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How Similar Are the East Asian Economies? A Cluster Analysis Perspective on Economic Cooperation in the Region*

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Recent economic calamities such as the 1997 Asian financial crisis have amply demonstrated the need for increased economic integration in the East Asian economic region. While various forms of economic cooperation are possible, it is important to identify groups, or clusters, of countries that are similar to each other economically. Such similarity not only has been shown to be associated with the increased bilateral trade flows, but also with the increased net welfare gains to the participating countries. I employ a variety of clustering techniques and come up with a clustering solution containing four groups of economically similar countries. The clusters are robust across the estimation procedures. Hierarchical clustering also conducted in this study suggests a sequential agglomerating path for the countries to follow. The results of this study are intended as one of the (many) decision tools used by the parties considering multilateral economic cooperation and trade agreements in the region.

Keywords: Economic cooperation, Free trade agreements (FTAs), Clustering analysis, East Asian economies

1. INTRODUCTION

In a world of globalization, no nation can be considered to be isolated from the rest of the world, the East Asian countries being no exception. The recent decennia brought about immense technological progress that made transportation costs cheaper, communication faster, capital flows more abundant, and the extent of economic interconnectedness very high. A well-known example of how interdependent the East Asian countries are is the Asian financial crisis of 1997. A precipitous depreciation of Thai baht that occurred in the summer of 1997, presumably as a result of Japan hinting it might raise the interest rate in order to protect the yen, first triggered negative economic developments in the nearby countries of Malaysia, the Philippines, and Indonesia, which in turn initiated the second wave of currencies depreciation in Taiwan, South Korea, Singapore, and Hong Kong. Even if South Korea and other more developed countries in the region were able to stage a comparatively quick recovery, the event underscored the extent to which the East Asian economies are interconnected with each other.

The issues of regional cooperation and economic exchange in this light are gaining more importance than ever because not only such cooperation expands the set of each country's production possibilities, it also serves as a basis for the creation of an institutional framework that coordinates economic activities of the individual countries and helps absorb the possible shocks originating in any one of them.

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Table 1. Free Trade Agreements in East Asia, 2010

Country	GDP ($ billion) 2008	Simple Average MFN Tariffs (%) 2008	FTAs in Effect (number) 2010	FTAs under Negotiation/ Proposed (number) 2010
Northeast Asia				
China, People's Republic of	4,327	8.7	10	12
Japan	4,991	2.6	11	9
Korea, Republic of	929	6.6	6	18
Southeast Asia				
Philippines	167	5.7	6	5
Singapore	182	0.0	18	12
Thailand	272	8.2	11	12

Source: Kawai and Wignaraja (2010).
Note: GDP: Gross Domestic Product, FTA: Free Trade Agreement, MFN: Most Favored Nation.

Economic cooperation is well-founded in the theoretical economic concepts such as those of comparative advantage, production possibilities frontiers, gains from trade, and productive efficiency, to name just a few. The most obvious example of economic cooperation is a free trade agreement (FTA) that removes trade barriers between member countries resulting in an increase of total wealth in each one of them due to the more efficient allocation of productive resources and to a higher extent to which each country's comparative advantage is exploited.

In East Asia alone the number of FTAs increased from only 2 in 1975 up to 16 in the year of 2000 (Shin 2002). By 2010, more than 45 FTAs were concluded in the East Asian region (Asian Development Bank 2010), and an even larger number is being negotiated on.

The scope of countries and areas covered by the regional FTAs is continuously increasing, which is naturally bringing up the problem of sequencing since it is unlikely for all the diverse countries in the East Asian region to conclude a comprehensive FTA all at once. Such prospects are much bleaker when it comes to the conclusion of trade agreements between East Asian countries (as a group or individually) and the European Union or North American economies (Kawai and Wignaraja 2010). Depending on the sequence in which the East Asian countries will be agglomerating into groups in the form of e.g. free trade agreements, the economic implications will be different both for the individual countries and the region as a whole. I will argue that it makes sense from the welfare perspective that the free trade agreements be first formed among countries that are similar to each other in the economic sense. While some studies (e.g. Baier and Bergrstrand 2004) argue that both similarity and dissimilarity matter for the size of the trade flows between the two countries, this study focuses on the role of the economic similarity alone.

In what follows I briefly review the theoretical and empirical background behind the formation of FTAs, the general conclusion being that similar countries are relatively more suited (both positively and normatively) to establish economic cooperation ties. I will then discuss the problem of measuring the extent of economic similarity that essentially deals with identifying groups among multi-dimensional objects. Country groups in this context are identified within the framework of *cluster analysis* that is also outlined in this paper. In the empirical part I will present the results of cluster analysis I apply to the East Asian countries based on their economic characteristics. This analysis will result in the identification of

several levels of such groupings corresponding to the extent of agglomeration (i.e. a few large clusters versus smaller clusters), which can be interpreted in terms of the *sequencing* of the economic cooperation or trade agreements. I will conclude by discussing the policy implications for the future development of FTAs in the East Asian region.

2. WHY DOES ECONOMIC SIMILARITY MATTER?

In attempting to answer the question of why countries would trade or economically cooperate more or less with their counterparts has long been a subject of discussion among the economists. The so-called gravity argument that likened individual economies to celestial bodies characterized by a certain mass and located at a certain distance from each other led to empirical research that amply corroborated an intuitively appealing result: countries that are similar in terms of their geographical proximity to each other trade more. While these empirical findings were lacking sound theoretical support for a long period of time, gradually the theoretical justifications for including the extent of economic similarity (not just in terms of the geographical distance) into the list of trade flows' determinants started to appear both on the supply and demand side.

The supply-side line of research linking economic similarity and the size of the trade flows probably starts with the seminal contribution of Helpman and Krugman (1985) that integrated the model of monopolistic competition into the more traditional Hecksher-Ohlin general equilibrium framework. Their supply-side explanations of why most of the world trade occurs between countries that are similar in terms of factor endowments and technology is based on the assumption of increasing returns to scale and competition in differentiated products. Bergstrand and Egger (2007), among others, also included the extent of the two countries' similarity into the list of determinants of the size of bilateral trade flows. Their study is in turn based on Baier and Bergstrand (2004) who studied the economic determinants of free trade agreements (FTAs) by developing a numerical version of the Krugman-type general equilibrium monopolistic competition model of international trade. Their model reinforces the notion that similarity between countries is important not only because it helps explain the empirically observed trade flows, but also when seen from the normative point of view. To be more precise, their study estimated net welfare gains from concluding an FTA which turned out to be an increasing function of the *similarities* of the prospective country members. Similarity was measured in terms of the countries' real GDPs, geographical proximity, and remoteness from the rest of the world. The (supply side) importance of economic similarity in Baier and Bergstrand (2004) model arises from the elimination of supply distortions caused by the imposition of the import tariffs. The authors argue that such gains will be greater in case the two trading countries are of more similar economic size since otherwise the increase in bilateral trade due to tariffs elimination will be negligible, and so will be the associated welfare gains.

An interesting feature of the Baier and Bergstrand (2004) is that it also includes economic *dissimilarity* in the list of the factors that determine the size of the trade flows. In particular, their model predicts that dissimilarity in the capital-to-labor ratios will increase the size of the trade flow due to increased inter-industry trade. However, as the gap between capital-to-labor ratios widens, more trade specialization resulting in the higher volumes of intra-industry trade will offset the inter-industry trade effect so that the "average" effect of the increased difference in production factor endowments appears to be unclear. As mentioned in

the introduction, in this study I am focusing on the similarity dimension behind the countries' decision to form a cluster.

The demand-side argument emphasizing the positive role economic similarity plays in determining the size of the trade flows between countries has been probably first put forward by Linder (1961). According to his theory, consumers in countries with a similar level of development will also have similar preferences, making it easier for the producers in both countries to adapt their products to the tastes prevalent in the countries with which they trade. For example, consumers in more developed countries will likely demand more technologically advanced goods compared to the countries that are less developed. The author draws a hypothetical example of why U.S. goods might find less demand in Bangladesh and concludes that since the living standards in the two countries are different, their consumption patterns will be different as well. Differences in income, of course, will *per se* ensure that most of the Bangladeshi consumers will not have enough means to pay for the expensive U.S. imported goods. Interestingly, this demand-side view runs somewhat counter to the statement in Baier and Bergstrand (2004) that differences in capital-to-labor ratios will reinforce inter-industry trade conducive to higher trade flows as a whole. According to Linder's (1961) insights, more capital intensity in one country will hamper development of trade with a labor-intensive country since the two will likely be at different stages of economic development (e.g. industrialized versus agricultural) so that differences in consumer tastes may outweigh gains from the inter-industry trade increase. Sailors *et al*. (1973) provide an empirical confirmation of the views expressed in Linder (1961)'s book.

Lancaster (1979) considers the combination of supply-side and demand-side reasons why economic similarity will increase the size of the trade flows between the two countries. According to their argument, it is impossible for a limited number of producers in any one of the trading countries to furnish the whole variety of brands in any differentiated product since there is a tradeoff between the number of varieties and the low unit production costs associated with mass production of one brand. The "missing" brand varieties will thus be provided by producers in the trading partner country, which will increase the volume of trade. Krugman (1979) also considers economies of scale as one of the factors limiting the producers' incentives to expand the number of their own product varieties with the exporters filling the gap.

Given ample theoretical and empirical evidence both on the supply and demand side to support the idea that similar countries in terms of the level of their economic development will trade more, and the normative conclusion by Baier and Bergstrand (2004) that countries with similar levels of real GDPs will be more likely to conclude an FTA, I find very appealing the idea of generalizing the concept of economic similarity to include a number of other dimensions. In fact, borrowing the gravity models' terminology, I would suggest talking about the "generalized distance" in this context. If this generalized distance between any two countries is relatively small, one can call these countries economically similar.

The question naturally arising in this regard is, what countries can be viewed as similar, and on what grounds. The answer to this question is important since, once the groups of economically similar countries are identified, the process of economic integration in the (East Asian) region can be, at least partially, based on those groupings, or clusters. The demand- and supply-side explanations of the importance of economic similarity discussed above both argue that the level of GDP per capita is an important determinant of this similarity. The demand side explanations, and especially Linder's (1961) theory emphasize that the structure of demand in trading partners has to be similar, which appears to imply

similarity in terms of the levels of per capita GDP as well.

Based on the available data published by the Asian Development Bank (2012), I chose nine characteristics that in my view account for the economic similarity between countries. I employed nine economic characteristics along four dimensions, namely: economic structure, the openness of international trade, extent of economic development, and economic size. The importance of similarity in terms of the economic size was already emphasized by the supply-side explanation of Baier and Bergstrand (2004). Economic size is represented in this study by the size of the population and the level of GDP in the constant prices of 2005. The real GDP per capita accounting for the similarity of demand structures in the two countries is discussed in Linder (1961) on the demand-side and Baier and Bergstrand (2004) on the supply side, and is included in the more general category of economic development. The two other variables in this category are the share of urban population and the human development index by the World Bank. The close link between the extent of urbanization and economic development has been demonstrated by e.g. Laumas and Williams (1984), while the choice of the human development index is self-evident. The economic structure is represented by the shares of agricultural, industrial, and the service sectors in the economy. The choice of the structural dimension thus defined is motivated by Linder's (1961) notion that international trade is positively influenced by the similarity of demands in the two countries. Roughly speaking, the demand in a mostly agricultural country will likely be different from demand in a country that is industrialized. Finally, international trade openness reflects the extent to which the potential trading partners' economies are already integrated in the world economy.

The nine variables employed in this study for the measurement of economic similarity are summarized in Table 2, Section IV. Since economic theory provides little guidance as to what variables should serve as a basis for measuring economic similarity between the two countries (except, perhaps, for the level of per capita GDP), this study may be the first attempt to offer a formalization in that area.

While in no way suggesting that the results of this study are unequivocally indicating that Laos, for instance, should immediately form a regional trade agreement with Cambodia, I believe that those results can be used as useful background information for the practical implementation of free or regional trade and cooperation agreements in the region.

3. GROUPING COUNTRIES BY CLUSTER ANALYSIS

The idea of grouping objects into clusters is undoubtedly a very old one, having played a crucial role in the mankind's ability to survive. From time immemorial, the ability to distinguish friends from foes, edible plants from noxious weeds, and carnivorous from herbivore animals have all been important survival skills for our ancestors. Grouping objects that have multiple attributes, however, presents a more challenging problem since a simple comparison of the values of just one attribute (e.g., edible or not) does not work in this case. One needs a methodology that would identify the two or more objects as being *close* to each other based on some measure of similarity that depends on a multitude of parameters. This is exactly what the cluster analysis is doing: dividing objects (e.g., countries) in groups according to the extent of their similarity in terms of some measurable attributes.

As argued in Section II, economically similar countries are more likely to form trading clusters (i.e. by concluding a trade agreement) compared to the countries with rather different

economies. While this kind of difference is in no way precluding the possibility of concluding an FTA in principle, it would be economically rational for the more similar countries to form a trading block first, which would then agglomerate with the other blocks also formed according to the economic similarity principle. The major question in this regard is thus: how do we measure the extent of economic similarity between any two countries?

Euclidean distance is probably the most obvious choice for measuring an "economic distance" between any two countries. It has a clear geometric representation in the two parameter space, like the one represented in Figure 1 below.

X and Y in Figure one can be thought of as any two economic parameters characterizing the country. Thinking in terms of the GDP per capita and the percentage of urban population, for example, one may interpret the large Euclidean distance measured in this way between, say, Thailand and Mongolia as representing the extent of differences between the two countries' economic systems. Figure 2 below is illustrating how Euclidean distances can be

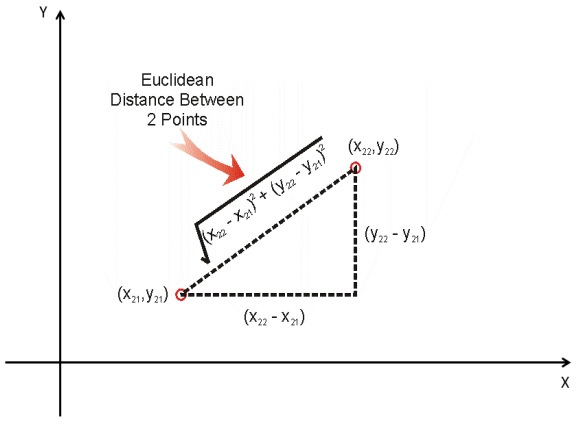


Figure 1. Euclidean distance between two points

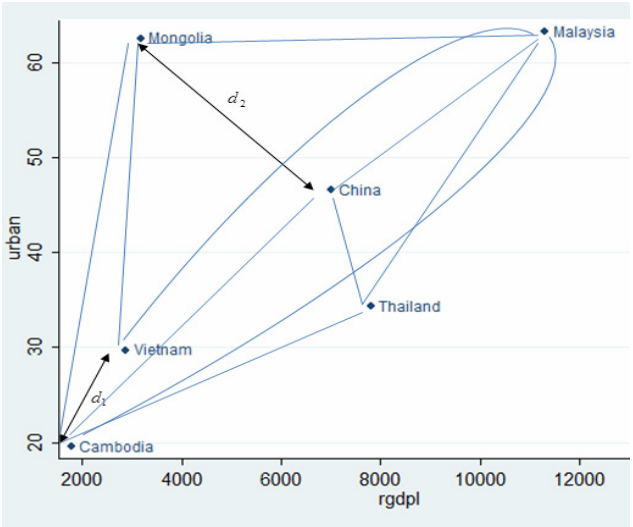


Figure 2. Euclidean distance, an economic example

computed between several Eastern Asian countries. Cambodia and Vietnam can be inferred to be more similar to each other compared to e.g. Mongolia and China.

The example above already gives an insight into the complexity of the grouping problem. Not only the number of possible distances between all possible countries increases quickly with each additional country added to the sample, sorting these countries into two or more groups becomes less obvious. While Vietnam and Cambodia may appear to belong to the same group (in terms of the two economic parameters under consideration), one may wonder whether China and Thailand form a separate group or Malaysia should be included as well. The result of such comparison is the so-called dissimilarity square matrix whose dimension is equal to the number of countries in the sample, and whose elements are equal to the economic distances between countries. The subsequent clustering procedures use this dissimilarity matrix as an input.

Clearly, when the number of economic parameters is greater than two, the graphical analysis becomes grossly impaired, and the problem of grouping gets even more intractable, although the idea of Euclidean measure still works perfectly well. As a result, several grouping methods were developed based on alternative similarity measures and different definitions of what a group is. Avoiding the discussion of technicalities, let me just mention that there are two broad categories of the grouping, or *clustering*, methods, namely, hierarchical and non-hierarchical. The hierarchical clustering methods start by considering each observation (e.g., a country in our case) as a separate cluster, gradually agglomerating the similar countries into clusters containing an ever increasing number of members. In the end of this process all countries in the sample form one big cluster (which is rather useless, of course). The non-hierarchical methods use the pre-defined number of clusters (e.g., three) in order to form three different groups of countries so that each group is characterized by rather similar economic characteristics.

In what follows, I will describe the data sources, and discuss the choice of the East Asian countries' economic characteristics used in this study in order to determine the extent of their similarity. I will then present clustering results obtained by competing grouping procedures and discuss policy implications.

4. DATA SOURCES AND ECONOMIC VARIABLES

I used the Penn World Data Tables (version 7), the Asian Development Bank and the Trading Economics databases for the analysis in this study. These are all open-access datasets downloadable from the web. Since the basic idea was to identify countries' clusters according to the extent of their similarity, I identified four dimensions along which to measure it. The shares of agricultural, manufacturing, and trading (wholesale and retail) sectors are representing the structural features of the East Asian economies, and trade openness is accounting for the role played by the international trade. The extent of economic development is captured by the real GDP per capita (computed in terms of the constant 2005 prices measured in international dollars), share of urban population, and the human development index. Finally, the size of the economy, which is an important factor entering the widely spread gravity models, is represented by the countries' populations, and the level of GDP measured in constant 2005 prices. Table 2 below provides the summary of the data I employed.

Table 2. Data Summary, 2005-2009, Constant 2005 International Dollar Prices.

	Mean	Standard Deviation	Skewness	Min	Max	Source	Computation
Structural Shares							
Agriculture, %	18.35%	0.13	0.53	1.46%	4.53%	ADB	SU501/SU499
Manufacturing, %	23.21%	0.12	0.19	5.96%	48.46%	ADB	SU504/SU499
Trading, %	13.98%	0.05	-0.34	5.76%	21.66%	ADB	SU508/SU499
International Trade							
Trade Openness, %	106.59%	46.84	0.77	24.31%	213.75%	Penn	openk
Economic Development							
GDP per Capita, $	$10167	11010	1.52	$1707	$34223	Penn	rgdpl
Share of Urban Population	44.10%	19.82	0.07	12.52%	84.68%	ADB, Trading Economics	SU1223
Human Development Index, %	0.62%	0.14%	0.61	0.44	0.89%	ADB	SU1023
Economic Size							
Population, mn people	61.2	65.6	2.86	2.9	240.3	Penn	POP
GDP in constant 2005 prices, bn USD	1229	2195	2.86	7.46	9276	ADB	SU499

Note: ADB stands for the Asian Development Bank's statistical database https://sdbs.adb.org/sdbs/index.jsp), Penn for the Penn World Table version 7 (http://pwt.econ.upenn.edu/php_site/pwt70/pwt70_form.php). Data on urban population shares in Papua New Guinea is taken from the Trading Economics Indicators database (http://www.tradingeconomics.com/papua-new-guinea/urban-population-percent-of-total-wb-data.html). The "Computation" column is based on the variable names provided by the original databases. Population statistics are given for the subsample that excludes China.

The region under study is, indeed, a very diverse one with the data's standard deviations comparable to or even exceeding the observed variables' means. Since most procedures employed in cluster analysis are rather sensitive to the scale of the measured variables with the ones characterized by larger standard deviations producing more impact on the final results, it has become common practice to standardize all quantitative variables by converting their values in the way that ensures there is some common scale for each variable. In this study I followed the straightforward path by computing a Z-score for each variable, namely, by subtracting from each variable value its mean and dividing it by the standard deviation. The resulting variables are all zero-mean, with the standard deviation equal to zero. Such standardization is highly recommended by several scholars including Jain *et al.* (1999). For the clustering procedures, I use the means of the variables for the period of 2005-2009 (2009 being the last available year for the variables in this analysis) to remove the influence of possible time-related developments.

Finally, the list of the East Asian countries for which enough data could be found for the present analysis, is as follows: Mongolia, Korea, China, Taiwan, Cambodia, Laos, Papua

New Guinea, Vietnam, Indonesia, Malaysia, the Philippines, and Thailand. While fully recognizing the fact that Taiwan is part of China, it is impossible to overlook the fact that both its economic past and present are very different from those of the continental China. For that reason the Chinese region of Taiwan is treated as a separate economic entity in this study. Japan was completely left out of the analysis because of the extent of its development compared to the other East Asian countries. For instance, the Japanese economy has been until recently the second-largest economy in the world (it is now the fourth largest if the European Union is not treated as a single country, according to the CIA Factbook), its currency is the only truly hard currency in the region, and until recently the extent of her economic development far exceeded that of the rest of the countries in East Asia.

5. RESULTS OF CLUSTERING ANALYSIS

While there are several types of the clustering analyses, not much (if any) theoretical background exists upon which to base an educated choice of a particular clustering procedure. I will therefore present the results based on several competing algorithms.

5.1. Clustering by K-Means

K-means is a group name for clustering algorithms placing observations in groups whose number must be specified in advance. The final clustering solution is such that the overall distance within each cluster of the individual observations from the cluster center (i.e. centroid) is minimized. The overall distance in case of a K-means procedure is understood in terms of the mean of all individual distances. The clustering process proceeds in iterations so that each observation (a country in our case) may change its assigned cluster several times. The iterative process stops when no observation changes its cluster assigned by the previous iteration. Technical procedures are implemented in order to avoid endless loops and the problem of tied distances. I choose to assign the initial group centers randomly since the observations are allowed to change "their" clusters during the grouping process. Having repeated the process with several initial seeds based on a randomly chosen number did not affect the final clustering solution. Since we only have twelve countries in the sample, I found it rational to limit the number of possible clusters to 2, 3, and 4. Table 3 below presents the K-means clustering results using the Euclidean distance measure of similarity between two observations.

Table 3 represents clustering procedure based on the Euclidean distance between the vectors whose elements are observed values on the nine variables defining a single country in this study. Since Euclidean distance measure is not the only possible one, I ran the same procedure using the absolute value distance (also known as city-block, or Manhattan distance). The groupings remained practically the same the only exception being Vietnam ending up in Group 2 rather than Group 3.

It is interesting how China retains a peculiar place when the number of groups is greater than 2. China's huge population and the sheer size of its (world's second-largest) economy might play a role here, but since each country is represented by nine variables, the finding of China's being very special appears to be rather robust. The colored sections of Table 3 represent groups of countries that tend to remain in the same cluster even if the number of clusters changes. Korea and Taiwan, for instance, stick together, and so do Indonesia, the

Table 3. K-means Clustering, Euclidean Distance Measure

	2 groups	3 groups	4 groups
Group 1			
	China		
	Indonesia		
	Korea	Korea	Korea
	Malaysia	Malaysia	
	Philippines		
	Taiwan	Taiwan	Taiwan
	Thailand		
Group 2			
	Cambodia	Cambodia	Cambodia
	Laos	Laos	Laos
	Mongolia	Mongolia	Mongolia
	Papua New Guinea	Papua New Guinea	Papua New Guinea
	Vietnam	Vietnam	
		Indonesia	
		Thailand	
		Philippines	
Group 3			
		China	China
Group 4			
			Indonesia
			Malaysia
			Vietnam
			Philippines
			Thailand

Note: Author's calculations; the initial distribution of clusters assigned randomly.

Philippines, and Thailand. Cambodia, Laos, Papua New Guinea and Mongolia are another coherent group.

5.2. Clustering by K-Medians

As mentioned above, the iterative K-means clustering procedure is "aiming" to minimize the overall distance of individual observations within each cluster from its centroid, with the overall distance understood in terms of the mean of all such distances. An alternative procedure that employs the median distances, rather than the mean ones, is also sometimes used. Table 4 represents the results:

Table 4. K-medians Clustering, Euclidean Distance Measure

	2 groups	3 groups	4 groups
Group 1			
	China		
	Indonesia		
	Korea	Korea	Korea
	Malaysia		Malaysia
	Philippines		
	Taiwan	Taiwan	Taiwan
	Thailand		
Group 2			
	Cambodia	Cambodia	Cambodia
	Laos	Laos	Laos
	Papua New Guinea	Papua New Guinea	Papua New Guinea
	Vietnam		
	Mongolia	Mongolia	
Group 3			
		China	
		Indonesia	Indonesia
		Malaysia	Mongolia
		Philippines	Philippines
		Thailand	Thailand
		Vietnam	Vietnam
Group 4			
			China

Note: Author's calculations: the initial distribution of clusters assigned randomly.

When the distance from clusters' centroids is computed as the median, rather than the mean, of all distances, the resulting clustering solution is a bit different. For example, in the four-group solution Mongolia is grouped with the more advanced economies of Thailand and Indonesia compared to Laos and Papua New Guinea in case of the K-means clustering. On the other hand, the general trends persist: China is still singled out into a separate cluster, albeit at a later stage (i.e. when four clusters are defined, rather than three in case of the K-means solution), Korea and Taiwan still stick together in one group across all the three groupings, and so do Indonesia, Philippines, and Thailand. The poorest countries in the region (i.e. Cambodia, Laos and Papua New Guinea) robustly remain in the same cluster as well.

The fact that the K-means results are similar to the results obtained by applying the K-

medians procedure suggests that the distributions of the nine variables employed to identify clusters' centroids are not particularly skewed. However, this would be a wrong conclusion to make since each variable in this study is characterized by a significant extent of non-zero skewness, as evidenced by Table 2. Indeed, the distributions of all nine variables are positively skewed (implying that most of the observations are *smaller* than the mean), except for the trading sector share whose distribution is skewed negatively, with the magnitudes of the skewness coefficients being far from uniform and varying within the 0.07 to 2.86 range. I am thus concluding that the similarity of results between K-means and K-medians procedures is indicative of the robustness of the underlying clustering structure rather than the consequence of the technical characteristics of the variables' distributions.

5.3. How Many Clusters to Choose?

As mentioned above, the number of clusters identified by both K-means and K-medians procedures must be selected prior to implementing these procedures. In Tables 3 and 4 I presented clustering solutions for the cases of two, three, and four clusters. There are at least two formal procedures that are often used in order to help determine the optimal number of clusters. These procedures are based on the hierarchical approach to clustering that agglomerates observations into groups starting with the situation when each observation (country) is its own single-member cluster. The hierarchical clustering process ends when there remains but one cluster comprising the whole sample.

Clusters in the hierarchical procedure are gradually agglomerated according to the extent of their similarity to each other. Stopping rules are widely used in order to determine the number of clusters that use stopping values computed for each (hierarchical) cluster solution. The two stopping rules used in this study are the pseudo-F index due to Calinski and Harabasz (1974), and the Duda-Hart index (Duda and Hart 2001). Large values of the Calinski-Harabasz pseudo-F index correspond to more distinct clustering, the same holding true in case of the Duda-Hart index.

The hierarchical clustering procedures start by computing dissimilarity matrices based on a certain distance measure such as e.g. Euclidean. The elements of dissimilarity matrices in the context of this study are exactly the distances between nine-element vectors representing specific countries. Based on these dissimilarity matrices the initial cluster solution where each country is its own single-element cluster is agglomerated into a solution that has fewer clusters in it by merging those clusters that are similar. There are several ways to define similarity in this context. For example, the single-linkage method looks at the shortest distance from any country in one cluster to any country in the other cluster. The complete linkage method, on the contrary, defines similarity in terms of the minimum diameter sphere that can encompass all observations in the two clusters. Similarity can also be defined in terms of the average linkage (i.e. average distance between the two clusters' observations), cluster centroids (the distance between two clusters is equal to the distance between their centroids), and the sum of squared distances within the clusters summed over all variables (Ward's method). Table 5 below displays the values of pseudo-F and Duda-Hart indices corresponding to the five approaches to measuring the similarity between different clusters described above.

Table 5. The Number of Clusters According to Different Similarity Measurements

	Average Linkage		Single Linkage		Complete Linkage		Centroid		Ward's Method	
Number of Clusters	Pseudo-F	Duda-Hart	Pseudo-F	Duda-Hart	Pseudo-F	Duda-Hart	Pseudo-F	Duda-Hart	Pseudo-F	Duda-Hart
2	5.33	0.6	5.33	0.92	5.33	0.58	5.33	0.79	4.47	0.46
3	6.99	0.55	2.98	0.75	7.3	0.41	4.26	0.56	7.3	0.41
4	8.94	0.54	3.19	0.68	9.13	0.47	6.62	0	9.13	0.47
5	9	0.33	3.91	0.64	9	0.33	5.02	0.77	9	0.48
6	8.34	0	4.86	0.68	8.34	0.48	4.86	0.49	8.6	0.33
7	7.76	0.48	5.36	0.82	8.93	0	7.76	0	8.93	0
8	9.54	0	4.62	0.58	9.54	0.23	6.72	0.65	9.54	0.23

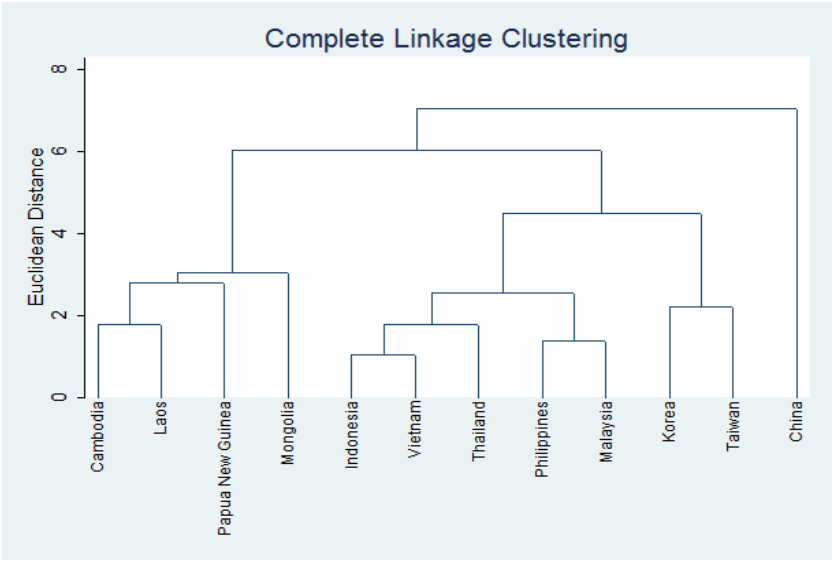
Note: Author's calculations. The higher value of both pseudo-F and Duda-Hart statistics indicates more distinct clustering. Shaded cells contain values of the two statistics indicating the most distinct clustering. Higher values of these statistics at unrealistically high disaggregate levels (e.g. 8 clusters for 12 countries) are ignored.

With the sole exception of single linkage, the number of clusters identified by the hierarchical agglomeration process based on the Euclidean measure similarity matrix is grouped around the value of four, the average number of clusters "recommended" by all the statistics being 4.2. The non-hierarchical clustering results presented by Tables 3 and 4 for that reason are based on the clustering solutions characterized by the most distinct clusters.

5.4. Clustering Trees

Since the hierarchical clustering algorithms work their way up by agglomerating more objects into fewer clusters it is possible to draw a "tree", otherwise known as a dendrogram, depicting the agglomeration process. The dendrogram is usually drawn as a graph relating the values of the distance between clusters (Euclidean in my case) on the vertical axis. Figure 3 below represents the dendrogram for the complete linkage agglomeration process:

The four-cluster solution according to the above diagram will have China constituting a separate single-member cluster, Korea and Taiwan forming another one, Cambodia, Laos, Papua New Guinea and Mongolia grouping into the third group, and the remaining countries agglomerating into yet another cluster. In fact, this four-cluster grouping coincides with the four-cluster solution obtained by the K-means methodology based on the Euclidean distance (last column of Table 3). Similar dendrograms were obtained for the single, average, centroid, and Ward's linkages. Except for the single-linkage solution, the four-cluster groupings closely resembled each other and the K-means and K-median solutions for the same number of clusters with China always staying aside, Korea and Taiwan grouping together, with Cambodia, Laos and Papua New Guinea doing the same. Mongolia would be found in the group of less affluent countries for complete and Ward's linkage clustering procedures, while it would join the more advanced economies of e.g. Thailand and Malaysia for the average and centroid solution. The single-linkage solution is special in the sense that it grouped China, Mongolia, and Korea into single-member clusters, while dumping all of the remaining



Source: Author's calculations

Figure 3. Complete Linkage Clustering Dendrogram

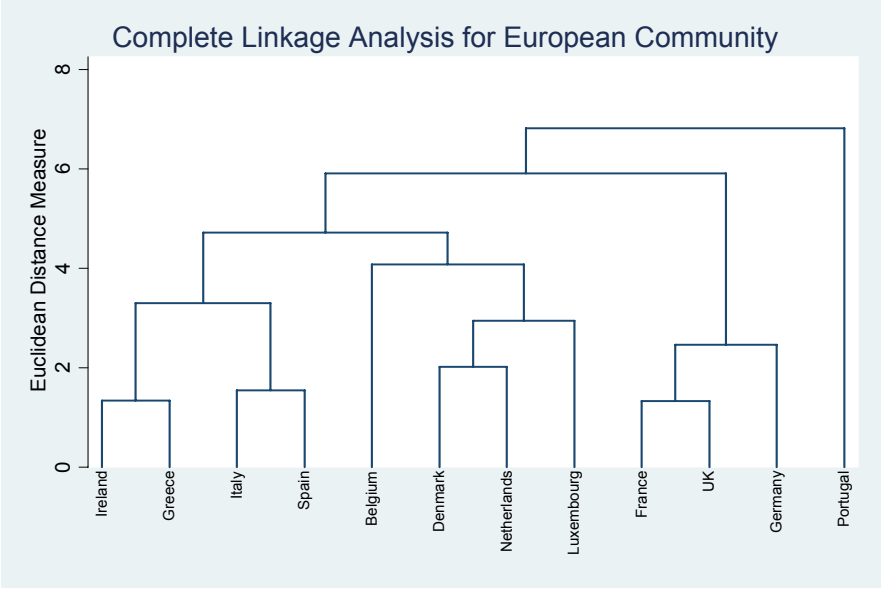
countries into the fourth group. Given the single-linkage results being also quite dissimilar to the other linkages in terms of the pseudo-F and Duda-Hart indices (Table 5), I decide to disregard the results suggested by the single-linkage procedure.

6. A EUROPEAN CASE STUDY

The process of European integration that has started with the conclusion of the Treaty of Rome in 1957, resulting in the formation of European Union as we know it today is a natural experiment that happen rather rarely in the economics field. Using very similar data for the twelve Western European countries that constituted the European Community (the immediate predecessor of the European Union) prior to the collapse of the Soviet Union in 1991, I conduct the same type of analysis to see how different (or similar) the integration path based on the concept of economic similarity is to the one actually realized in Europe.

The variables for this case study are taken from the World Development Indicators database by the World Bank (2012) and are identical to the ones used for the analysis in Section V, except for the human development index that came into being in 1990 and so could not be used for the post-war period. I found it best to use life expectancy as a proxy for the human development in the region. I look at the period between 1957 when the customs union was formed between the Benelux countries and France, Italy, and Germany, and 1986 when Portugal and Spain joined the European Community. The in between stages were the accession of Denmark, Ireland, and UK in 1973, and Greece joining in 1981.

Due to the missing data problems I used data for the period between 1970 and 1980. The variable code names and summary statistics are available from the author immediately upon request. Figure 4 below presents the "unification dendrogram" similar to the one discussed in the previous section.



Source: Author's calculations

Figure 4. Clustering Dendrogram for the European Community, 1957-1986

The accession sequence suggested by the clustering dendrogram above exhibits both similarities and differences with the actually realized sequence of accession. Thus, Portugal in the above diagram joins the last, and so do Greece and Spain, which is what happened in reality. However, the latter two countries are suggested to have formed a union first with Ireland and Italy, which never actually happened. Further, Denmark, Ireland and UK all joined the European Community at the same time in 1973, and this is what the dendrogram above suggests (except for the exact year, of course), but before that at the initial stages the UK should have had to couple up with France and German.

The process of Western European unification from the point of view of the clustering approach suggested in this paper should have proceeded in a more uniform manner, starting with relatively small blocks of similar countries that gradually agglomerate in the twelve-member European Community by 1986. France, UK and Germany being the locomotives of the post-war economic growth in Western Europe should have formed one group (the "pivotal" block), while the poorer Southern European countries of Spain, Greece and Italy should have formed a "southern block" that would have to join the "pivotal" block later. (Ireland being a similarly less developed country at that time would have to join this block, too.) At the same time the "southern" and the "pivotal" blocks should have been joined by another group consisting of small Northern European countries such as Belgium, Netherlands, Luxembourg, and Denmark. Finally, Portugal should have joined the community of eleven countries last of all.

Contrary to the balanced path suggested by the cluster analysis offered in this study, the Treaty of Rome concluded in 1957 created a customs union that consisted of the six countries that should have grouped up with the other peers prior to 1957 based on the idea of economic similarity. It is interesting to notice that the group of countries that have recently

experienced severe problems with their financial sectors, namely, Portugal, Italy, Greece, and Spain are all belonging to the two groups (Portugal actually being a special one-member group in itself) that the cluster analysis suggests should have joined the European Community at the latest, which they actually did.

7. DISCUSSION AND POLICY IMPLICATIONS

The empirical work presented in Section V suggests a way to group twelve East Asian countries into several clusters according to the extent of their similarity with each other, which is the basic idea of cluster analysis. Several clustering procedures have resulted in very similar groupings in case the single-linkage results are disregarded. Dividing the twelve countries into four clusters appears to be optimal on the basis of formal indicators that suggest the maximum extent of dissimilarity between clusters while ensuring a high extent of similarity between countries within each cluster. It is interesting to note that the clustering solution did not result in the groups of geographically close countries. Thus, Mongolia is in the same cluster with Cambodia, but both have China in between which is a cluster in itself, and the two are far away from Papua New Guinea that is geographically close to Indonesia that belongs to another cluster yet. It would not be correct to say, however, that geography did not get reflected in the clustering solution obtained in this study. Indonesia, Malaysia, the Philippines, Thailand and Vietnam are all relatively close geographically, and they do form a separate cluster. Of course, I am alluding to the clustering solution that appears to be most robust across the variety of clustering algorithms presented in this study, namely, the K-means algorithm based on the Euclidean measure with the number of clusters equal to four.

The cluster solutions from the five hierarchical algorithms discussed in the previous section do not only suggest country groupings at various levels of aggregation, but they can be interpreted as a sequential roadmap for the development of regional economic cooperation in East Asia. Figure 3, for instance, suggests that the Philippines should link up with Malaysia before considering an economic cooperation agreement with Thailand or Vietnam. In the same way, Laos is advised to stick to Cambodia before considering close economic ties with Mongolia or China. In fact, a dendrogram such as the one depicted by Figure 3, suggests the type of regional or free trade agreement a country should seek if it decides to give preference to associating with the countries similar to herself.

Political issues may interfere with the practical implementation of the economic cooperation strategies suggested in this study. Korea, for instance, is consistently placed in the same cluster with Taiwan with no other members in the same cluster in case of a four-cluster solution. However, Taiwan is considered part of China which implies certain political inconvenience associated with treating it as an independent country.

The fact that China is always placed into a separate single-member cluster by all of the employed clustering procedures is, of course, reflecting both the size of its population and economy. However, it would not be correct to ascribe its separateness exclusively to these two factors alone since the clustering analysis was conducted on the basis of nine economic variables. Given China's historical influence in the region, especially in case of the countries geographically adjacent to her (e.g. Korea), it might be hard to believe that it is economically desirable to establish close ties with smaller and less significant economies first before engaging in a full-fledged economic cooperation with China, which is the largest economy in the region that keeps on gaining increased importance, also in the global way. However, if

one believes that it is more natural for the similar countries to form close trade and economic cooperation ties first, China should be the last country to join any economic agreement in the region. The same is true for the other two most developed economies in East Asia (excluding Japan), namely, Korea and Taiwan.

The results of this study are useful in case one believes that similar countries should agglomerate into free or regional trade agreements prior to seeking economic association with their more different counterparts. Since economic similarity can be defined in a variety of ways depending on one's view of what similarity is, this type of analysis is rather flexible, also because it does not impose any constraints on the number of dimensions along which economic similarity should be defined, or on the scope of the countries covered by the analysis.

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