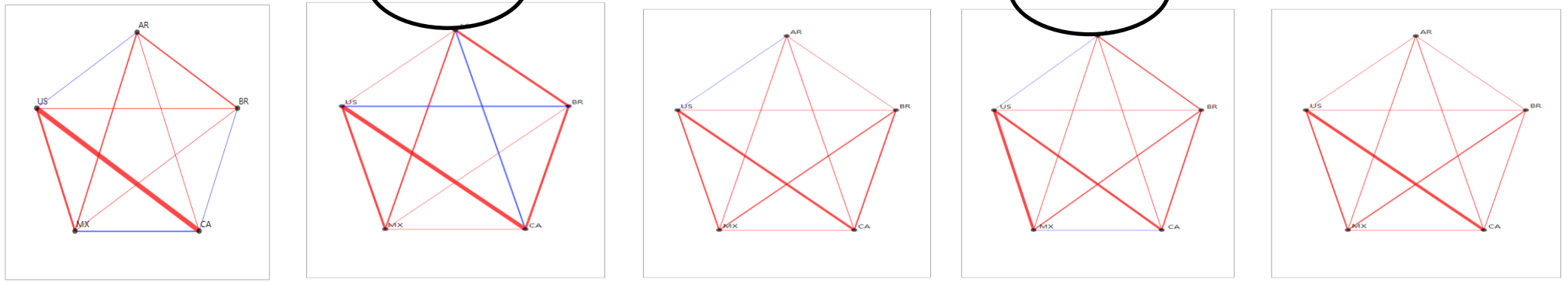
Empirical Results – Regional Networks



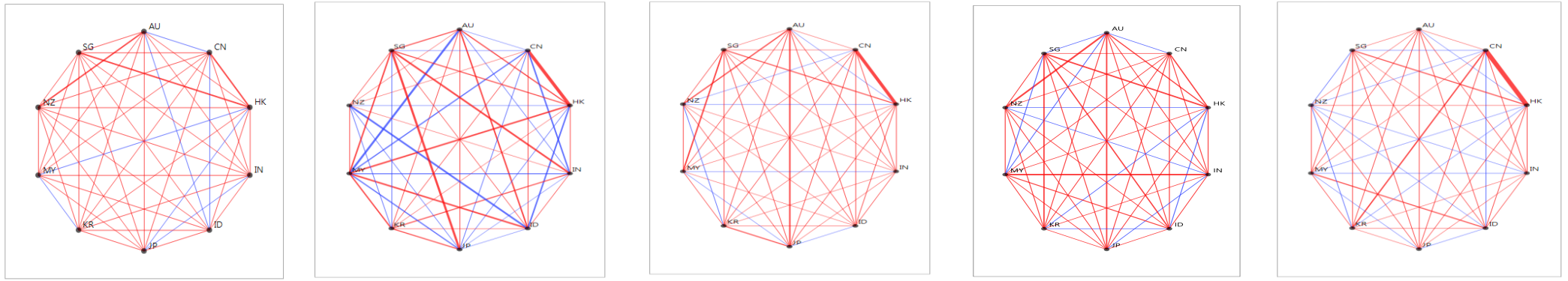
Empirical Results – Regional Networks

Period 1 | Period 2 | Period 3 | Period 4 | Period 5

Americas

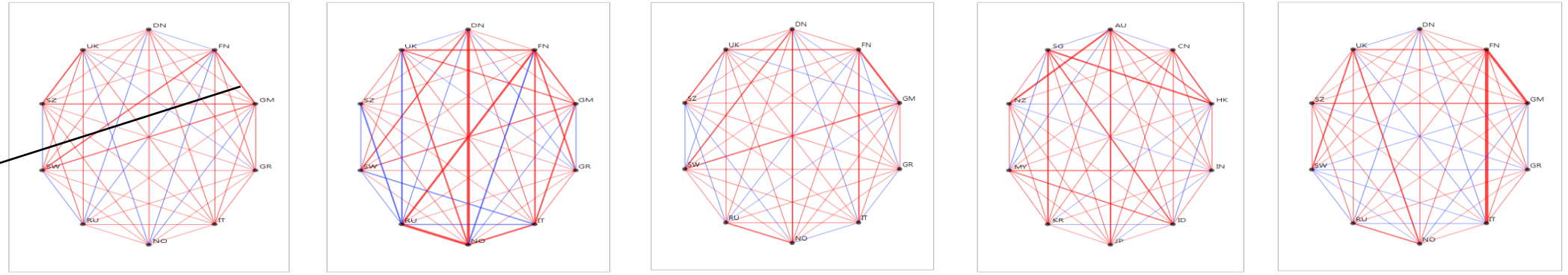


Asia-Pacific



Europe

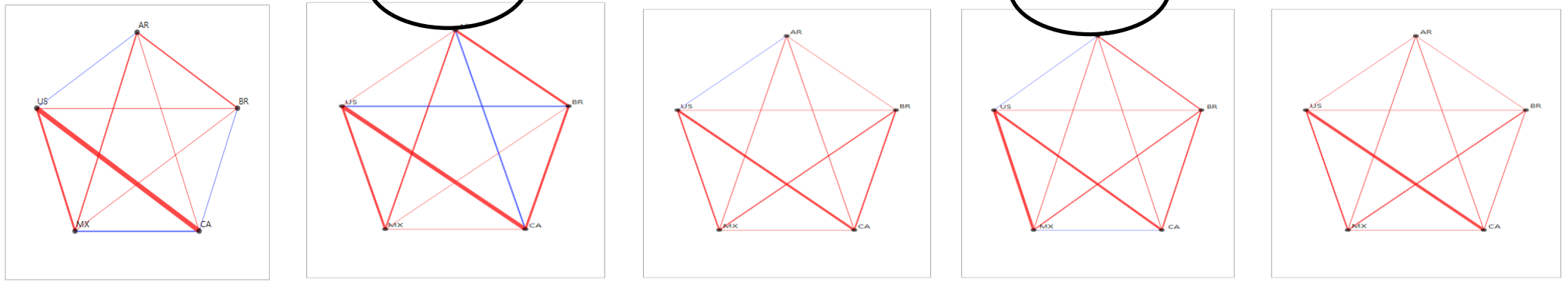
GM-France



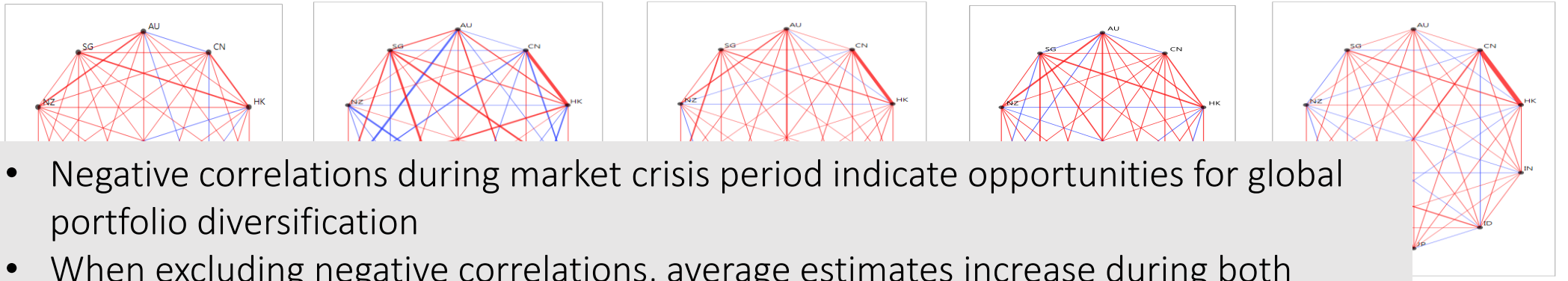
Empirical Results – Regional Networks

Period 1 | Period 2 | Period 3 | Period 4 | Period 5

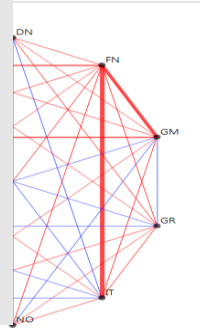
Americas



Asia-Pacific



Europe

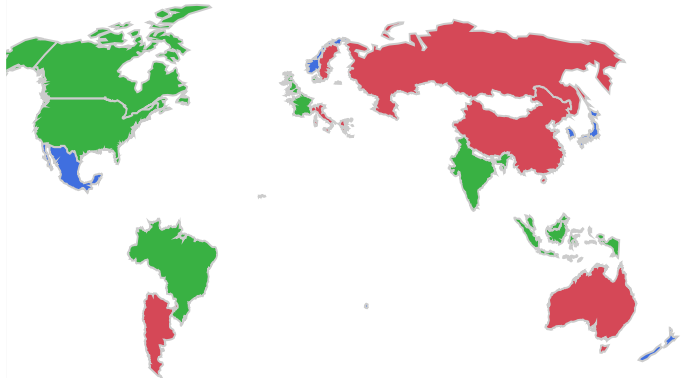


- Negative correlations during market crisis period indicate opportunities for global portfolio diversification
- When excluding negative correlations, average estimates increase during both periods of market crisis
- However, decreasing segmentation in markets does not necessarily increase linkages.
- Regional comparisons show stronger market linkages in the Americas compared to the other regions.

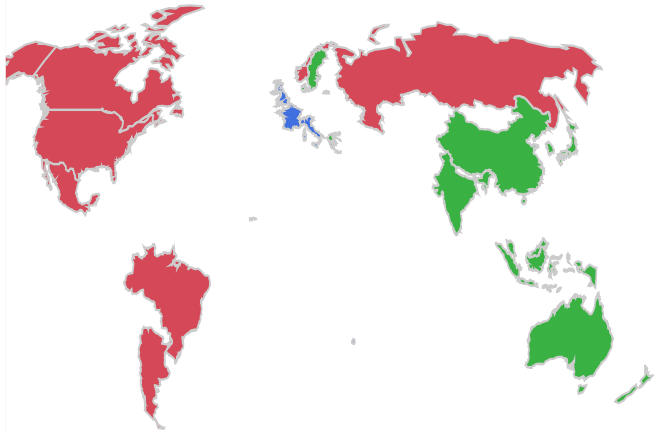
Empirical Results – Network Clusters

Period 1

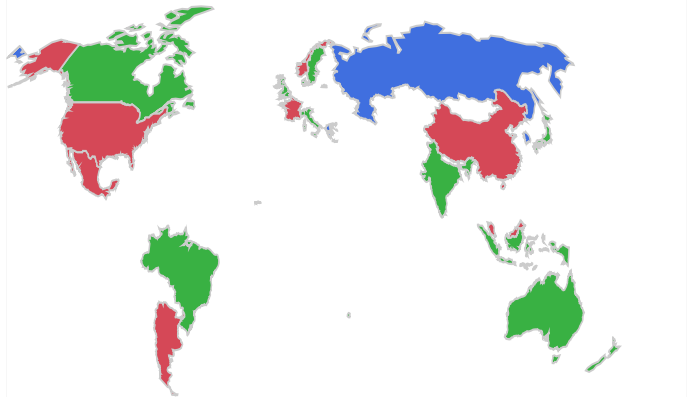
Period 2



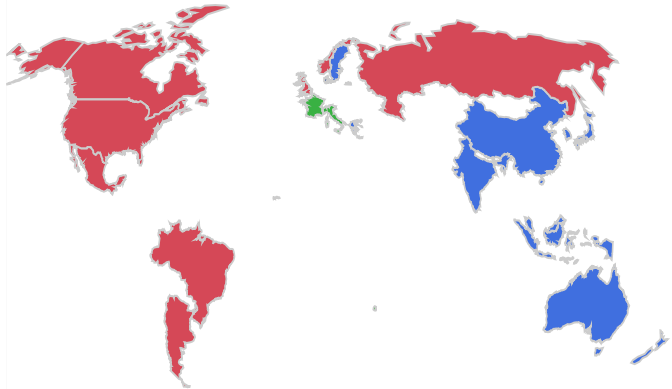
Period 3



Period 4



Period 5

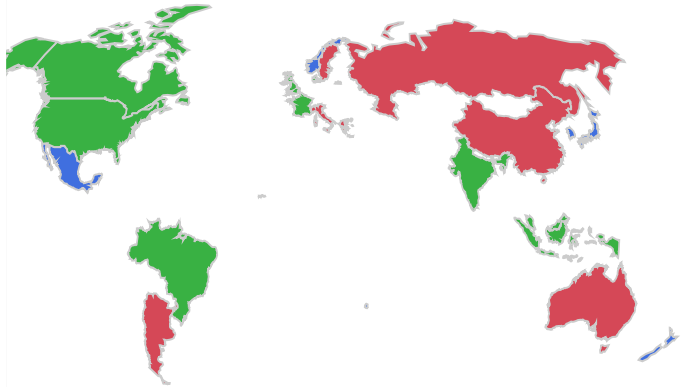


The objective is to detect patterns by segmenting the data into various groups or clusters, in which the markets within are relatively homogenous, yet the clusters differ from each other.

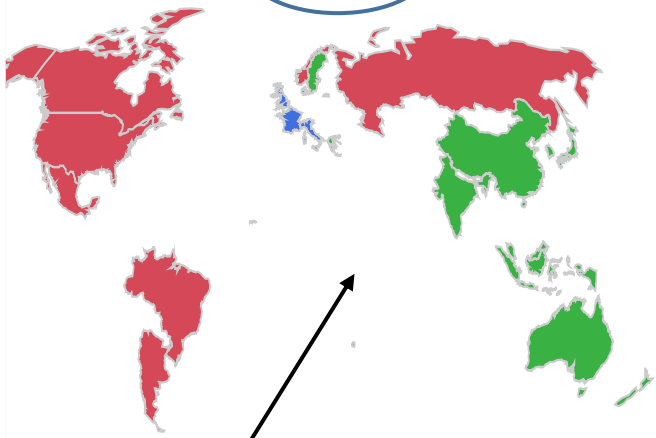
Empirical Results – Network Clusters

Period 1

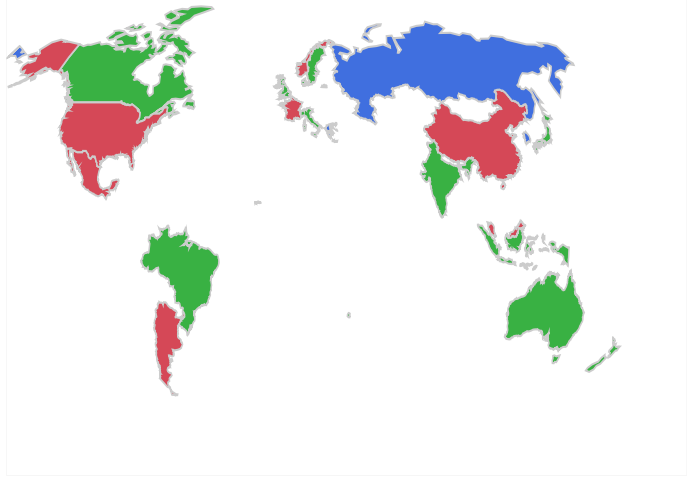
Period 2



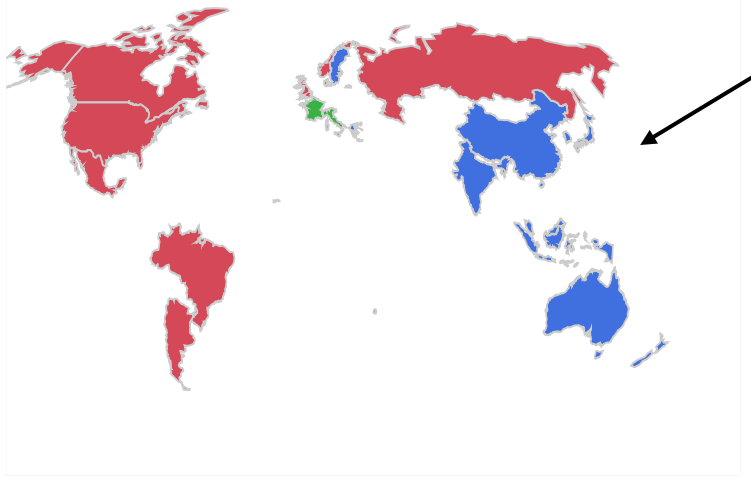
Period 3



Period 4



Period 5

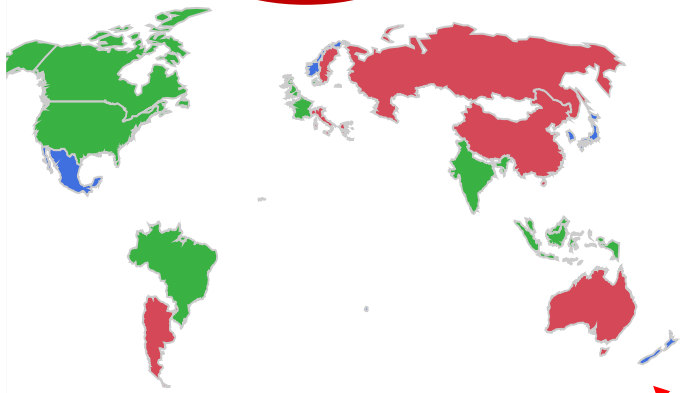


- The clusters depict geographic patterns supporting Heaney and Hooper (2001)
- China in recent period

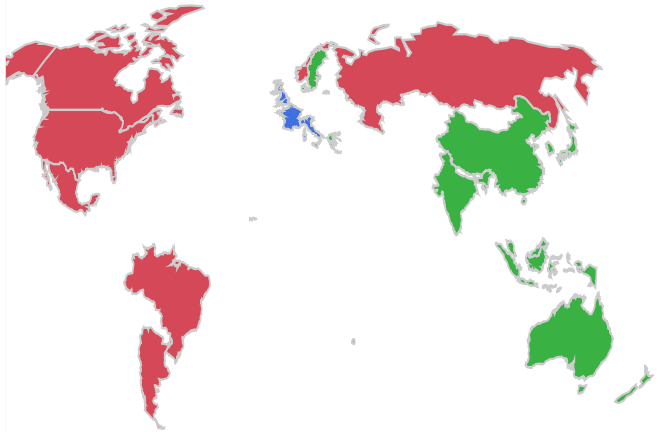
Empirical Results – Network Clusters

Period 1

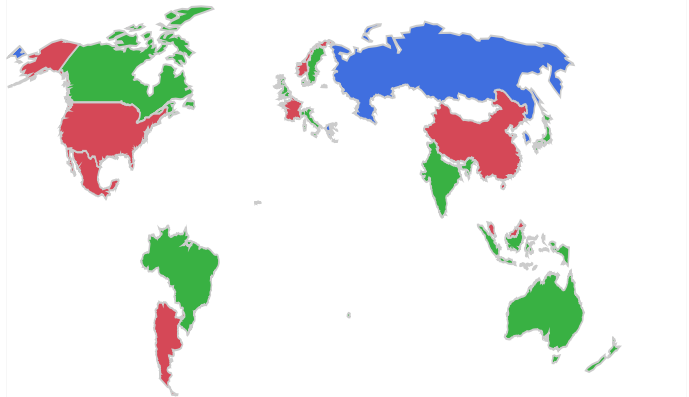
Period 2



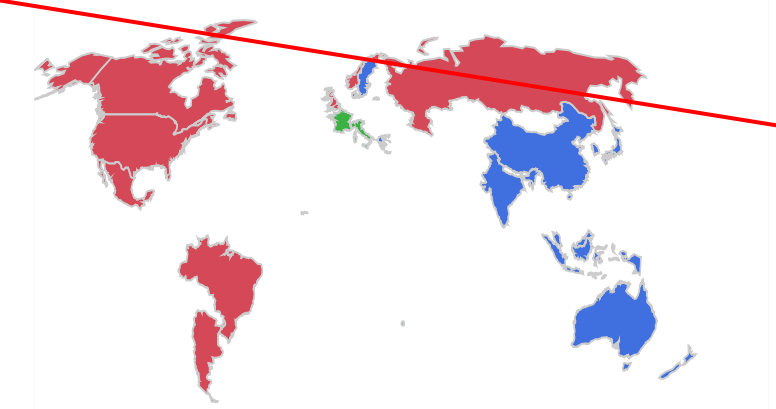
Period 3



Period 4

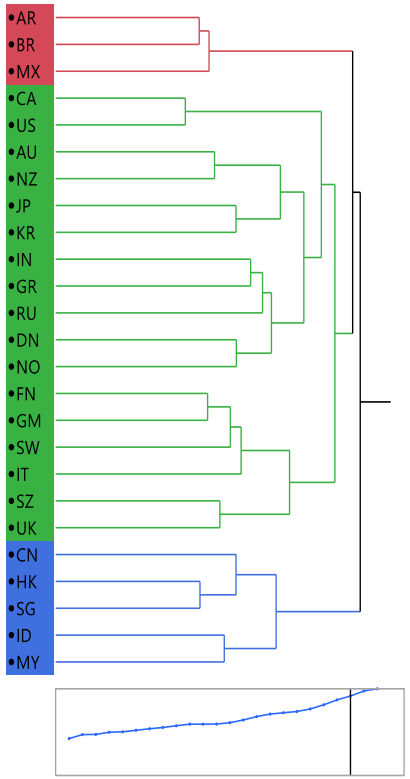


Period 5

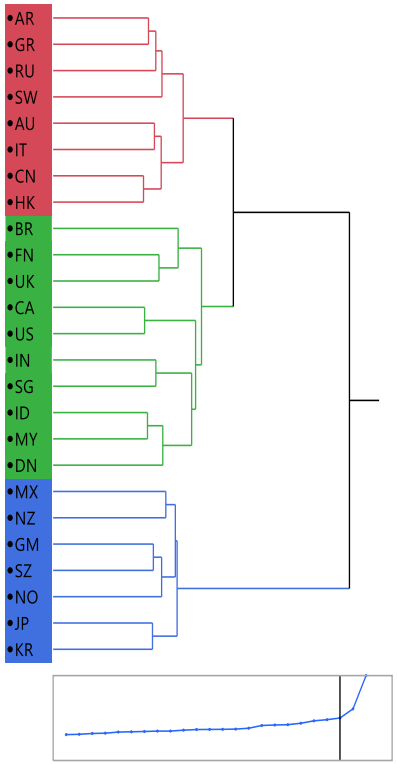


The regional geographic patterns are disrupted during times of market crisis

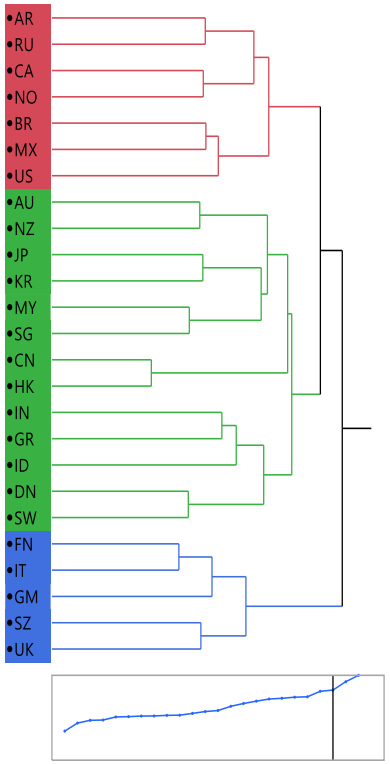
Empirical Results – Network Clusters (Dendrogram)



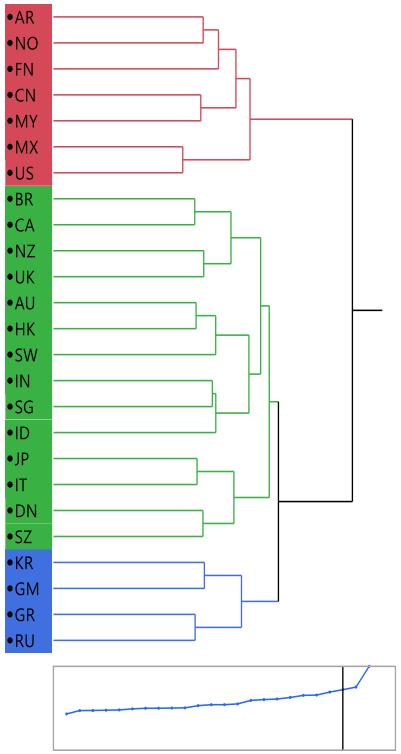
Period 1



Period 2



Period 3



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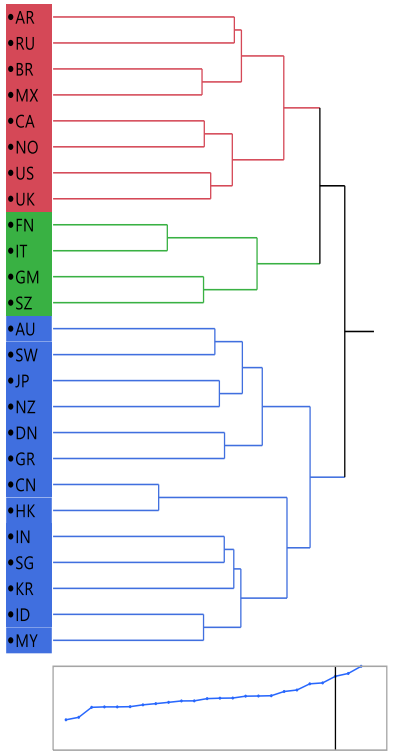
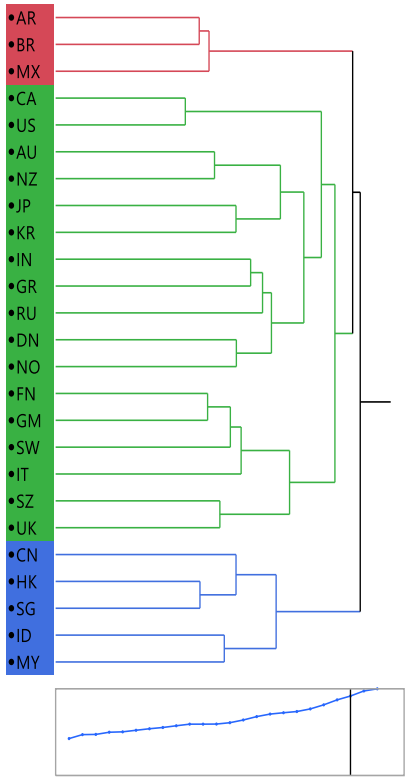


Period 5

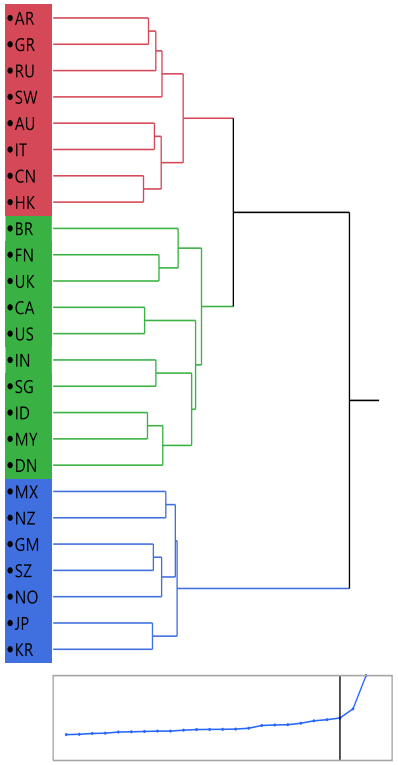
Dendrograms are hierarchical binary tree plots used to assess when the markets enter the clusters.

Empirical Results – Network Clusters (Dendrograms)



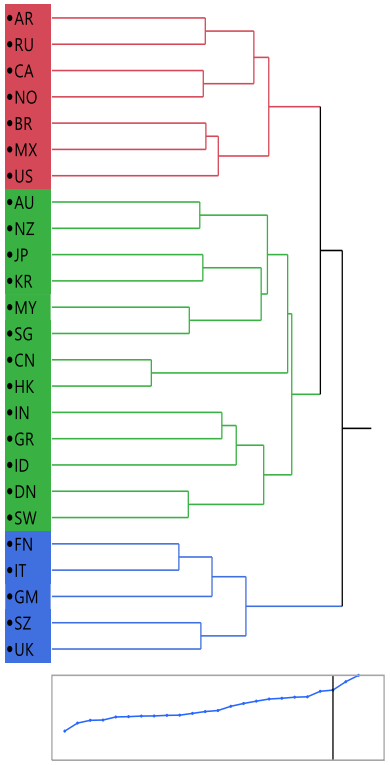
Period 1

Canada-US



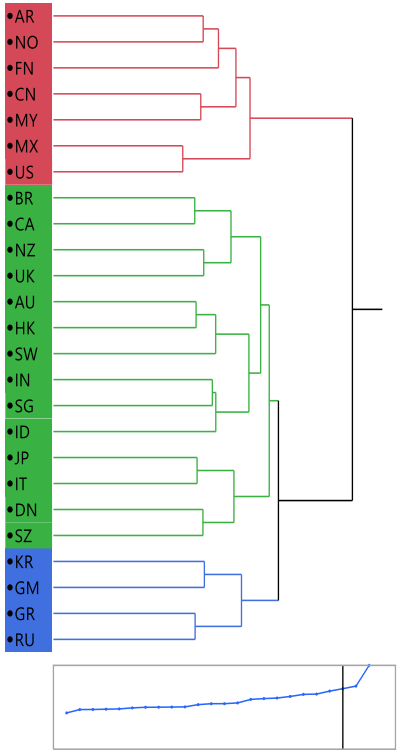
Period 2

China-HK



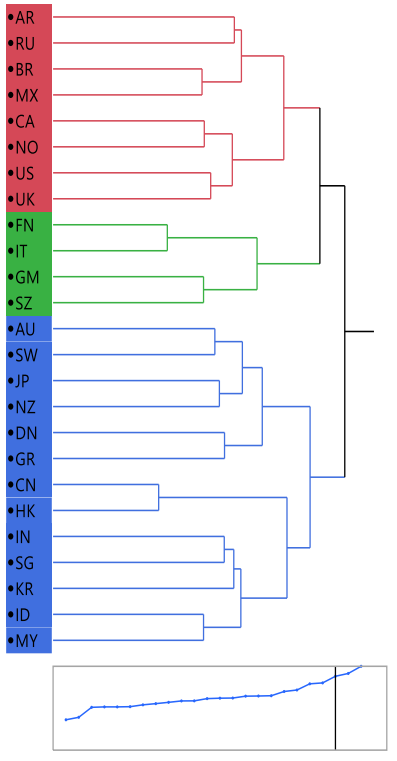
Period 3

China-HK



Period 4

US-Mexico



Period 5

China-HK

Shortest Distance

Markets within common regions depict lower distance compared to those across regions.

Conclusion

- Not all market pairs move together during times of market crisis disputing studies that claim that global portfolio diversification opportunities are eliminated (Sandoval and Franca, 2012).
- Market pairs reporting negative correlations are global whereas those with positive correlations are regional. Market stress impacts the behavior of regional markets.
- Financial network traffic increases during the market crisis and reverts to pre-crisis levels after the crisis is over indicating contagion and not a general increase in interdependence.

Conclusion

- Networks in the Americas and Europe are regional in all periods whereas those in Asia-Pacific are global during the market crisis and regional otherwise. Regional comparisons show stronger market linkages in the Americas compared to the other regions.
- The networks between Europe and the Americas display greater traffic during the GFC period due to the similar nature of banking crisis occurring in both regions.
- The network analysis confirms that geographical factors remain an important determinant of cross-border linkages during normal times, with clusters showing geographical traits. Also, the market pairs with shorter distances are likely to be located in the same region.
- However, market crisis disrupts these regional patterns as the clusters become global.

Conclusion

Implications:

- For investors and risk managers, the availability of global market pairs with negative correlations and market clusters presents opportunities for international portfolio diversification during times of crisis despite the increase in positive correlations between some markets. The availability of market pairs with negative correlations during periods of uncertainty also allows for arbitrage trading opportunities (e.g., short selling) for global investment managers. The breakdown of geographic patterns in cluster formation further raises the importance of active trading versus passive trading during such times. Thus, markets during uncertain times still present attractive opportunities for active international portfolio management.
- Policymakers continue to be challenged due to the increasing market linkages during times of market uncertainty, leading to transmission of market volatility. They need to take into account the shifts in market linkages to evaluate policy responses during such periods especially due to contagion effects caused by information effects from unrelated markets.