A Cluster-Based Approach for identifying East Asian Economies: A foundation for monetary integration

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Abstract: This paper uses the agglomerative hierarchical cluster analysis as a grouping procedure to classify relatively similar regional economies into clusters. The hierarchical cluster technique permits a set of macroeconomic indicators to be jointly assessed, as a basis for identifying similar groups of economies better poised for monetary integration. In particular, economies of the European and Asia-Pacific regions were assessed respectively. The cluster results supported a natural 'core' and 'periphery' group of European countries prior to the formation of the European monetary union (EMU). When the EMU convergence criteria were applied to the Asia-Pacific economies, it is found that they were not sufficient to sort the heterogeneous regional economies into relatively similar clusters. Due to the diversity of the Asia-Pacific region, a practical approach towards regional monetary integration would be to begin with smaller clusters first. The rationale is that the economic costs of monetary integration reduce with the degree of similarity or convergence of its potential union members.

Keywords: *Regional Monetary Integration; EMU Convergence Criteria; Agglomerative Hierarchical Clustering*

1. INTRODUCTION

The experience of European monetary integration is instructive. The quest for accommodating a fairly large number of relatively dissimilar economies (for instance, Germany and France versus Spain and Greece) in the monetary integration process could possibly undermine its stability and puts into question its sustainability. Although the drive towards European Monetary Union (EMU) might deliver benefits to its members, it also has costs. The greater the divergence of the participating economies, and the less flexible are their economic structures, the greater the costs.

Due to Asia's diverse economic circumstances and conditions, the practical approach to any form of regional co-operation or integration would be to begin with smaller clusters first, and the enlargement of these clusters at a later stage. If clustering of Asian economies to regional integration is deemed necessary, then the logical question is how to determine the various clusters.

This paper adopts the *Agglomerative Hierarchical Cluster Analysis* to organize observed data into meaningful classes, that is, to develop taxonomies.

We assume that 'countries' are non-homogenous entities, but can be categorized as members of relatively similar clusters. We consider the variants of the EMU convergence indicators in this clustering

exercise. Based on the indicators of the EMU convergence criteria per se, we could not adequately delineate the economies of Asia Pacific. This is because the EMU convergence indicators alone do not necessarily capture the structural differences and levels of economic development of the participating countries. Therefore, the implication from our study is that: to better facilitate the delineation of heterogeneous economies, other key characteristics should be included as well.

The paper is organized as follows: Section 2 discusses briefly the clustering technique, Section 3 clusters the economies based on the EMU convergence criteria, section 4 provides an analysis of the results, and section 5 concludes the paper.

2. METHODOLOGY

This study presents a rigorous technique to cluster countries into convergent sub-groupings. In particular, the agglomerative hierarchical cluster analysis is selected as a grouping procedure because it is an effective tool for identifying distinct groupings within a population or sample (Everitt, 1993).

This agglomerative hierarchical cluster technique uses an algorithm that classifies observed data into related clusters, based on the 'proximity' or similarity

of their indicators. In our study, the method permits us to identify various groupings of similar economies in terms of their characteristics. In this way, the hierarchical cluster methodology makes sense of multivariate data in a systematic manner.

3. ESTIMATION - DEGREE OF REGIONAL CONFLUENCE

3.1. EMU Convergence

As of Jan 1st 1999, the countries that qualify into entry into the EMU are namely, Austria, Belgium, Finland, France, Germany, Italy, Ireland, Luxembourg, the Netherlands, Spain and Portugal. The *Euro* effectively became the single currency for eleven EU member states and their national currencies are, in effect, subdivisions of the euro.

Prior to the EMU, the Maastricht Treaty has specified five key criteria of convergence that must be met by the candidates for EMU. These convergence criteria as stipulated in the Maastricht Treaty were namely: CPI inflation, nominal interest rates, exchange rate index, government debt-to-GDP and budget deficit-to-GDP ratio. The clustering analysis in the following sections is based on these EMU convergence characteristics.

Standardization of Data

The hierarchical cluster method accounts for the scale differences by transforming or standardizing the variables, since larger valued variables contribute more to the calculations of distance measures than the smaller valued variables. In this way, we avoid problems associated with scale differences. The values of each variable are standardized to a range of between 0 and 1 (the smallest value for each becomes 0 and the largest becomes 1). The dataset is drawn from The World Bank's *World Development Indicators CD-ROM*.

The sample period covers 1990-97. This is a critical period delimited on one end by the *Delors* Report, the document that launched the drive for economic and monetary union, and on the other by the deadline for determining the EU founding members for European monetary union.

3.2 Results of the Cluster Analysis

Proximity Matrix

Table 1 presents the proximity matrix among this group of countries. Based on the EMU convergence indicators, the most similar pair of economies appeared to be Austria and Netherlands. As such, both Austria and Netherlands were combined as stage 1 of the *Agglomeration Schedule* (see **Table 2**). France and Germany were found to be the next most similar pair of economies and hence combined as stage 2 in the *Agglomeration Schedule*. This was to be followed by Austria and France at stage 3. The rest of the economies were likewise identified based on their pair-wise distance, and grouped in ascending stages of the *Agglomeration Schedule*.

The graphic representation of the clustering process is reflected in the *Dendrogram* map (**Figure 1**). Moving across from the left to the right of the *Dendrogram* map, the groupings become more heterogeneous. In the final step, all countries are combined into one big cluster.

Cluster Membership

Table 3

Cluster Membership

Country/ Clusters	10	9	8	7	6	5	4	3	2
1:Austria	1	1	1	1	1	1	1	1	1
2:Belgium	2	2	2	2	2	1	1	1	1
3:Finland	3	3	3	3	3	2	1	1	1
4:France	4	4	1	1	1	1	1	1	1
5:Germany	5	4	1	1	1	1	1	1	1
6:Ireland	6	5	4	1	1	1	1	1	1
7:Italy	7	6	5	4	4	3	2	2	2
8:Luxemburg	8	7	6	5	5	4	3	1	1
9:Netherlands	1	1	1	1	1	1	1	1	1
10:Portugal	9	8	7	6	6	5	4	3	2
11:Spain	10	9	8	7	6	5	4	3	2

Table 1:

Proximity Matrix

| Case | Squared Euclidean Distance | | | | | | | | | | |
	1:Austria	2:Belgium	3:Finland	4:France	5:Germany	6:Ireland	7:Italy	8:Luxembg	9:Netherl	10:Portuga	11:Spain
1:Austria	.000	.394	.419	.115	.207	.378	1.759	.637	.076	1.771	1.032
2:Belgium	.394	.000	.685	.486	.526	.547	1.305	1.403	.285	1.690	1.038
3:Finland	.419	.685	.000	.261	.643	.724	1.032	1.228	.609	1.698	.672
4:France	.115	.486	.261	.000	.121	.305	1.541	.431	.127	1.630	.734
5:Germany	.207	.526	.643	.121	.000	.464	1.946	.223	.107	1.334	.782
6:Ireland	.378	.547	.724	.305	.464	.000	1.313	.836	.246	2.126	.978
7:Italy	1.759	1.305	1.032	1.541	1.946	1.313	.000	2.957	1.773	1.423	.566
8:Luxembg	.637	1.403	1.228	.431	.223	.836	2.957	.000	.507	1.889	1.276
9:Netherl	.076	.285	.609	.127	.107	.246	1.773	.507	.000	1.707	.987
10:Portuga	1.771	1.690	1.698	1.630	1.334	2.126	1.423	1.889	1.707	.000	.419
11:Spain	1.032	1.038	.672	.734	.782	.978	.566	1.276	.987	.419	.000

This is a dissimilarity matrix

Table 2:

Agglomeration Schedule

| Stage | Cluster Combined | | Coefficients | Stage Cluster First Appears | | Next Stage |
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	1	9	.076	0	0	3
2	4	5	.121	0	0	3
3	1	4	.139	1	2	4
4	1	6	.348	3	0	6
5	10	11	.419	0	0	9
6	1	2	.447	4	0	7
7	1	3	.557	6	0	8
8	1	8	.752	7	0	10
9	7	10	.995	0	5	10
10	1	7	1.457	8	9	0

Fig 1:

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* * * * * * H I E R A R C H I C A L C L U S T E R   A N A L Y S I S * * * *
*


Dendrogram using Average Linkage (Between Groups)


                    Rescaled Distance Cluster Combine


   C A S E     0         5        10        15        20        25
  Label    Num  +---------+---------+---------+---------+---------+

  Austria     1  ⇩×⇩⇘
  Netherl     9  ⇩⇗ ◻⇩⇩⇩⇩⇩⇘
  France      4  ⇩×⇩⇗      ◻⇩⇩⇩⇘
  Germany     5  ⇩⇗         ⇔    ◻⇩⇩⇩⇘
  Ireland     6  ⇩⇩⇩⇩⇩⇩⇩⇩⇩⇗    ⇔    ◻⇩⇩⇩⇩⇩⇩⇩⇘
  Belgium     2  ⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇗    ⇔         ◻⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇘
  Finland     3  ⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇗      ⇔                        ⇔
  Luxemburg   8  ⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇗                   ⇔
  Portugal   10  ⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩×⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇘               ⇔
  Spain      11  ⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇗            ◻⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇗
  Italy       7  ⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇩⇗
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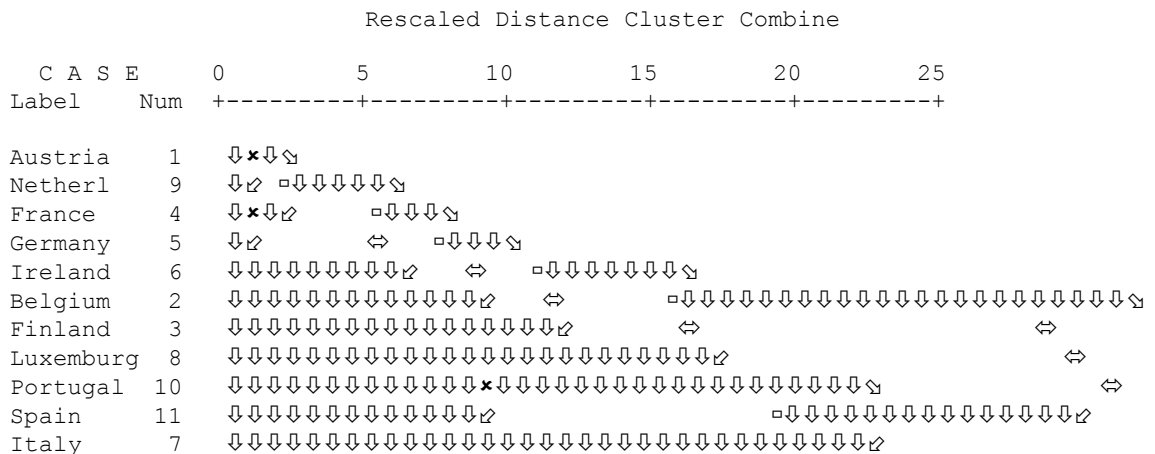
The hierarchical cluster analysis searches for similar groups of countries sequentially and combines them into clusters. **Table 3** displays the groupings of the European economies based on their extent of similarity. The table reports solutions ranging from *2-cluster* to *11-cluster*. The way to interpret the cluster membership is to look at the 'number' assigned to the country under each cluster. For instance, beginning with the right hand side of *2-clusters,* one observes that Spain, Portugal and Italy had been assigned a number '2', while the rest of the countries were assigned a number '1'. This indicates that Spain, Portugal and Italy had membership in Cluster '2' while the remainder of the cases or countries formed the other Cluster (i.e. cluster '1') for a *2-clusters* solution.

Under a *3-clusters* solution, Italy had been assigned a number '2', Portugal and Spain designated a number '3' and the remainder of the countries assigned a number '1'. This means that Italy belongs to Cluster '2', Portugal and Spain belong to Cluster '3' and the balance of the countries belong to Cluster '1'. Similarly, the rest of the cluster assignments follow the same reasoning.

Selecting the Candidate Cluster Solutions

The next logical question which arises is how to select the 'optimal' cluster solution(s). There is however no purely objective method to determine the optimal or "correct" cluster solution. The critical question is when to stop clustering (Aldenderfer & Blashfield, 1984; Everitt, 1993). Everitt (1993) indicates that analysis of the agglomeration schedule, specifically the change in the agglomeration coefficient, is the most commonly employed guide to halt clustering. The agglomeration coefficient is the sum of the within-group variance of the two clusters combined at each successive stage. Therefore, a marked increase in the value of the agglomeration coefficient between two stages indicates that heterogeneous clusters are being combined. The result is a large increase in total variance. At this point, an assessment should be made as to whether the optimal cluster solution has been reached.

The decision rule in this study for selecting the candidate cluster solution is as follows: when there is a marked increase in the coefficient of the *Agglomeration Schedule*, the previous stage of the cluster solution is a candidate solution. The stages in which there are marked changes in the slope and acceleration coefficients of the *Agglomeration Schedule* are identified to be at *8, 2* and *4* clusters. These are indicated by the relative substantial jumps

in the agglomeration coefficient from the *seventh to eighth* stage, followed by that from the *first to second* stage, and that of *third to fourth* stage. The clusters that are candidate solutions are marked by boldface in **Table 3**. These various candidate solutions in turn reflect the several tiers of EU economies based on their similarity in the EMU convergence characteristics.

Under a *2-clusters* solution, Italy appears to be a distinctive 'outsider' (or 'runt') among the EU countries. Italy was not joined to the group until the very last step. This implied that it could be more costly for Italy to join a monetary union, as there would be some relinquish of control over national policy and sovereignty. And Italy appeared an exception to the group.

An intermediate candidate solution is that of *4-clusters*. The respective members were namely: 1) Austria, Belgium, Finland, France, Germany, Ireland and the Netherlands, 2) Italy, 3) Luxembourg and 4) Portugal and Spain respectively.

For another candidate solution, that of *8-clusters*, the results coincidentally reflected a distinct inner core comprising: Germany, France, Austria and Netherlands. One observes that this inner core of economies had also appeared first as a cluster on the left hand side of the *Dendogram* (**Figure 1**).

Core and peripheral

These cluster results remind us that there existed a 'core' and 'periphery' group of countries among the EU countries. Therefore, on an economic basis, the support for at least a *2*-speed EMU is justifiable. This means that the strategy towards monetary union could limit first to the inner core group of countries and extend to the rest of the prospective members at a later time. The economic rationale being that the costs of monetary union decrease with the degree of similarity of its members, since this reduces the adjustment costs and the political strain of sustaining an asymmetric union.

3.3 Asia's Convergence

The above clustering analysis helped to identify several sub-groupings of European economies, based on the convergence of the EMU characteristics. It could be interesting to extend this clustering analysis to the East Asian countries to determine their extent of similarity with each other. This serves an economic precondition for forming a monetary union. In that connection, the following section applies first

the main EMU convergence characteristics to the East Asian economies.

The data used in this section include: the CPI inflation, nominal interest rates, exchange rate index and the budget deficit-to-GDP ratio. The government debt-to-GDP ratio is excluded, as this ratio is non relevant or existent for most of the regional countries.

The main economies included are: Japan, South Korea, Singapore, Malaysia, Indonesia, Philippines, Thailand and China. It however did not include Hong Kong, Taiwan and several other economies, due to data unavailability. In addition, the Asia-Pacific economies of Australia, New Zealand and the United States of America (USA) are included to offer additional perspectives to the clustering analysis. The period under study is that between 1990-97, which concludes just before the Asian financial crisis erupted. The 1990s also witnessed a rapid degree of market liberalization and integration among most East Asian economies.

Clustering Results

Australia and United States were found to be the most similar and combined as stage 1 of the *Agglomeration Schedule* (see **Table 4**). The next most similar sub-groupings of economies were Malaysia and New Zealand, and South Korea and Thailand respectively. They were combined as stages 2 and 3 of the *Agglomeration Schedule*. This was followed by South Korea and Malaysia and, Indonesia and Philippines at stages 4 and 5. South Korea and Australia, Indonesia and China, and South Korea and Indonesia, were combined next as stages 6, 7 and 8 in the *Agglomeration Schedule*. Japan and Singapore were introduced only at stage *9*. This could mean that Japan and Singapore were relatively dissimilar among the group of countries.

Cluster Membership

Table 5 below presents the country members for cluster solutions ranging from *2 to 10* clusters.

Cluster Membership

Case	10 Clusters	9 Clusters	8 Clusters	7 Clusters	6 Clusters	5 Clusters	4 Clusters	3 Clusters	2 Clusters
1:Japan	1	1	1	1	1	1	1	1	1
2:S. Korea	2	2	2	2	2	2	2	2	2
3:Singapore	3	3	3	3	3	3	3	3	1
4:Malaysia	4	4	4	2	2	2	2	2	2
5:Indonesia	5	5	5	4	4	4	4	2	2
6:Philippines	6	6	6	5	4	4	4	2	2
7:Thailand	7	7	2	2	2	2	2	2	2
8:China	8	8	7	6	5	5	4	2	2
9:Australia	9	9	8	7	6	2	2	2	2
10:New Zealand	10	4	4	2	2	2	2	2	2
11:USA	9	9	8	7	6	2	2	2	2

According to the agglomeration schedule, the marked jumps occurred at the candidate solutions with *8, 5 and 2* clusters respectively. These were marked by the large jumps in the agglomeration coefficient from the seventh to eighth stages, from the fourth to fifth stage and from the first to second stage.

For a solution of *2-clusters*, the country members were: 1) Japan and Singapore and 2) the rest of the economies. For a solution of *5-clusters*, the respective members were: 1) Japan, 2) South Korea, Malaysia, Thailand, Australia, New Zealand and USA, 3) Singapore, 4) Indonesia and Philippines and 5) China.

As regarding a solution of *8-clusters*, the members were 1) Japan, 2) South Korea and Thailand, 3) Singapore, 4) Malaysia and New Zealand, 5)

Indonesia, 6) Philippines, 7) China, and 8) Australia and the USA.

3.4. Implications of Clustering results for monetary union membership

This study discovers that the EMU convergence characteristics might not be sufficient in classifying heterogeneous countries into distinct groupings, especially for diverse regions such as Asia Pacific. In this study for instance, Malaysia, a developing

economy has been lumped with New Zealand, a developed economy, based on their similarity in the EMU convergence characteristics. In the case of the European region, it could seem logical that countries such as Austria and Netherlands and Germany and France, were grouped together, since they are at similar stages of development.

The failure to appropriately assign the heterogeneous group of regional economies could be attributed to the exclusion of other key variables, such as structural and real characteristics of economies. Comparing with the European countries, the countries of Asia Pacific are even more dissimilar.

4. SUGGESTIONS FOR FUTURE RESEARCH

An extension to this study could be made in several directions. First, other key (both real and nominal) variables should be included in the clustering analysis in the selection of prospective union members.

Second, some form of sensitivity analysis could be conducted over several shorter periods of the entire period to ascertain how the clustering results might have changed or how countries could have converged (or diverged) with time. A preliminary test was made along this line. There appeared to be no major distinct differences in the cluster results over the sub-periods.

Other non-traditional characteristics could also be used to assess the degree of similarity among countries, as long as these variables are quantifiable. For example, the degree of political freedom, rule of law, regulatory burdens and market restrictions and others could also be assessed.

5. CONCLUSION

Given Asia's diverse economies, the practical approach to any form of regional integration would be to begin with smaller clusters first. This study has used the agglomerative hierarchical cluster technique to organize the set of economies under study into relatively similar groupings. The preliminary results suggested several similar clusters of economies based on their economic characteristics over the recent past. The findings of this study is crucial in providing a foundation for identifying distinct groups of economies for monetary integration, which is especially significant given the recent trends towards regional integration.

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