

## **Similarity of Economic Structure among Asean+3 Economies: A Multivariate analysis based on Maastricht Treaty Criterion**

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### **Abstract**

The success story of the EU in establishing a single market in 1999 have motivated ASEAN region to further integrate their economy towards ASEAN Economic Community (AEC) 2020. Theoretically, economic integration can succeed, when there is homogeneity among the member countries. The purpose of this paper is to classify the economy of ASEAN+3 countries based on Maastricht Treaty Criterion using k-means clustering analysis. Then, multivariate statistical analysis using biplot and procrustes will be applied for observing the characteristic differences between two periods, i.e. before the Asian economic crisis (1996-2001) and after the crisis (2002-2006).

The results show that there are still some clusters among ASEAN+3 countries. The advanced countries tend to gather in one cluster, while the developing countries gather in another cluster. Furthermore, the results also suggest that the configurations tend to be stable over time, i.e. in the crisis period and in the period after the crisis. The advanced countries do not have any great movements and therefore they are more stable in compare to the developing countries in the region. As a result, the integration process among ASEAN+3 countries should be handled carefully. Otherwise, the integration will not function well and the benefits of the integration will mainly goes to the more developed countries as warned by Yamazawa.

**Keywords:** ASEAN+3, economic integration, clustering, biplot, procrustes

**JEL Classification Codes:** C14, F15, F31, F36

## **1. Introduction**

Entering the 21<sup>st</sup> century, many regions tend to integrate their economy, such as the European Union (EU), North American Free Trade Area (NAFTA), Association of South East Asian Nation (ASEAN), West African Union, and Latin America. The impact of this regionalization process has created the economy poles, where the NAFTA and EU become the focus in the world nowadays.

The phenomenal process was the establishment of EU, which integrated European economy toward single market, with the single currency EURO. The single market involves the free movement of goods and services, capital as well as labor within the EU, and the customs union involves the application of a common external tariff on all goods entering the market. The integration has boosted the economy of EU countries more and more efficient so that they EU can better compete in the global market.

In order for the monetary union to be successful, its members needed to be part of an optimal currency area, and that stability among members was extremely important. In order to meet these requirements, the Maastricht Treaty set out convergence and stability criteria before a country could become a member of the EU. The Maastricht criteria are simply rules for price and fiscal stability. The criteria were as follows:

- an inflation rate no more than 1.5 percentage points above the average of the three countries with the lowest inflation rates
- nominal long-term interest rates not exceeding by more than 2 percentage points those for the three countries with the lowest inflation rates
- no exchange rate realignment for at least two years
- a government budget deficit not in excess of 3 percent of each country's GDP
- a gross debt to GDP ratio that does not exceed 60 percent

Beside EU, regional economic cooperation is also established in East Asia region, where is dynamically center of the economic growth in the world. Before economic crisis, ASEAN was the most rapid growth in the world with their economic growth more than 7 percent. Following the economic crisis in 1997, however, the economy slowed down and the economic growth 1998 was the worst in the last three decades.

The history of East Asian Economic integration itself was begun on 8 August 1967, when the Association of Southeast Asian Nations or ASEAN was established in Bangkok, with the aims and purposes to:

- 1) accelerate the economic growth, social progress and cultural development in the region through joint endeavors in the spirit of equality and partnership in order to strengthen the foundation for a prosperous and peaceful community of Southeast Asian nations, and
- 2) promote regional peace and stability through abiding respect for justice and the rule of law in the relationship among countries in the region and adherence to the principles of the United Nations Charter.

The Framework Agreement on Enhancing Economic Cooperation was adopted at the Fourth ASEAN Summit in Singapore in 1992, which included the launching of a scheme toward an ASEAN Free Trade Area or AFTA. The strategic objective of AFTA is to increase the ASEAN region's competitive advantage as a single production unit. The elimination of tariff and non-tariff barriers among the member countries is expected to promote greater economic efficiency, productivity, and competitiveness. The Fifth ASEAN Summit held in Bangkok in 1995 adopted the Agenda for Greater Economic Integration, which included the acceleration of the timetable for the realization of AFTA from the original 15-year timeframe to 10 years.

ASEAN cooperation has resulted in greater regional integration. Within three years from the launching of AFTA, exports among ASEAN countries grew from US\$43.26 billion in 1993 to almost US\$80 billion in 1996, an average yearly growth rate of 28.3 percent. In the process, the share of intraregional trade from ASEAN's total trade rose from 20 percent to almost 25 percent. Tourists from ASEAN countries themselves have been representing an increasingly important share of tourism in the

region. In 1996, of the 28.6 million tourist arrivals in ASEAN, 11.2 million or almost 40 percent came from within ASEAN itself.

The success story of the EU in establishing a single market in 1999 have motivated ASEAN region to further integrate their economy. At its Ninth Summit in Bali October 2003, the ASEAN announced its intention to create a so-called ASEAN Economic Community (AEC) as the realization and end-goal of economic integration as outlined in the ASEAN Vision 2020. It rearticulates its aims to create a stable, prosperous and highly competitive ASEAN economic region in which there is a free flow of goods, services, investment and a freer flow of capital, equitable economic development and reduced poverty and socio-economic disparities. The AEC plans to establish ASEAN as single market and production base, turning the diversity that characterizes the region into opportunities for business complementation making the ASEAN a more dynamic and stronger segment of the global supply chain.

Furthermore, Mr. Osamu Watanabe (the Director of JETRO Japan) said that the single market should include not only ASEAN countries, but ASEAN+3 (Japan, South Korea and China). So, it would give markedly greater impact, since it will result in a huge market with population more than 3 billion people. Currently, ASEAN has even already closer cooperation with the three countries, i.e. ASEAN-China Free Trade Area, Comprehensive Economic Partnership between ASEAN-Japan, and Korea.

Theoretically, economic integration can succeed, when there is homogeneity among the member countries. Therefore, it is interesting to classify the ASEAN+3 countries based on their economic condition with several scientific approaches. It will support in deciding the monetary policy of the single market establishment in the South Asian and East Asian regions.

The main purpose of this paper is to classify the economy of ASEAN+3 countries based on Maastricht Treaty Criterion using k-means clustering analysis. Then, biplot and procrustes analysis will be applied for observing the characteristic differences between two periods, before the Asian economic crisis, i.e., 1996-2001 and after the crisis, i.e., 2002-2006.

The rest of the paper will be organized as follows: Section 2 will explain the data and research methodology, followed by a discussion on section 3. Summary of the results and the policy implications will be provided in section 4.

## **2. Data and Methodology**

We used the macroeconomic data covering the period 1996–2006, from ten ASEAN countries (i.e. Indonesia, Malaysia, Singapore, Thailand, the Philippines, Brunei Darussalam, Vietnam, Myanmar, Cambodia, and Lao’s Peoples Democratic Republic) plus three other East Asian countries of Japan, China and South Korea.

The data are collected from ASEAN Statistical Yearbook 2007, Indonesia Capital Market Supervisory Agency, Ministry of Finance, Republic of Indonesia, *World Economic Outlook Database* April 2008, and *United Nation Statistics Division* ([www.unstats.un.org](http://www.unstats.un.org)). The data are summarized as follows.

**Table 1:** Macroeconomic Variables Based on Maastricht Criterion

<b>Variable</b>	<b>Explanation</b>
$x_1$	Inflation rate
$x_2$	Volatility of exchange rate
$x_3$	Long-term interest rate
$x_4$	Budget deficit/GDP ratio
$x_5$	Debt/GDP ratio

### The $k$ -means Clustering Analysis

Cluster analysis is the assignment of a set of observations into subsets (called clusters) so that observations in the same cluster are similar in some sense. An important step in most clustering is to select a distance measure, which will determine how the similarity of two elements is calculated. This will influence the shape of the clusters, as some elements may be close to one another according to one distance and farther away according to another. The Euclidean distance is the more regular measure, expressed as:

$$d_{ij} = \left[ \sum_{k=1}^p (x_{ik} - x_{jk})^2 \right]^{\frac{1}{2}},$$

where  $d_{ij}$  is distance between object  $i$  and  $j$ ,  $x_{ik}$  is value of object  $i$  at the  $k$ th variable,  $x_{jk}$  is value of object  $j$  at the  $k$ th variable, and  $p$  is number of variables.

According to Jolliffe (2002), if there is measuring unit difference of the data, we have to transform the measuring unit into the standard form. That transformation is useful to lose the variance among the data. When there is correlation among the data, then transform the data by using the principal component analysis. However, the Euclidian distance between two objects with or without transformation will be same when we take all the principal components (Hartigan in Wibowo, 2004). In this paper, we didn't transform the variables by using the principal component analysis.

The  $k$ -means clustering is a method of cluster analysis, which aims to partition  $n$  observations into  $k$  clusters in which each observation belongs to the cluster with the nearest mean. This type of clustering was first used by James MacQueen in 1967 (Anderberg, 1973). This method is very simple and adopts the algorithm which uses *squared-error criteria*. The main problem of the algorithm is choosing the appropriate initial means. This method is also very sensitive to the outlier (Kantardzic, 2002). The algorithm of the  $k$ -means clustering is formally described as follows (Anderberg, 1973):

1. Choose  $k$  initial means, where  $k$  is the number of clusters desired.
2. Each point is then assigned to the closest mean, and each collection of points assigned to a mean is a cluster. The mean of each cluster is then updated based on the points assigned to the cluster by using centroid method. It aims to minimize the distance among the means. The squared distance between centroid A and B is:

$$d_{AB}^2 = (\bar{X}_A - \bar{X}_B)'(\bar{X}_A - \bar{X}_B),$$

where  $\bar{X}_A$  and  $\bar{X}_B$  are the centroids of A and B, respectively.

3. We repeat the assignment and update steps until no point changes clusters, or equivalently, until the centroid remain the same

### Biplot Analysis

Biplot is one of descriptive statistics which useful to present  $n$  samples toward  $p$  variables in two-dimension so that characteristics and relative position between variables and samples can be analyzed (Jolliffe, 2002). A biplot allows information on both samples and variables of a data to be displayed graphically. Samples are displayed as points while variables are displayed either as vectors, linear axes or nonlinear trajectories. Two variables with high correlation are described as two vectors with acute angle ( $< 90^\circ$ ). Moreover, the variables having high variance are described as long vectors, otherwise the variables with low variance are displayed as short vectors. When two samples are adjacent, then they have the same characteristics. Biplot, which gives 70 percent of the information, is considered to represent the population (Sartono, 2003). Variance  $\rho^2$  of biplot is defined as:

$$\rho^2 = \frac{\lambda_1 + \lambda_2}{\sum_{i=1}^p \lambda_i},$$

where  $\lambda_i$  is the biggest  $i$ th characteristic root of matrix  $X^T X$ . If  $\rho^2$  is closer to one, then biplot gives better information of the actual data.

### Procrustes Analysis

Procrustes analysis aims to compare two points configuration, which represent the same  $n$  samples (Digby, 1987). One of configuration is unchanged, whereas another configuration is transformed in such a way that the shape and size are closer to the first configuration.

According to Digby (1987), there are three types transformation of procrustes analysis: translation, rotation, and dilatation. Translation is moving every point a constant distance in a specified direction. It can be defined as

$$X_T = XT, \quad [4]$$

where  $T$  is a translation matrix,  $X$  is a data matrix (configuration), and  $X_T$  is matrix obtained from translation. Rotation is a transformation that describes the motion around a fixed point. In the procrustes method, it is defined as

$$X_R = X\Gamma, \quad [5]$$

where  $\Gamma$  is rotation matrix and  $X_R$  is a matrix obtained from rotation. Dilatation is applied when two configuration have different scales. Three types of transformation above are operated by minimizing sum-squared distance between the points in one configuration and the other points in fixed configuration (Digby, 1987).

Assume there are two points configuration in dimension space  $r$ , i.e., data groups  $P$  and  $Q$  which written in forms of matrix. Suppose that matrix  $P$  is unchanged, while matrix  $Q$  is transformed to a new matrix, called  $Z$ .

$$Z = \beta Q\Gamma + I_r \tau', \quad [6]$$

where  $I_r$  is a identity matrix with  $r$  dimension. Sum-squared distance  $m^2$  of the transformed points is defined as

$$m_{PQ}^2 = \text{tr}(P - z)^T (P - Z), \quad [7]$$

where  $\text{tr}$  is a trace matrix operator. The value of  $m^2$  can be minimized by centralizing the matrix  $P$  and  $Q$  in the origin point. The translation matrix is assessed through the equation

$$(P - \hat{P}) - \beta(Q - \hat{Q})\Gamma = I_r \tau', \quad [8]$$

where  $\hat{P}$  and  $\hat{Q}$  are centralized data matrix of  $P$  and  $Q$ , respectively.

Suppose the *singular value decomposition* (SVD) of  $P'Q$  is defined as

$$P'Q = ULA', \quad [9]$$

Because the matrix  $A$  and  $U$  are the orthogonal matrix, then matrix  $\Gamma := AU'$  is also orthogonal and can be used as rotation matrix. Whereas, the parameter of  $\beta$  is supposed

$$\beta = \frac{\text{tr}(P'Q\Gamma)}{\text{tr}(Q'Q)}. \quad [10]$$

The value of  $R^2$  can be used in measuring the similarity of shape between two configurations. This value indicates the percentage of the same configuration and can be defined as

$$R^2 = 1 - \frac{\text{JKG}}{\text{JKT}}, \quad [11]$$

where  $\text{JKT} = \text{tr}(P'P)$  and  $\text{JKG} = \text{tr}(P - Z)'(P - Z)$ . If  $R^2 = 100$  percent, then that two configurations have the same shape and size.

### 3. Empirical Results

The results concerning the ASEAN+3 clustering using the various methods will be explained clearly in this part.

#### Clustering using the *k*-means Analysis

The clustering of ASEAN+3 countries is carried out by using non-hierarchical *k*-means method. In this study, we apply 3-means and 4-means clustering. First, we analyze the correlation among the variables before and after crisis, which briefly described in Table 2.

**Table 2:** Correlation among the Variables

Variables	Before Crisis				After Crisis			
	$x_1$	$x_2$	$x_3$	$x_4$	$x_1$	$x_2$	$x_3$	$x_4$
$x_2$	0.485				0.398			
$x_3$	<b>0.705**</b>	<b>0.592*</b>			<b>0.560*</b>	0.029		
$x_4$	-0.495	-0.296	<b>-0.573*</b>		-0.358	-0.309	-0.488	
$x_5$	0.010	0.427	0.318	-0.190	0.014	0.090	0.021	-0.263

**Note:** \* = significantly different at  $\alpha$  5 percent, \*\* = significantly different at  $\alpha$  1 percent.

The table above gives us information that variable  $x_4$  (budget deficit/GDP ratio) has a negative correlation with other variables before and after crisis. Moreover, there is positive correlation between  $x_1$  (inflation rate) and  $x_3$  (long-term interest rate). It can be occurred because economically inflation is very affecting the interest rate. Besides that, there are positive correlation between  $x_2$  (volatility of exchange rate) and  $x_3$ , also between  $x_3$  and  $x_4$ . After crisis, variable  $x_1$  is positively correlated with  $x_3$  at  $\alpha$  5 percent.

As we stated previously, correlation problem among the variables can be solved by using principal component analysis. But, we didn't use this transformation because the Euclidian distance will be same when we use all the principal components. The study is not also to reduce the variables and their correlation (see Table 2), so that the orthogonality of the variables can be fulfilled.

The result of 3-means clustering during and after crisis is presented in Table 3. In the crisis period, members of cluster I are Brunei Darussalam and Singapore. But, after crisis, Singapore move to another cluster, together with Malaysia, Thailand, China, South Korea, and Japan. It is also occurred in Laos, where it has own cluster in crisis, but after crisis, joins another cluster together with Cambodia, Indonesia, Myanmar, Philippines, and Vietnam.

Based on Table 3, it can also be seen that cluster II has the greatest members, but after crisis, the members are decreased. Moreover, after the crisis period, the advanced countries, i.e., China, South Korea, Japan, Singapore, and Thailand merge into one cluster, whereas the developing countries, i.e., Indonesia, Philippines, Vietnam, Myanmar, and Cambodia merge into another cluster.

**Table 3:** The 3-means Clustering

Clusters	In the Crisis Period	After the Crisis Period
I	Brunei Darussalam, Singapore	Brunei Darussalam
II	Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Thailand, Vietnam, China, South Korea, Japan	Cambodia, Indonesia, Laos, Myanmar, Philippines, Vietnam
III	Laos	Malaysia, Singapore, Thailand, China, South Korea, Japan

The countries, which have no movement to other clusters in the crisis period and after the crisis period, are Cambodia, Indonesia, Myanmar, Philippines, Vietnam, and Brunei Darussalam.

Furthermore, the result of 4-means clustering is described in Table 4. In the crisis period, cluster II has the greatest number of members, whereas cluster I, III, and IV only have one member, i.e., Brunei Darussalam, Indonesia, and Laos respectively. This result is not different far from the 3-means case. However, in the 4-means clustering, Indonesia forms its own cluster. After the crisis period, the advanced and developing countries merge into their own cluster. Besides that, Brunei Darussalam always forms its own cluster in the two periods. It can be understood because Brunei Darussalam is a small and rich country.

The position of Brunei Darussalam is relatively special. It may be comparable with Luxemburg in the European Union. Sometimes Brunei Darussalam is in the same cluster with Singapore. But, sometimes Brunei Darussalam forms an individual cluster. It depends on the type of clustering methodology and the number of clusters desired.

**Table 4:** The 4-means Clustering

Clusters	In the Crisis Period	After the Crisis Period
I	Brunei Darussalam	Brunei Darussalam
II	Cambodia, Malaysia, Myanmar, Philippines, Thailand, Vietnam, Singapore, China, South Korea, Japan	Cambodia, Indonesia, Laos, Philippines, Vietnam, Thailand
III	Indonesia	Malaysia, Singapore, China, South Korea, Japan
IV	Laos	Myanmar

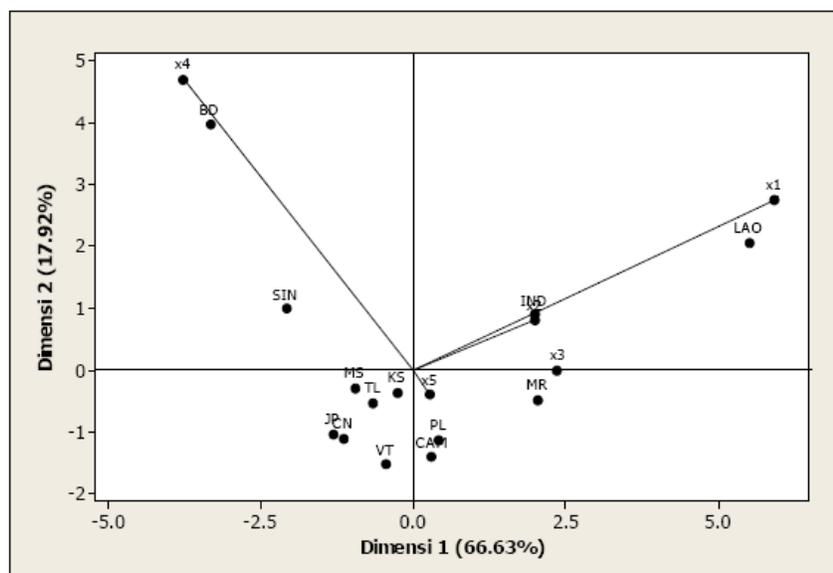
As a summary based on Table 3 and Table 4, we find that the relatively consistent clusters in the crisis period and after the crisis period, as follows:

- Cluster I : Malaysia, Thailand, Singapore, Japan, South Korea, China
- Cluster II : Indonesia, Philippines, Cambodia, Vietnam
- Cluster III : Laos, Myanmar
- Cluster IV : Brunei Darussalam.

**Biplot Analysis**

Result of biplot analysis during the crisis period is presented in Figure 1. That figure describes that variance of the biplot is 84.55 percent. It indicates that biplot interpretation concerning data in the crisis period is good enough, because the variance is greater than 70 percent.

**Figure 1:** Biplot in the Crisis Period

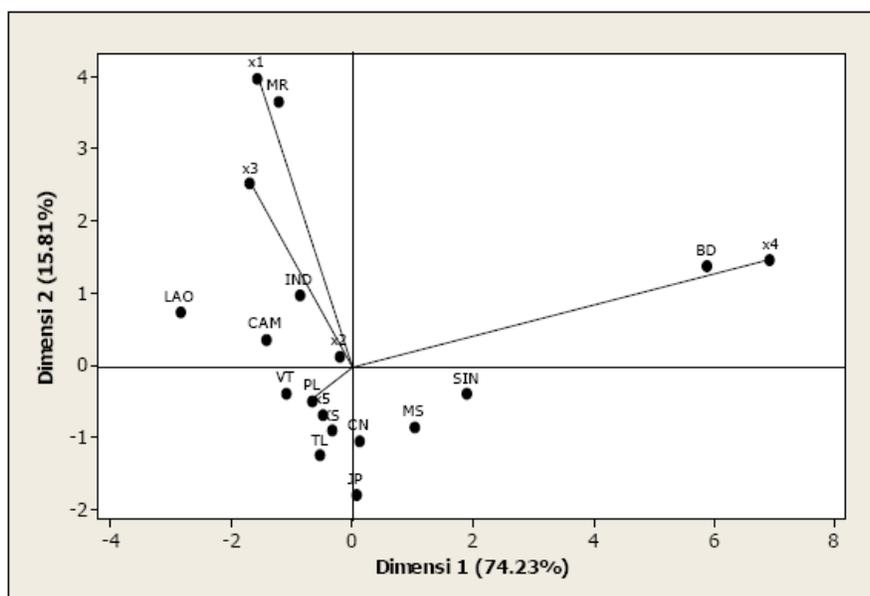


The biplot analysis shows the similarity of the countries and the relative position of the variables in each country. Brunei Darussalam has a great value in variable  $x_4$  because their positions have same direction. Furthermore, Laos and Indonesia also have the great values in variables  $x_1$  and  $x_2$ . Otherwise, Japan has a small value in variable  $x_1$  because their positions have the opposite direction. Myanmar, Cambodia, and Philippines also have the opposite direction with variable  $x_4$ . In this period, many countries take place in around the centroid. As can be seen, Cambodia is closed to Philippines; it means that countries have a similar characteristic in debt/GDP ratio (variable  $x_5$ ). Japan, China, Malaysia, Thailand, and South Korea also get on together. The biplot result is good enough and representative, because those countries are economically included in the advanced countries.

In the biplot analysis, the angular shape of two variables describes the correlation between them. The high positive correlation is occurred in variable  $x_1$  and  $x_3$ , represented as acute angle and in the same direction. However, between variable  $x_4$  and  $x_1, x_2, x_3, x_5$  indicate the negative correlation, because the angle is obtuse and in the opposite direction. Furthermore, the length of variables describes their variance. As can be seen that variables  $x_4$  and  $x_1$  have a big variance. It implies that inflation rate and budget deficit per GDP ratio of the ASEAN+3 countries are very different. Variable  $x_5$  has the smallest variance, so the debt per GDP ratio of the ASEAN+3 countries are very similar.

The result of biplot analysis after crisis period can be seen in Figure 2. It shows that the variance is 90.04 percent, that means it can explain about 90 percent of the data variability and therefore it can be good interpreted.

Figure 2: Biplot after the Crisis Period



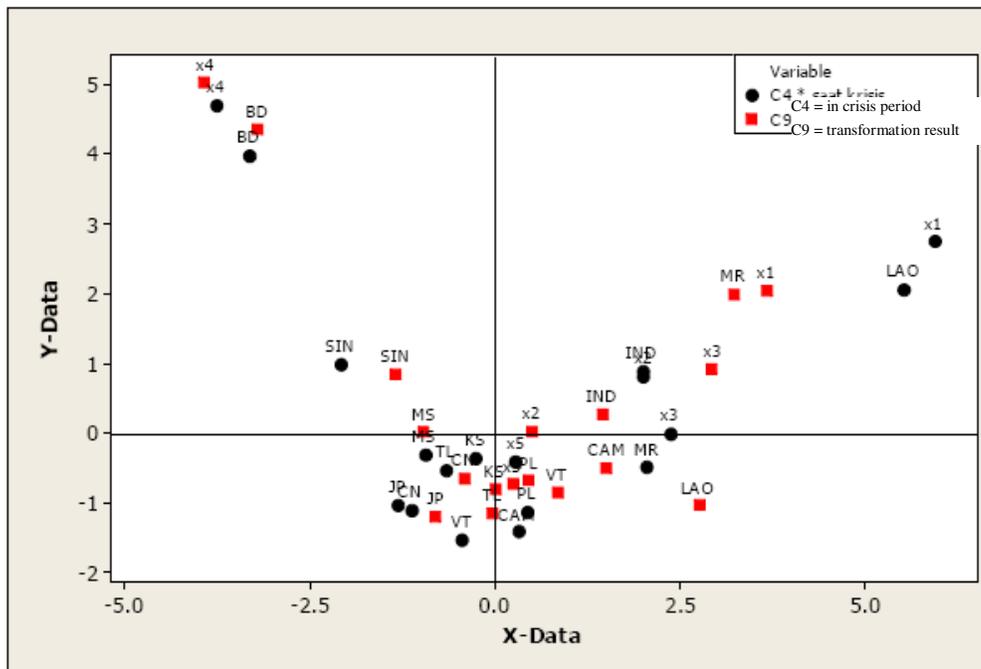
During this period, Brunei Darussalam still has a great value for variable  $x_4$  and far away from other countries. It implies that crisis did not affect the Brunei's economic. Moreover, Myanmar has a great value for variable  $x_1$ ; it is very different from the previous period. The advanced countries, i.e., Malaysia, China, Japan, South Korea, Thailand, and Singapore are much closer than crisis period. Even now, Laos is neighbor with Indonesia and Cambodia.

The correlation among the variables is similar with those of the crisis period. Variable  $x_4$  negatively correlated with variables  $x_1, x_2, x_3,$  and  $x_5$ , whereas positive correlation is shown between variables  $x_1$  and  $x_3$ . It is economically valid; if inflation rate is high, then interest rate must be increase in order to keep the exchange rate stable. So far, biplot analysis and  $k$ -means clustering method show the similar result after the crisis period.

### Procrustes Analysis

Procrustes analysis is employed to find the similarity of the shape and size of two configurations. Data during the crisis period (matrix  $P$ ) is considered as the objective matrix, while data after crisis period (matrix  $Q$ ) is transformed.

**Figure 3:** Result of Procrustes Analysis



Based on the result, the values of JKG and JKT are 43.017 and 178.770, respectively. Thus, we have  $R^2 = 75.94$  percent. It means that two configurations have 75.94 percent of similarity, or 24.06 percent of difference. It can be occurred when the best part of objects does not move far. In the other words, the influence of economic crisis are not linear or not equal among the variables.

The difference between two periods only 24.06 percent, indicates that there are some movements among the objects. As can be seen in Figure 3 that there is a few movement of the points, both the objects and variables. However, there are also movements in Laos, Myanmar, Vietnam, Indonesia and Cambodia. It indicates that the crisis brings structural movements in some countries, but it brings only minor movements in other countries.

### 4. Summary and Policy Implications

This paper aims to classify ASEAN+3 countries based on Maastricht Treaty Criterion. The results show that k-means clustering and biplot analysis gave generally the similar result. Until now, economically there were still some clusters among ASEAN+3 countries.

The advanced countries tend to gather in one cluster, while the developing countries gather in another cluster. However, Brunei Darussalam tends to form an individual cluster because it is a small and rich country. The position of Brunei is similar with Luxemburg in the European Union. Some countries show the cluster movement in the crisis period and after the crisis period. It indicates that crisis affects the economy of the ASEAN+3 countries, especially the developing countries. The result is consistent with the previous findings by Achسانی and Siregar (2010) and Achسانی and Partisiwi (2010).