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# Economic Indicator Evaluation Based on Shape Deformation Analysis of Indonesian Provinces Statistics

Catur Apriono[1)], Riri Fitri Sari[1)], Yuriko Yano[2)], and Yukari Shirota[2)]

**ABSTRACT**

This paper presents our work on analyzing provincial economic differences in Indonesia based on economic indicators. The data were obtained from the official website of Indonesian Central Bureau of Statistics (Badan Pusat Statistik Indonesia) that is responsible for conducting national statistical survey, and is a non-departmental government institute which directly report to the president. In this paper, we studied the provinces Gross Domestic Product (GDP) percentage, the average monthly expenditure per capita for food, the electricity distribution per province, and the distribution of cleaned water. We conduct the statistical analysis to data of 33 provinces in a time series from the year 2007 to 2015. We performed the deformation analysis to indicate the local economics movement/changes. The analysis of GDP percentage in 2000 to 2013 shows that the economic distribution tends to be from Java Island to other provinces. This analysis indicates the emerging regional economy which is happening in provinces located outside the Java Island. Our shape analysis of the deformation data of the average monthly food expenditure and GDP percentage shows that the higher expenditure group of provinces tends to move down and the lower expenditure group of provinces tends to move up. Therefore, the trend is that the food expenditure and GDP becomes closer to the average value in all provinces in Indonesia. For electricity distribution per province and the GDP percentage, the deformation analysis shows that there are almost no significant changes in all provinces. From clean water and the GDP percentage, the deformation shows that the Jakarta data tends to move down insignificantly, although almost all other provinces analysis move up. These results indicate that economic emergence happened in various provinces.

## 1. Introduction

In this paper, we analyzed the trend and differences of provincial statistics in Indonesia based on economic indicators by conducting the statistical shape analysis. Republic of Indonesia consists of 34 provinces and located in five main islands of Sumatera, Jawa, Kalimantan, Sulawesi, and Papua as well

1）　Department of Electrical Engineering, Faculty of Engineering, Universitas Indonesia
2）　Department of Management, Faculty of Economics, Gakushuin University

as the islands of Nusa Tenggara and Maluku. Indonesia is located in the maritime continent bordered to the west to the Indian Ocean and to the east to the Pacific ocean (See Figure 1). Indonesian current economic growth is remarkable among Asian countries, and predicted by Price Waterhouse Cooper to be the 5$^{th}$ largest world economy by year 2030 with GDP of $5.424 trillion [5]. Hence, Indonesia is a very important spot from business point of view. However, because there are cultural and geographic diversities, it is difficult for Japanese people to spot the economic differences between provinces in Indonesia. In this paper, we focus on identifying the differences among the provinces and explain the differences in economics indices such as GDP and electricity distribution by provinces.

Recently a new morphometric statistical analysis using clustering approach has been emerged as a popular analysis tool. This method was developed by the University of Leeds in 1998 and is called statistical shape analysis or commonly known as geometric statistics [1, 2]. Using this statistical analysis we can measure the change in the shape of an object or so-called deformation. The problem on transforming data sets in different size, orientation and shape of an object into a coordinate system is a complex task, using a coordinate system called register mark or landmark. By this analysis, we can quantify the shape of an object by eliminating information of location, rotation, and scale [3]. We have analyzed economic data using the method [4]. In this work, given two economic indexes, we made a two dimensional shape. A shape consists of 33 provinces data which is called a landmark. The economics data is time series data. For a time series data analysis, we select two time points such as from year 2007 and 2015 so that we can define a deformation of the shape from the start time to the shape at the end time. The deformation analysis can tell us the local movement/change.

The data we used is from Statistics Indonesia (https://www.bps.go.id/). The original website name is "Badan Pusat Statistik Indonesia" (BPS-Statistics Indonesia), a non-department government agency directly report to the president (See Figure 2). The BPS is instituted by Law Number 16, 1997 on Statistics; Government Regulation Number 51, 1999 on Statistics Undertakings (cited from https://www.bps.go.id/ index.php/masterMenu/view/id/1#masterMenuTab1). Therefore, this website's data is very reliable and suitable for researches.

In Section 2, we will illustrate each province's GDP differences. In Section 3, we will analyze the movements of the average monthly food expenditure and GDP percentages in each province. In Section 4, we will analyze the movements of electricity generated and GDP percentages in each province between 2007 and 2015. In Section 5, we will analyze the movements of cleaned water and GDP percentages in each province between 2007 and 2015. Finally, we will conclude this paper in the last section.


Figure 1: Indonesia provinces map (Source: http://www.emapsworld.com/images/indonesia-provinces-map.gif)

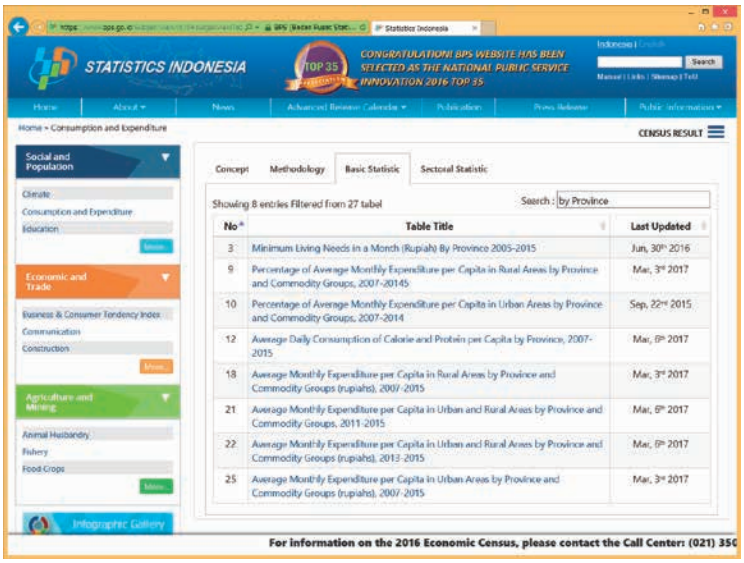


Figure 2: The website of Indonesian Central Bureau of Statistics "Statistics Indonesia" (Source: https://www.bps.go.id/)

## 2. GDP Percentage of Provinces

In Section 2, we will evaluate the GDP percentage of the Indonesian provinces. Figure 3-a shows the GDP percentage distribution in Indonesia in 2015. The highest number of GDP can be found in Daerah

Khusus Ibukota (Special Capital Region) of Jakarta or known as DKI Jakarta which is 17.02%. This area is the most populous city in Indonesia and is located in the northeastern part of the Java Island. Jakarta is the capital of Indonesia as well as the country's business and industry center. Many national and multinational corporations' headquarters are in this city. Jakarta economic activities are supported by Soekarno-Hatta International Airport and Tanjung Priok International Seaport which are the main gates to the city. The two ports are the largest transportation infrastructure facilities in Indonesia.

After DKI Jakarta, the next three largest GDP provinces in the Java Island are as follows: Jawa Timur (East Java), Jawa Barat (West Java), and Jawa Tengah (Central Java) consecutively. The GDP percentages of Jawa Timur, Jawa Barat and Jawa Tengah are 14.5%, 13.09% and 8.7%, respectively. They are mostly supported by industries as well as large/retail trade and agriculture. Surabaya is the capital city of Jawa Timur. As the second largest city in Indonesia, Surabaya has the characteristics of being a center for business and industries in that province. The total percentage of GDP in Java Region, including Yogyakarta and Banten out of the total GDP of Indonesia, is 58.28 %. This indicates that economy in Indonesia is still centralized in Java, although the size of the area is only approximately 6.7% of Indonesia.

The next largest GDP is owned by Riau Province which reaches 5.6%. This province is located around the center of Sumatera Island and close to Malacca Strait, which is also near the border to the neighboring countries of Malaysia and Singapore. The Riau economy is mainly supported by the abundance of natural resources, such as petroleum, natural gas, plantation, and processing industries. Subsequently, located in the same region of Sumatera, Sumatera Utara (North Sumatera) province also shows a high GDP of 4.91 % out of the total national GDP. This province's capital city of Medan is also known as the third largest city in Indonesia after Jakarta and Surabaya. This province's economy is also supported by agricultural industries like palm oil plantations, processing industries and large/retail trade. The total GDP of all provinces in Sumatera region is about 22.2 %, which place Sumatera as the second highest GDP Island after Java.

Kalimantan Timur (East Kalimantan) has the next highest GDP which is 4.31% of national GDP. This province is located in the eastern part of Kalimantan (Borneo) Island. The economy is supported mainly by mining and processing industries, such as oil exploration, natural gas, and coal. Together with other three provinces in Kalimantan, the total GDP in the region is 7.61 % of national GDP. This total percentage indicates that most of the GDP contributing area is Kalimantan Timur.

After Kalimantan Timur, the next largest GDP contributor is Sulawesi Selatan (South Sulawesi) province, which is 2.93%. This province is located in the south of Sulawesi Island. The economy is mainly supported by agriculture, forest, fishery, processing industries and large/retail trade. The capital city of Makassar is also known as the largest city in the eastern part of Indonesia and a hub city that connects cities in the eastern Indonesia region. Together with other provinces in Sulawesi Island, this region contributes 5.9% of the national GDP.

The rest of the areas are Bali-Nusa Tenggara and Maluku-Papua. These areas contribute 2.52% and 2.18% to the total Indonesian GDP, respectively. The Bali-Nusa Tenggara economy is mainly based on tourism and agriculture. The Maluku economy is mainly based on agriculture and marine fisheries. Compared to Maluku area, Papua, which comprises of Papua Barat and Papua Provinces are more

emerging in their economy mainly because of mining industries.

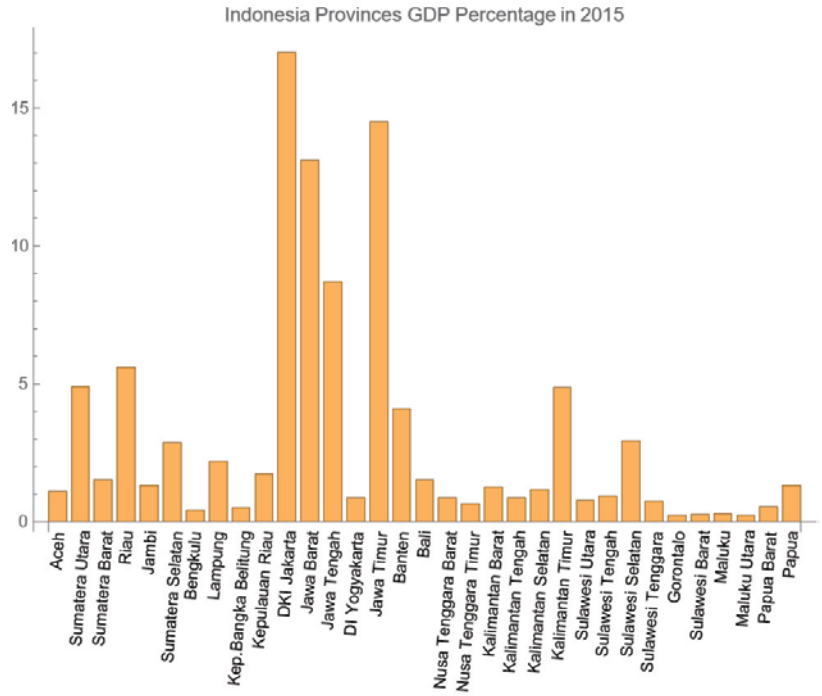


Figure 3-a: Indonesia provinces GDP percentage in 2015 (Source: https://www.bps.go.id/)

Let us then see the time series changes on the GDP percentage data from 2000 to 2013. Figure 3-b shows the changes in proportions almost in all provinces. The connected list line shows the 2013 data. The x-axis shows the province IDs order which is the same as one in Figure 3-a. Currently in Indonesia there are 34 provinces but the data shown in the paper are data in 33 provinces. The 34th province of Kalimantan Utara was formed on 25 October 2012. Before that time, it had been part of Kalimantan Timur. In this paper, we still include the newest province as part of Kalimantan Timur because we consider data from the year 2000 to 2015. In Figure 3-b, other year data are illustrated with dots. In the Java Island, the percentages of GDP tend to decrease in all five provinces. In contrast in Sumatera Island, the percentage tends to increase almost in all provinces. Therefore, these indicate that GDP enhancement in Java Island is slower than Sumatera. The figure indicates that the economy in Sumatera region, especially in Riau, Jambi and Lampung, and Kepulauan Riau are still emerging for the mining production, plantations and other emerging sectors, such as industries and tourism. More GDP contributions is still open in the Sumatera area considering various infrastructures that have been built by the Indonesian government, i.e. Sumatera-toll road that has been planned to connect Bakauheni seaport in the southern most point to Banda Aceh in the northern most point of the Sumatera Island, development and improvement of various airports in Sumatera, such as Kualanamu International airport in Medan, Sumatera Utara and Sultan Syarif Kasim II International Airport in Pekanbaru, Riau. Those

infrastructures are planned to boost the connectivity and productivity. Therefore, Sumatera area still has potentials to enhance its economy and contribute a higher GDP portion in the following years.

The increase of GDP percentage and at the same time the decrease of GDP percentages also occurs in Kalimantan region, especially Kalimantan Timur province, and Sulawesi Island, especially Sulawesi Selatan Province. Sulawesi Selatan national GDP contribution has increased that can be still considered as the most potential emerging economy in central and eastern region of Indonesia.

Provinces in Bali-Nusa Tenggara region tends to contribute a higher GDP percentage constantly. This enhancement is mostly contributed by significant enhancement of tourism industries in this area in the last decade. There are many popular tourist areas for national and international tourists, such as Bali Island, Lombok Island, and Komodo Island.

Maluku and Maluku Utara provinces GDP tend to increase slightly. While, Papua and Papua Barat are still in fluctuations. The latter could be affected by the transportation infrastructure issues. Papua covers a very large area, although the population is the smallest in the country. To enhance productivity and connectivity, the Indonesia Government has been developing Sea-toll and Papua-toll road infrastructure to improve economic equality, especially in the Papua area. The success of the program can be noticed through the improvement of GDP percentage in a couple of years.

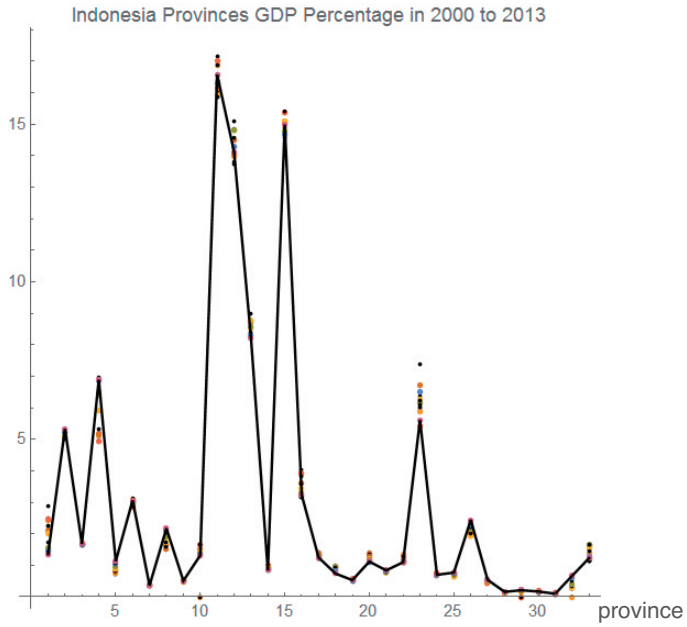


Figure 3-b: Indonesia provinces GDP percentage from 2000 to 2013 (Source: https://www.bps.go.id/)

## 3. Monthly Expenditure for Food of Provinces

In the next Section we will analyze the movements of an average monthly expenditure for food and provinces GDP percentage. First let us explain the latest data of year 2015 of the average monthly expenditure for food per capita by provinces which can be seen in Figure 4. It can be seen that the location with the highest food expenditure food is in Papua. This condition is mostly affected by high prices of consumer products because of the high distribution cost. For example, air transportation is used to distribute food products to remote areas. Expensive transportation system must be used because of the large coverage area and its mountainous topographical nature, as well as lack of land transportation system. Another factor is that there are not many locally produced products. Therefore, the products must be supplied from other places, especially from the Java Island. These factors are also contributed to the high expenditure of Papua Barat that is next to Papua. After the Papua region, Bangka Belitung and Kepulauan Riau are also more expensive than others because these two provinces are located in separate islands with industrial characteristics and limited locally produced consumer products. Therefore, they need a good distribution system to transport the products from other islands, such as Sumatera and Java. On the other hand, provinces with the lowest food expenditure are Jawa Tengah, DI Yogyakarta, Sulawesi Barat, and Nusa Tenggara Barat. These areas are well-known as agriculture centers.

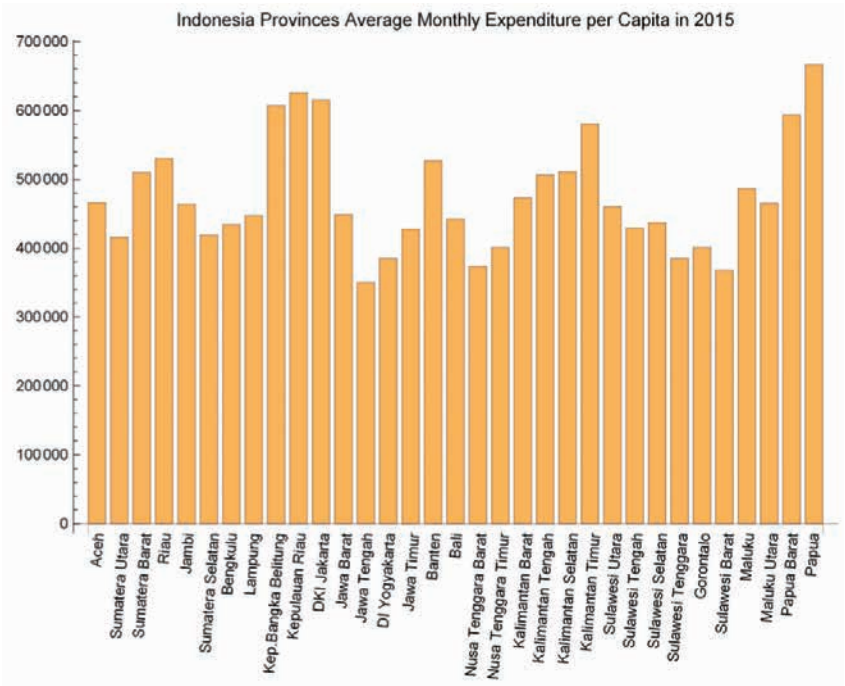


Figure 4: Indonesia provinces average monthly expenditure for food per capita in 2015 (Source: https://www.bps.go.id/)

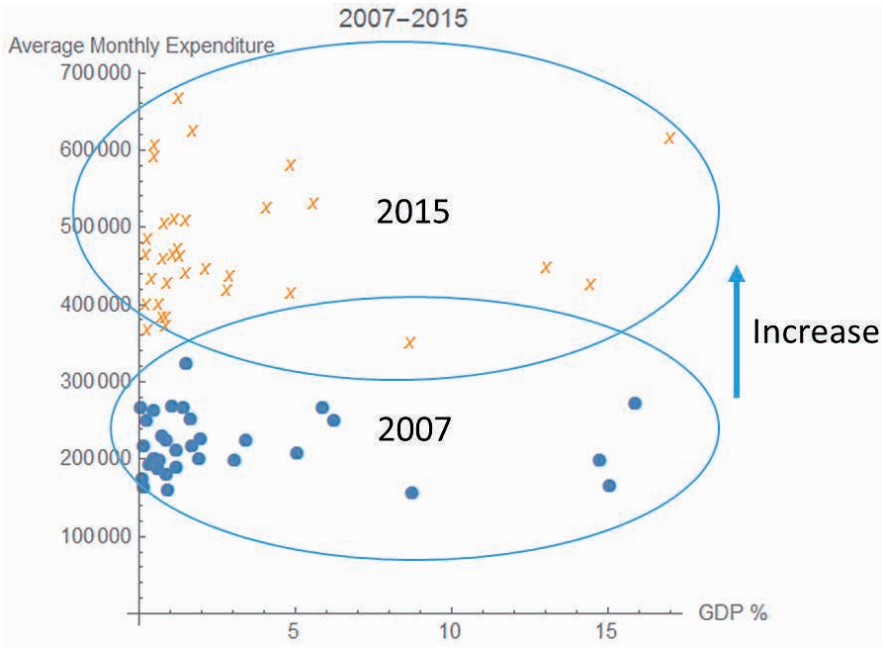


Figure 5: Relationship between GDP percentage and the average monthly expenditure for food per capita

Then let us analyze the relationship between the GDP percentage and the average monthly expenditure. As this is a time series data, we shall analyze the changes from 2007 to 2015 to see what has happened in the last eight years. Figure 5 illustrates the year 2007 to 2015 data. The figure depicted that in every provinces there are some increase in the expenditure for food. In order to underline the relation of condition in each province, we draw arrow lines between the 2007 and 2015 data (See Figure 6). An arrow line corresponds to a province's change. The arrow directs from the point in 2007 to the one in 2015. As the ranking of the GDP percentage does not change so much, the the declining direction of each arrow is almost perpendicular.

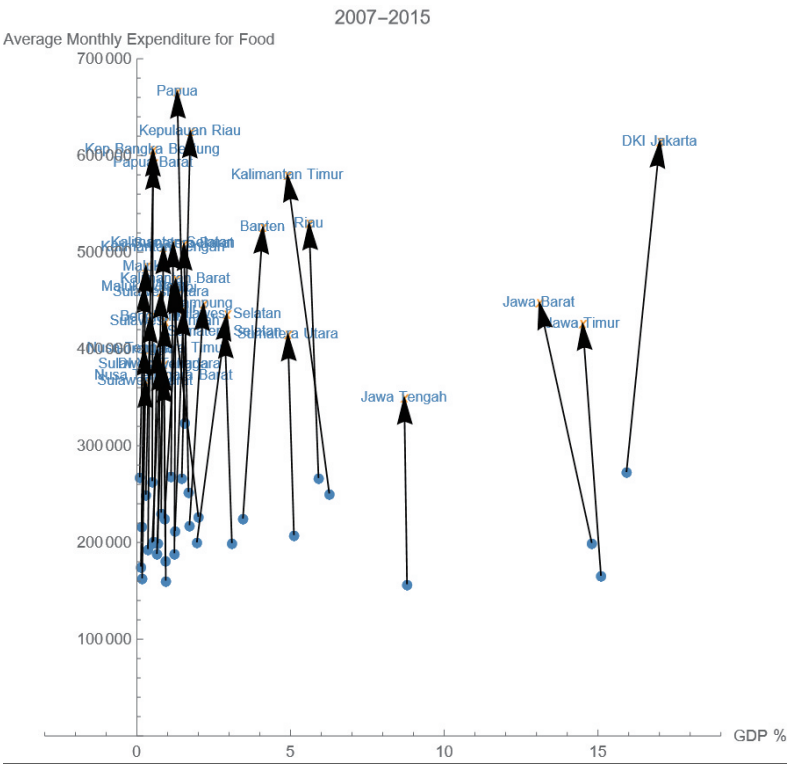


Figure 6: Relationship between GDP percentage and average monthly expenditure between in 2007 and in 2015.

Then by centering and scaling on the two shapes data in Figure 6, which are the 2007 shape to the 2015 shape, we conducted the pre-shaping of the data. The pre-shapes are shown in Figure 7. The axis option "GDP%" and "Average Monthly Expenditure for Food" have no dimention because we did scaling by the centroid distance to find pre-shape coodinate values.

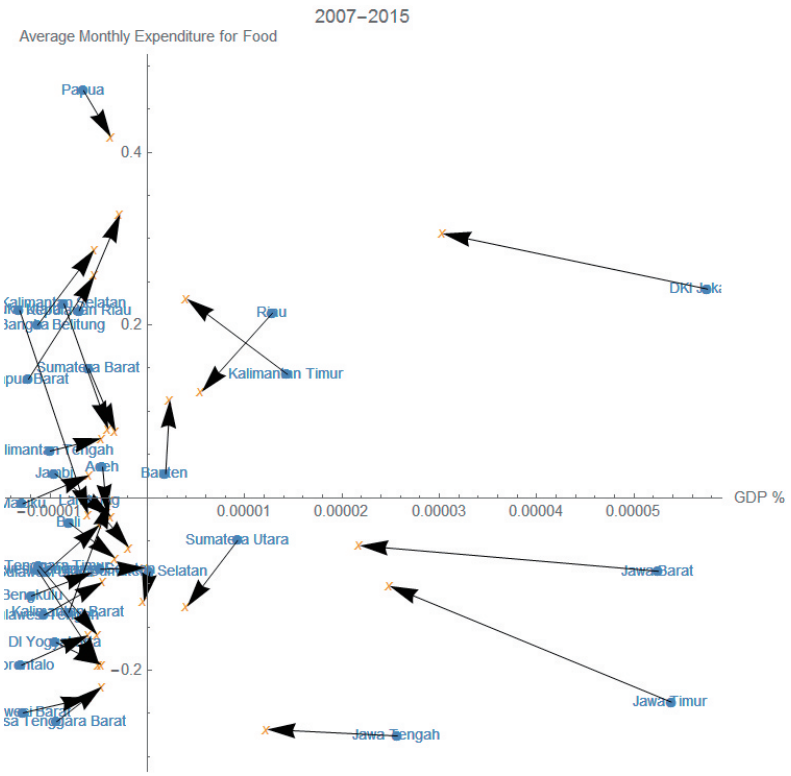


Figure 7: Pre-shapes deformation from 2007 to 2015 of the shape data in Figure 6.

In this case, a pre-shape consists of 33 province landmarks. Let us consider the deformation from 2007 to 2015. In the provinces that have a number of big cities such as DKI Jakarta, Jawa Barat, Jawa Timur, Jawa Tengah, Kalimantan Timur, Riau and Sumatera Utara, the GDP have been increasing. However, because other provinces economy emerged more rapidly, the GDP percentage decreased in the existing big provinces.

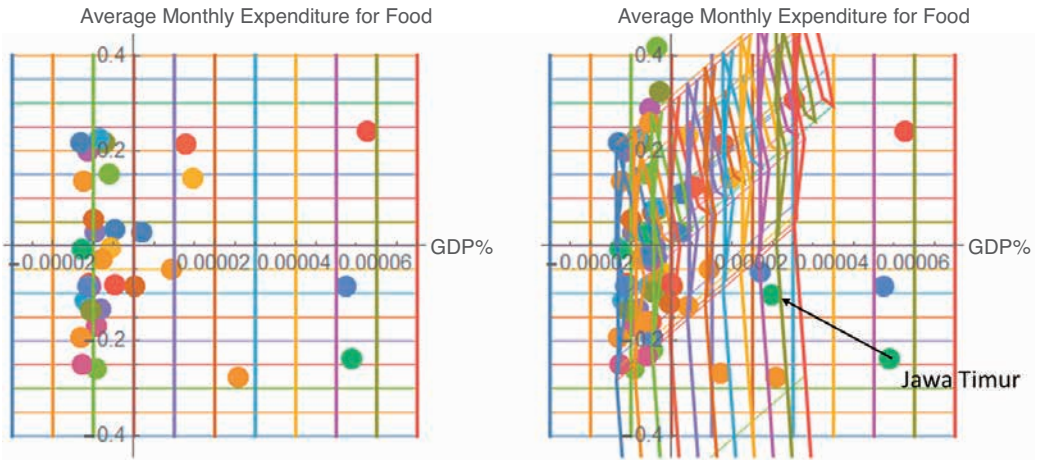


Figure 8: The pre-shape in 2007 and the pre-shape in 2015.

Then we conducted a statistical shape analysis on the deformation between 2011 and 2015 data. First, we display the landmarks on the transformation grid as shown in Figure 8. The left figure shows the pre-shape of the 2007 data and the right figure shows the pre-shape of the 2007 and 2015 data. In the right figure, the change in Jawa Timur is represented as a movement of an arrow from a circle to another one with the same color. The change for every province is also represented by an arrow as shown in Figure 7. To visualize the deformation, a transformation grid is effective to be used. The position on the grid is still fixed but the grid itself has changed as shown in the right figure of Figure 9.

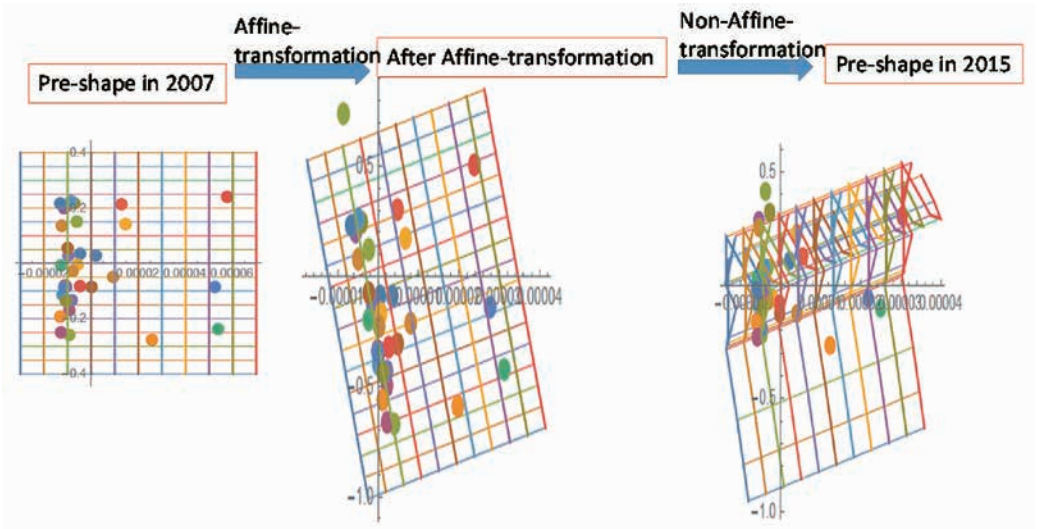


Figure 9: The deformation from 2007 to 2015 can be decomposed into the Affine transformation part and the non-Affine transformation part.

In general, a pre-shape deformation can be decomposed into the Affine transformation and the non-Affine transformation as shown in Figure 9. An Affine transformation can be expressed as the total movement on every landmark with a mathematical matrix operation. On the other hand, non-Affine transformation expresses local movements which cannot be expressed by one matrix transformation. The non-Affine transformation can be decomposed into several eigenvectors. The movement by each eigenvector is called a **partial warp** in the statistical shape analysis. In this paper, we analyzed two-dimensional data such as a pair of a GDP percentage and an expenditure for food. We did not analyzed three-dimensional data. Suppose that there are $k$ landmarks in $R^2$ then the number of partial warps is $k - 3$ which is based on the theory of the statistical shape analysis. Therefore, in this case we can get 30 partial warps because there are 33 landmarks analyzed in this research.

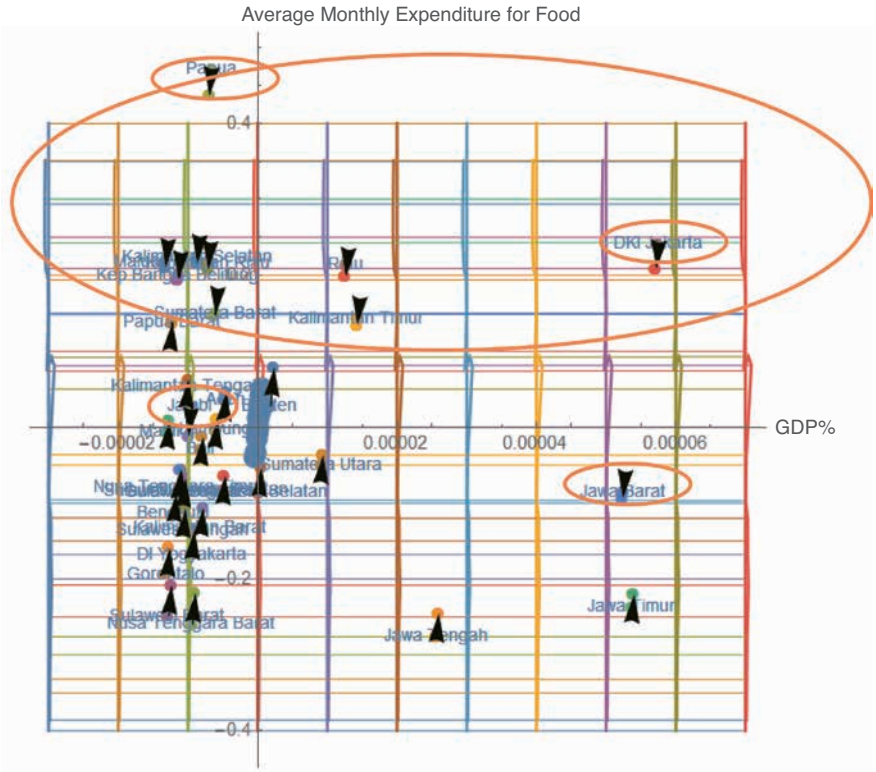


Figure 10: The partial warp #1 of the non-Affine transformation from 2007 to 2015 pre-shape data.

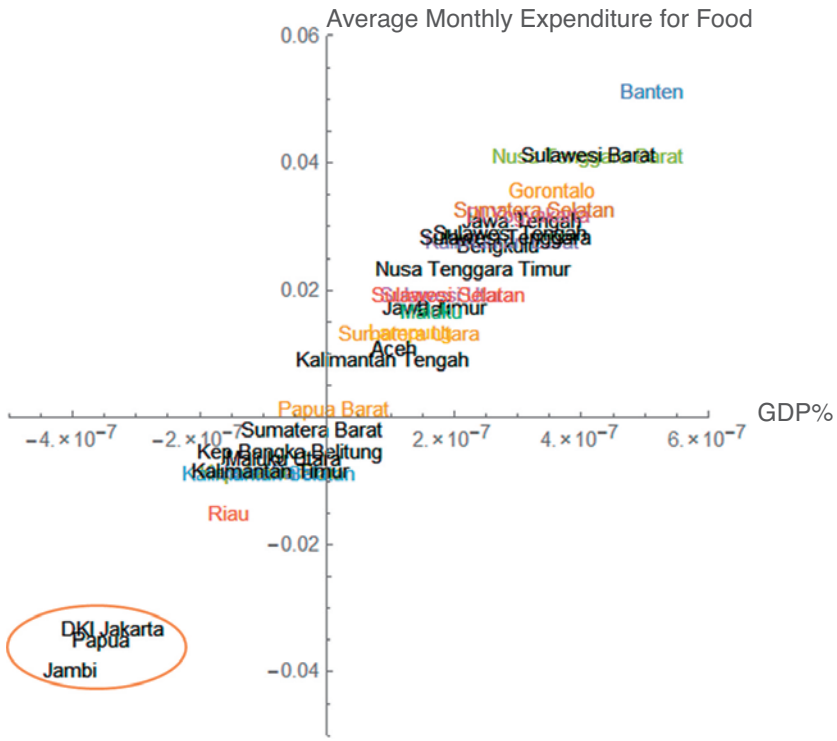


Figure 11: The partial warp #1 of the non-Affine transformation from 2007 to 2015 pre-shape data.

Figure 10 and 11 show the partial warp #1. The partial warp #1 is the dominant partial warp because it has the biggest eigenvalue. The arrows in Figure 10 show the deformation direction of each landmark. Roughly speaking, the landmarks can be divided into two groups; i.e. a higher expenditure group and a lower expenditure group. The higher expenditure groups are circled in Figure 10 which show a decreasing trend such as in the province of Jambi, Papua and DKI Jakarta. On the other hand, the lower expenditure group shows an increasing trend. However, the province of Jawa Barat is an exception since it has a decreasing trend. Because the two opposite direction forces exist, the distortion can be seen as a hill on the horizontal grid. Figure 11 shows each landmark's change vector in which the start point is set to be (0, 0).

In conclusion, for the dominant local movement of the deformation, it can be said that the data get closer to the average value, although the ranking on the GDP is almost unchanged.

## 4. Electricity Distribution by Province

In this section, we shall analyze the movement of the electricity distribution and the GDP percentage of provinces between 2011 and 2015. Figure 12 shows the electricity distribution by provinces in 2015. The province with the largest value are Jawa Barat, DKI Jakarta, and Jawa Timur.

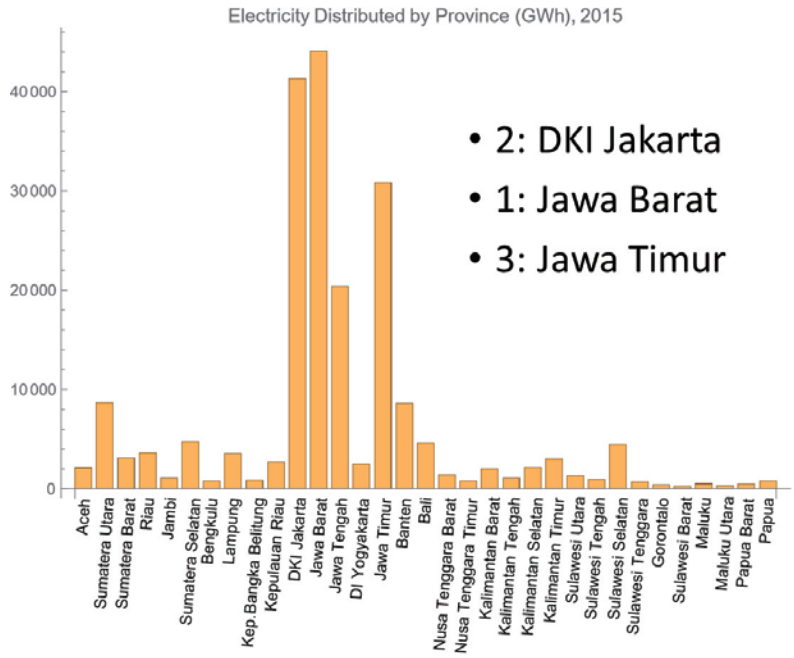


Figure 12: Electricity distribution by provinces in 2015

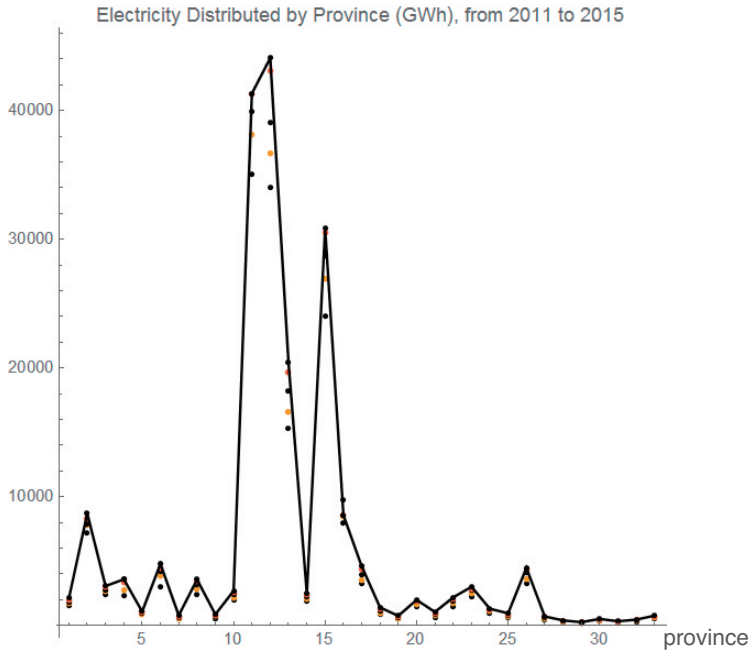


Figure 13: Electricity distribution by provinces in 2011 to 2015

Figure 13 shows the time series change of each province from 2011 to 2015. The connected line shows the data in 2015. We can see that, in every province, the electricity value is upraising. Figure 14 shows the shape changes in the electricity distribution between 2011 and 2015. The big provinces of Jawa barat, DKI Jakarta, Jawa Timur, and Jawa Tengah have the largest growth of the electricity consumption. In general, the electricity consumption increases when industries grow.

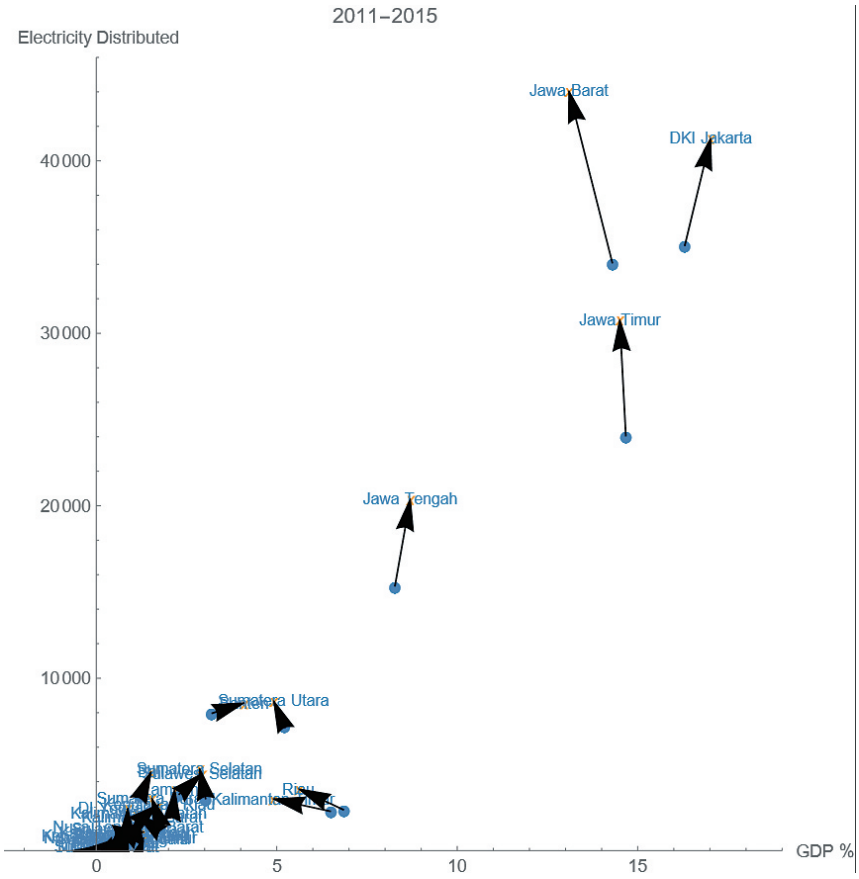


Figure 14: Change of GDP and electricity distribution by provinces from 2011 to 2015

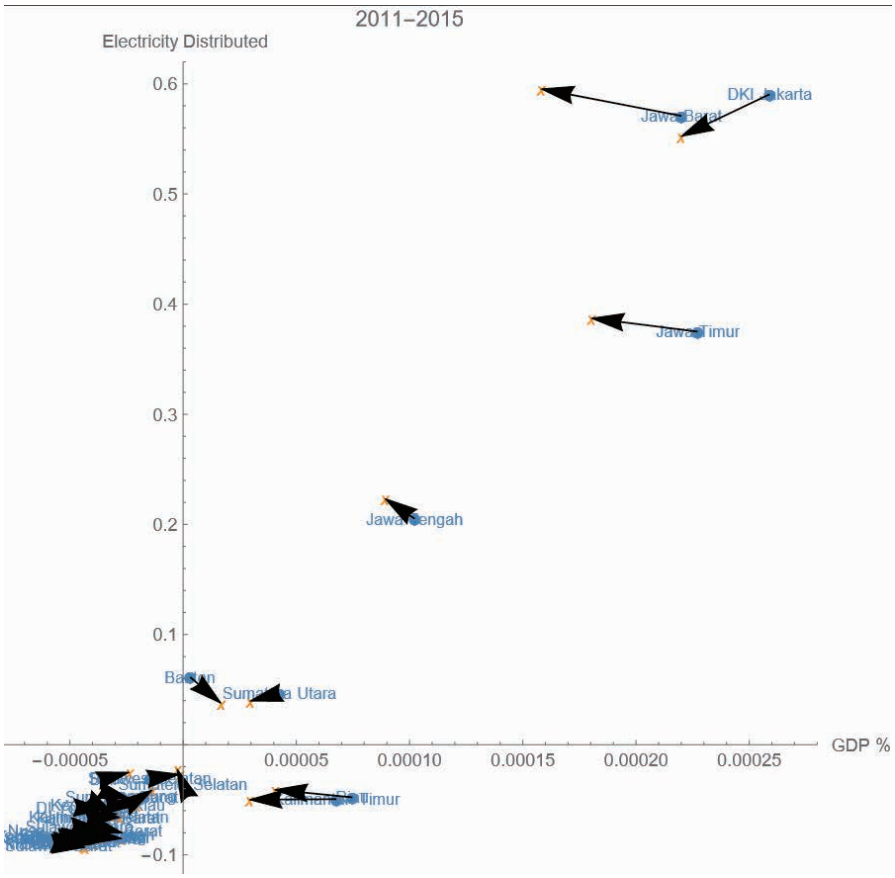


Figure 15: Pre-shape change of GDP and electricity distribution by provinces from 2011 to 2015

Figure 15 shows the pre-shape change on the deformation from 2011 to 2015. The city of provinces such as Jakarta show the decline of the GDP % share but the ranking share of the electricity distribution has not been changed or the changes are flat. To clarify the local movement, we shall conduct the statistical shape analysis.

Figure 16-a visualizes the Affine-transformation of the deformation that shows the big city provinces growth on electricity distribution that makes the transformation skewed. However, when we see the partial warp #1 in Figure 16-b, there is no change on the transformation grid. Therefore it can be stated that there is no large local movement. In addition, the changes can be expressed by the Affine-transformation.

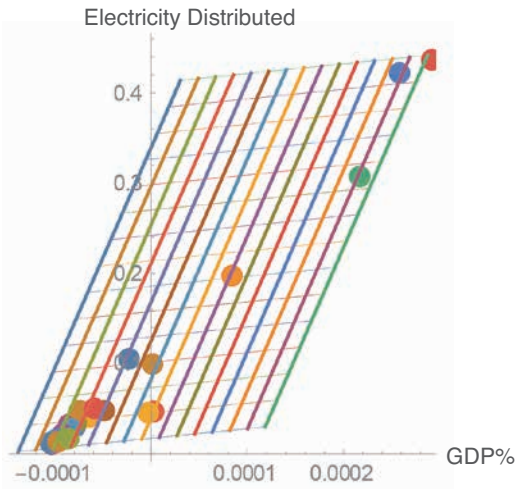


Figure 16-a: Affine-transformation of the deformation shown in Figure 15

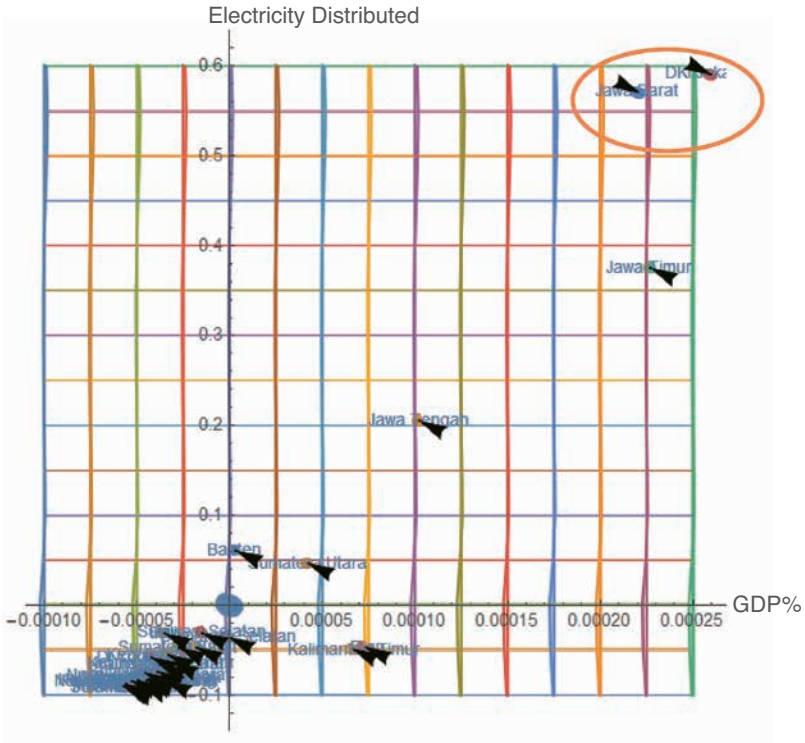


Figure 16: Partial warp #1 of the change shown in Figure 15

## 5. Clean Water Distribution by Provinces

In this section, we shall analyze the changes in of clean water distribution and a GDP percentage of the Indonesian provinces between 2007 and 2015. The data is the value of Clean Water Distribution in Million Rupiah, which is cited from the Indonesian Statistical Bureau website. First, let us see the water distribution by province in 2015 (See Figure 17). The provinces with the highest consumption of clean water are Jakarta, Jawa Barat, Jawa Timur.

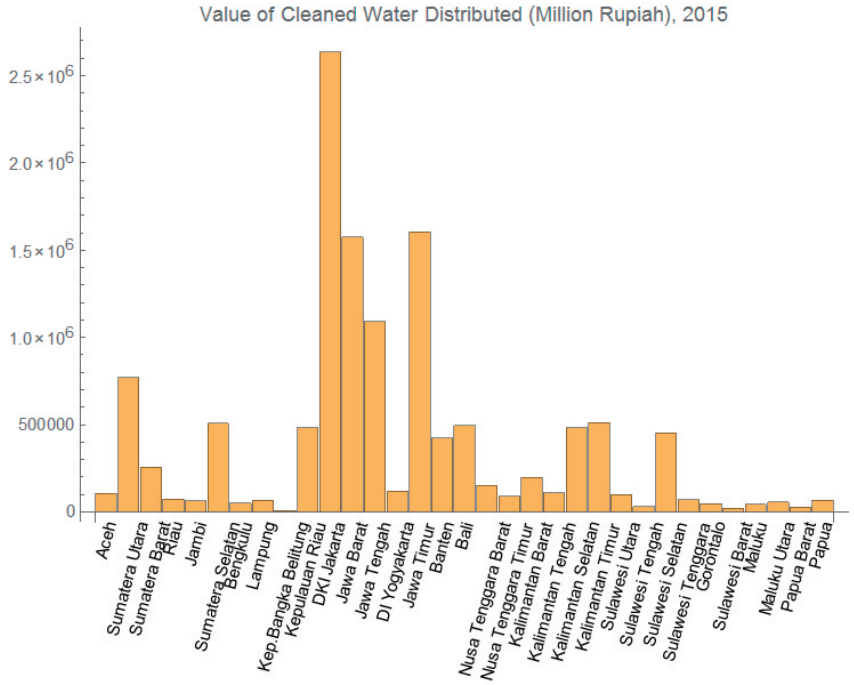


Figure 17: Water distribution by provinces in 2015

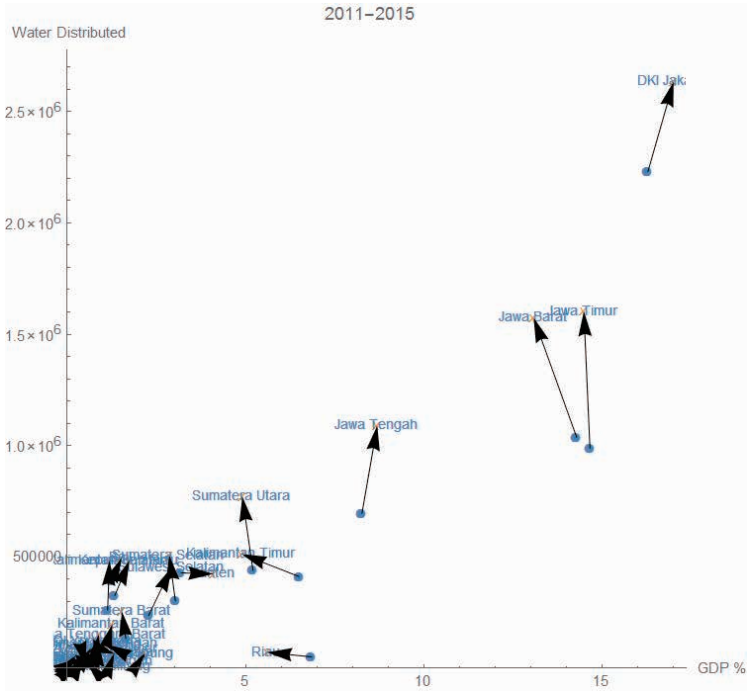


Figure 18: GDP and water distributed by province in 2011 and 2015

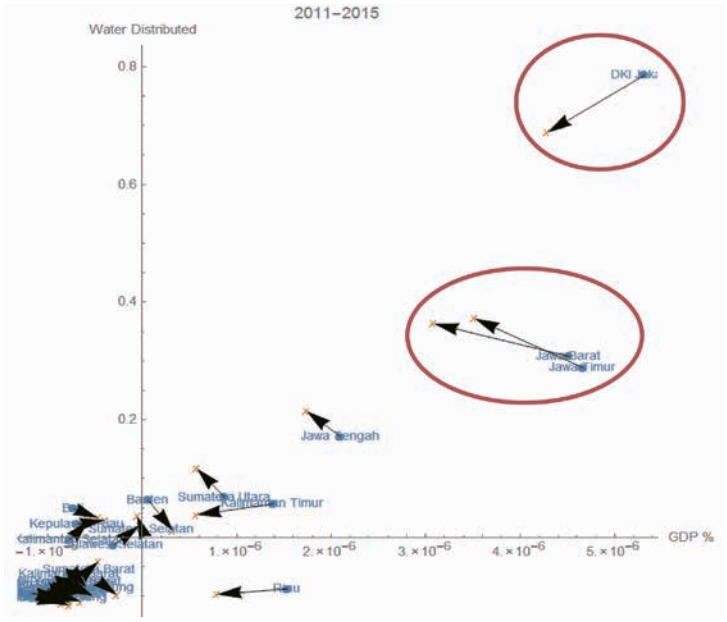


Figure 19: Pre-shapes of the GDP and water distributed by province in 2011 and 2015

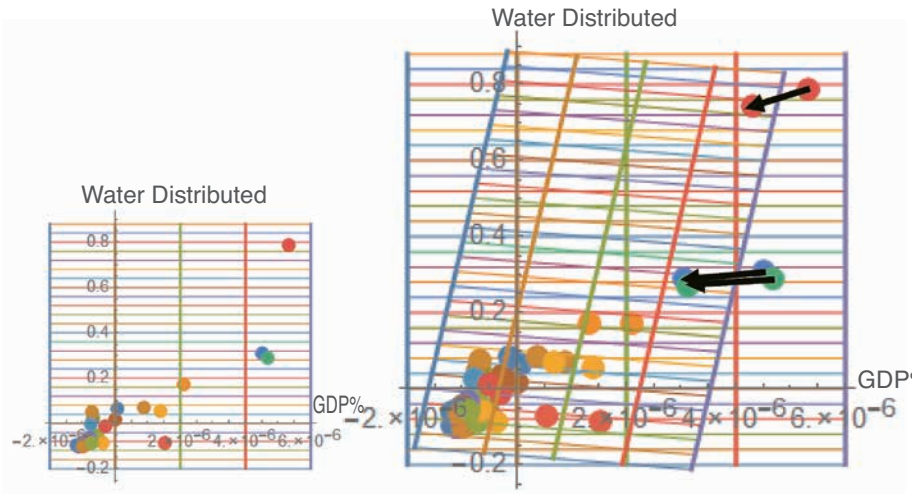


Figure 20: The 2011 pre-shape and the pre-shape after the Affine-transformation

We shall analyze the deformation from 2011 to 2015. Figure 18 shows the change between 2011 and 2015. The large changes can be seen in Jakarta, Jawa Timur, Jawa Barat, and Jawa Tengah. The pre-shapes are shown in Figure 19. First, let us see the Affine-transformation part of the deformation (See Figure 20). In Figure 20, the left figure is the original pre-shape which is the data in 2011. The right figure shows both the original pre-shape and its Affine-transformation. We can see that the landmarks shrink horizontally. It can be noticed that the changes in Jakarta, Jawa Barat, and Jawa Timur are remarkable. In Figure 21, we extracted the non-Affine transformation change. There, Jakarta's position goes down and Jawa Barat and Jawa Timur's position goes up. Then the distortion can be seen as the valley on the grid between Jakarta and the latter two provinces. In addition, Jawa Tengah which is located approximately in the center of the figure goes up. Then between Jawa Barat and Jawa Timur, and Jawa Tengah, the distortion appears as a hill. In Figure 22, the partial warp #1 is depicted. The Jakarta landmark goes down a little bit although other landmarks almost go up in the water distribution.

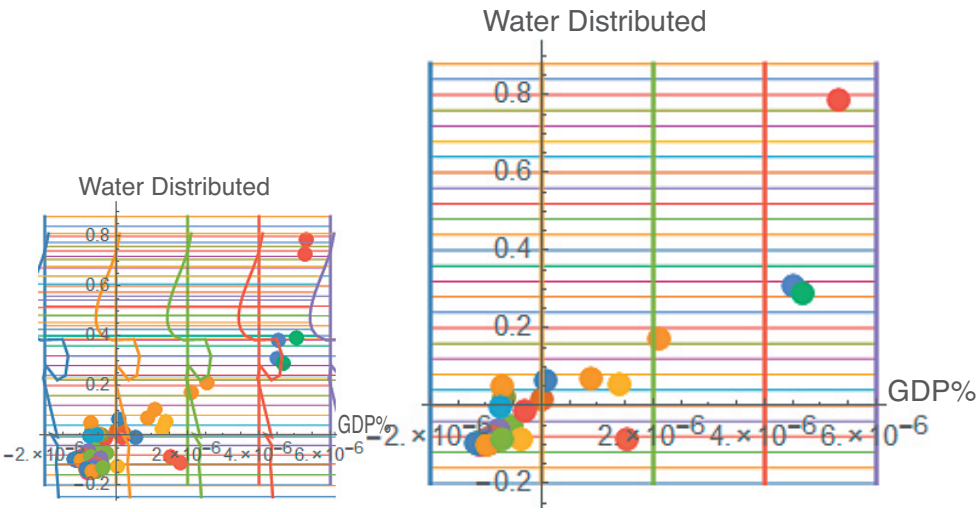


Figure 21: The 2011 pre-shape and the pre-shape after the non-Afine-transformation

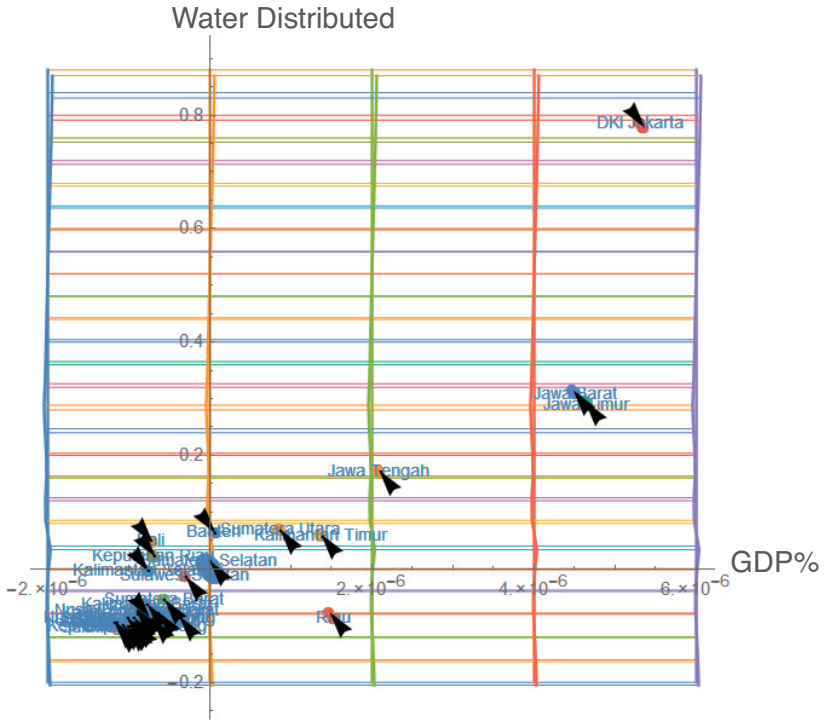


Figure 22: Partial warp #1 of the non Afine-transformation of the Figure 19 deformation

In conclusion, the clean water distribution increases in Jakarta, Jawa Timur and Jawa Barat. However, the growth rate of Jakarta is a bit smaller than that of Jawa Timur and Jawa Barat. Therefore, the non-Affine transformation shows the valet/ditch between Jakarta and Jawa Timur as well as Jawa Barat as shown in Figure 21.

## 6. Conclusion

This paper has presented an analysis based on statistical shape analysis of provincial differences in Indonesia which is based on economic indicators, i.e GDP percentage, monthly expenditure for food per capita, electricity, and water distribution by province. The results show that the higher expenditure provinces group tends to decrease and the lower tends to increase. Therefore, the data got closer to the national expenditure average. In terms of electricity distribution by provinces and the GDP percentage, the deformation shows no significant changes on almost all provinces. In terms of clean water and the GDP percentage, the deformation shows that Jakarta tends to decrease a little bit, however, almost all other provinces increase. These results may indicate that emerging economy is happening in many provinces in Indonesia.

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