Assessing the indicators of economic growth in Indonesia using spatial principal components analysis

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Abstract. The objective of this study is to reduce the number of indicators that affect correlated economic growth into the main component variables. The variables used are Gross Regional Domestic Product (GRDP) (X1), Foreign Direct Investment (X2), Domestic Direct Investment (X3), Employment (X4), Human Community (X5), Export (X6), and Import (X7). The data used are secondary data taken from Statistics Indonesia in 2018. This study uses the Geographical Weighted Principal Component Analysis (GWPCA) with the kernel weighting used is exponential kernel weighting. The results of this study are the main component variables or new variables that can be explained about 89% of the original variables. Based on the first main component (PC1) which consists of three groups of variables that affect economic growth indicators, namely: the area of which economic growth indicators are influenced by the Human Resources variable (X5) followed by the GRDP variable (X1), the region whose indicators of economic growth are influenced by the Export variable (X6) is followed by the Import variable (X7), and the region which is an indicator of economic growth is influenced by the Import variable (X7) is accepted by the Export variable (X6).

1. Introduction
Economic growth is a process of changing a country's economic conditions and continuing towards better conditions for a certain period. The expert of the economy is said to experience a change in its development if the level of economic activity is higher than that achieved in the previous period. Economic growth is always prioritized because economic growth indicates an increase in per capita income [1][2]. This is because economic growth enables economic development in many fields. According to Kuznets economic growth is a long-term increase in the ability of a country to provide more and more types of economic goods to its population, this capability grows in accordance with technological advances, institutional adjustments, and ideologies needed [3]. The central purpose of this paper is to understand the Indonesia economic from the perspective of spatial analysis.

Economic growth Indonesia has fluctuated from year to year. It was recorded that in 2012 Indonesia experienced an increase in the rate of economic growth, then there was a decline until 2015
and there was an increase again in 2016. Based on data Statistics Indonesia, capital expenditure always increases every year. In 2012 capital expenditure reached 61.1 trillion rupiah, in 2013 it added to spending 99.4 trillion rupiah, then in 2014 there was an increase of 157.0 trillion rupiah, and in 2015 capital expenditure reached 251.4 trillion rupiah. In the 2016 period, total capital expenditure spent by the government was 281.5 trillion rupiah. Apart from capital expenditure, the government's efforts to encourage regional economic growth are by attracting domestic and foreign investors. The results of government efforts to attract investors can be seen from the realization of private investment in the form of Foreign Direct Investment (FDI) and Domestic Direct Investment (DDI) [4-8].

Previous studies using the Geographically Weighted Principal Component Analysis (GWPCA) method, including [9] with the title Analysis of Regional and City Revenue Sources in Central Java with the Geographically Weighted Principal Component Analysis (GWPCA) method produce variables- Local income source variables at each location can be replaced/represented with new main component output variables namely PC1, PC2, and PC3 with a variance that can be explained by around 80% and there are three groups of variables that affect local revenue sources. [10] conduct Modeling of Local Revenue in Central Java produces variables that are thought to influence PAD in Central Java, namely population, regional retribution, regional expenditure, GRDP at constant prices, GRDP at current prices, local taxes can be manned by PC1 with a total variance of one 71.4 per cent and GWRPCA models with fixed Gaussian kernel weighting function are better used for PAD in Central Java because they have the largest R square value and the smallest AIC value.

In this paper, we want to analyze the presence of spatial effects as well as transforming original variables that are correlated into a new set of variables that are no longer correlated with economic growth data in Indonesia. Because the economic growth rate has an influence on the geographical layout of each province in Indonesia and differences in geographical location will affect the potential of a particular region, so it is necessary to add geographical information from the observed area. To analyze the main components of the economic growth variables of each province in Indonesia, the Geographically Weighted Principal Component Analysis (GWPCA) method is used. The result of the analysis GWPCA is the formation of local main components.

2. Method
The data used in this study are secondary data from Statistics Indonesia 2018. The observation unit in this study is the Provinces in Indonesia. The data used are data about GRDP, Employment, Human Capital, FDI, DDI, Exports and Imports. The selection of variables used in this study is an independent variable. The operational definitions of the variables are as follows:

| Variables | Variables                           | Unit       |
|-----------|------------------------------------|-----------|
| X1        | Groos Domestic Regional Bruto (GRDP)| Billion rupiah |
| X2        | Foreign Direct Investment (FDI)     | Dollars   |
| X3        | Domestic Direct Investment (DDI)    | Rupiah    |
| X4        | Labor                              | Person    |
| X5        | Human Capital                      | Jiwa      |
| X6        | Export                             | Million rupiah |
| X7        | Import                             | Million rupiah |

The analytical steps used in this study are described as follows [11]:

2.1. Test the assumptions of the GWPCA analysis consisting of:
- Multivariate normal distribution test.
- Collinearity test with the Barlett Test of sphericity.
- Test spatial dependencies by looking at the map on each variable.
2.2. Perform a GWPCA analysis consisting of
• Calculate the coefficient/loading of GWPCA.
• Determining the main components used to represent/replace the original data with the variance criteria described is 70% - 80%.
• Identifies the biggest coefficient/loading on the first main component (PC1).
• Make a visualization (Map) of spatial variations on variables that have the largest coefficient/loading in each province in Indonesia.

3. Results and Discussions
Table 2 shows the result of descriptive statistics from each indicator of economic growth indicators. In the table above there are mean values, median values, minimum values, maximum values, and standard deviation values of each variable. The GRDP variable (X1) has an average and standard deviation of 14,480 and 1,043, the foreign capital variable (X2) has an average and standard deviation of 5,947 and 1,545, the domestic modelling variable (X3) has an average and standard deviation of 7,812 and 1,678, the employment variable (X4) has an average and standard deviation of 12,200 and 1,162, the human capital variable (X5) has an average and standard deviation of 13,870 and 0,997, the export variable (X6) has an average and standard deviations of 4,918 and 3,719, and import variables (X7) have an average and standard deviation of 3,435 and 3,736.

|     | X1      | X2      | X3      | X4      | X5      | X6      | X7      |
|-----|---------|---------|---------|---------|---------|---------|---------|
| Mean| 14,480  | 5,947   | 7,812   | 12,200  | 13,870  | 4,918   | 3,435   |
| Median| 14,520  | 6,261   | 7,575   | 12,030  | 13,710  | 5,821   | 1,739   |
| Min  | 12,650  | 2,434   | 3,957   | 10,380  | 11,930  | 0,000   | 0,000   |
| Max  | 16,840  | 8,545   | 10,763  | 14,700  | 16,160  | 10,853  | 11,306  |
| Std.Dev| 1,043   | 1,545   | 1,678   | 1,162   | 0,997   | 3,719   | 3,736   |

Table 3 is an evaluation of assumption results. The Kolmogorov-Smirnov test show result p-value of 0,426 that indicates the data is normally distributed. Then, the Bartlett of Sphericity test obtained a p-value of 0.000 that indicates the data is there is a correlation between independent variables. It means that GWPCA has met the criteria of assumption.

| Assumption Test | Criteria       | Results |
|-----------------|----------------|---------|
| Normality       | p-value > α    | M       |
| Multivariate    |                |         |
| Collinearity    | p-value > α    | M       |

Note: M = Meeting criteria; TM = Not meeting criteria

The coefficient or loading states the amount of variance of a variable that can be explained by a major component. Large variance means that the variable has a large correlation (influence) on the main components that represent indicator data that affect the economic growth of the provinces in Indonesia. The main component (PC1) represents the largest proportion of variants around 79% so that the variable that has the highest coefficient or loading on the first main component gives a big influence on economic growth indicators in Indonesia. The coefficient or loading for the first main component (PC1) at each location can be seen in Table 5.

Based on Table 5, each location has the biggest coefficient/loading on variable X5, which is Human Capital, followed by variable X1 (GRDP). The three locations that have the greatest coefficient on variable X6 are exports followed by variable X7 (imports). Thirteen locations that have
the biggest coefficient/loading on variable X7 are imports followed by variable X6 (exports). Analysis using the largest coefficient/loading was chosen in the first main component (PC1) because PC1 was able to explain the variance of 79% of the original data.

Based on PC1 there are three major groups according to variables that affect economic growth indicators in Indonesia, the regional groups are mapped in Figure 1.

### Table 4. Coefficient/loading of PC1 provinces

| Provinces Code         | X1   | X2   | X3   | X4   | X5   | X6   | X7   |
|------------------------|------|------|------|------|------|------|------|
| Aceh                   | 0.100| 0.242| 0.200| 0.158| 0.098| 0.662| 0.647|
| Sumatera Utara         | 0.101| 0.234| 0.198| 0.157| 0.102| 0.658| 0.654|
| Sumatera Barat         | 0.102| 0.230| 0.200| 0.159| 0.104| 0.656| 0.656|
| Riau                   | 0.100| 0.228| 0.196| 0.157| 0.102| 0.661| 0.653|
| Jambi                  | 0.103| 0.226| 0.197| 0.158| 0.105| 0.659| 0.654|
| Sumatera Selatan       | 0.108| 0.224| 0.205| 0.164| 0.111| 0.644| 0.665|
| Bengkulu               | 0.108| 0.225| 0.209| 0.164| 0.110| 0.649| 0.659|
| Lampung                | 0.110| 0.224| 0.207| 0.168| 0.112| 0.623| 0.683|
| Kep. Bangka Belitung   | 0.113| 0.217| 0.198| 0.167| 0.116| 0.641| 0.670|
| Kep. Riau              | -0.097| -0.220| -0.181| -0.160| -0.096| -0.660| -0.663|
| DKI Jakarta            | 0.110| 0.223| 0.212| 0.172| 0.111| 0.610| 0.693|
| Jawa Barat             | 0.113| 0.222| 0.213| 0.171| 0.112| 0.609| 0.693|
| Jawa Tengah            | 0.127| 0.223| 0.220| 0.176| 0.122| 0.612| 0.682|
| DI Yogyakarta          | 0.126| 0.226| 0.222| 0.177| 0.121| 0.616| 0.677|
| Banten                 | 0.109| 0.225| 0.212| 0.170| 0.111| 0.609| 0.693|
| Bali                   | 0.130| 0.222| 0.202| 0.182| 0.121| 0.631| 0.668|
| Nusa Tenggara Barat   | -0.126| -0.226| -0.192| -0.182| -0.116| -0.641| -0.662|
| Nusa Tenggara Timur   | -0.128| -0.233| -0.198| -0.188| -0.116| -0.642| -0.656|
| Kalimantan Barat      | -0.114| -0.209| -0.192| -0.168| -0.111| -0.648| -0.669|
| Kalimantan Tengah     | -0.119| -0.203| -0.188| -0.170| -0.115| -0.650| -0.667|
| Kalimantan Selatan    | -0.124| -0.207| -0.187| -0.173| -0.117| -0.646| -0.667|
| Kalimantan Utara      | -0.121| -0.222| -0.194| -0.180| -0.115| -0.647| -0.659|
| Sulawesi Utara        | -0.132| -0.241| -0.199| -0.194| -0.120| -0.666| -0.624|
| Selawesi Tengah       | -0.132| -0.243| -0.192| -0.192| -0.121| -0.659| -0.633|
| Sulawesi Selatan      | -0.132| -0.241| -0.190| -0.190| -0.122| -0.648| -0.646|
| Sulawesi Tenggara     | -0.133| -0.240| -0.193| -0.192| -0.121| -0.651| -0.642|
| Gorontalo              | -0.131| -0.241| -0.196| -0.193| -0.120| -0.664| -0.627|
| Sulawesi Barat        | -0.132| -0.245| -0.189| -0.189| -0.122| -0.650| -0.643|
| Maluku                 | -0.139| -0.243| -0.229| -0.197| -0.123| -0.672| -0.604|
| Maluku Utara          | -0.137| -0.238| -0.212| -0.197| -0.123| -0.666| -0.618|
| Papua Barat           | -0.139| -0.244| -0.231| -0.194| -0.123| -0.667| -0.609|
| Papua                 | -0.132| -0.244| -0.219| -0.188| -0.117| -0.665| -0.619|
| Jawa Timur            | 0.134| 0.219| 0.218| 0.182| 0.126| 0.619| 0.674|
| Kalimantan Timur      | -0.114| -0.223| -0.196| -0.179| -0.108| -0.653| -0.655|

Note: the biggest coefficient is bold, the second-largest coefficient is italic
4. Conclusion

Based on the results of the GWPCA analysis, it can be concluded that the variables that affect economic growth indicators at each location can be replaced with two new main component variables, PC1 with a variance that can be explained around 89%. The first main component (PC1) is able to explain about 79% variant. Based on the first main component (PC1), there are three groups of variables that influence economic growth indicators, namely, regions where economic growth indicators are influenced by Human Capital (X5) followed by GRDP (X1) consisting of 18 Provinces, regions that are indicators of economic growth influenced by exports (X6) followed by imports (X7) consisting of 4 Provinces and regions whose economic growth indicators are influenced by imports (X7) followed by exports (X6) consisting of 12 Provinces.

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