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Indonesia's Provinces Clustering Based on Industrial Concentration as a Reference in Establishing Vocational Programs for Vocational High Schools

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Abstract

In Indonesia, industry has become the biggest contributor for Gross Domestic Product (GDP) which achieved 20.16 % in 2017 according to Indonesia's Ministry of Industry. As Indonesia's main economic force, it demands a skilled workforce. One way to generate such a workforce is through Vocational High Schools. However, they have the lowest enrolment rate compared to other education levels according to Statistics Indonesia. According to Indonesia's Ministry of Education and Culture, one reason for that phenomenon are mismatches of vocational programs with industry in the area. Thus, clustering provinces in Indonesia based on its industrial concentration is necessary. Therefore, data was collected from Indonesia's Ministry of Industry, including a number of middle to big industries and their workforce. Clustering was carried out based on Fuzzy C-Means, which enables each province to become a member of every cluster and eventually results in eight clusters. The results are used to recommend vocational programs in Indonesia based on industrial concentrations.

Keywords: clustering, Fuzzy C-Means, industry, Vocational High School

Introduction

The biggest contributor to Indonesia's gross domestic product is the industry sector. It's contribution achieves 20.16% with US$ 14.83 export value in 2017 (Ministry of Industry, 2018). In

response to these achievements, especially in the era of the Indusry Revolution 4.0, the ministry has already formulated strategies called 'Making Indonesia 4.0'. One of the priorites set forth is the development of human resources. Based on the Constitution of the Republic Indonesia Number 41 Year 2015, about the Development of Industrial Human Resources, the ministry has some programs, including development of industrial vocational education, industries internship, competency based on industrial workshop and competency certification. In 2016, there are 11,622 certified workforces absorbed and 4,556 workforces generated from industrial vocational education, while certified workforces are targeted to reach 1,040,552 in 2019 based on Indonesia's Ministry of Industry.

In 'Making Indonesia 4.0', Indonesia is targeted to become top ten of world's most powerful economic forces based on gross domestic product, by doubling productivity to cost ratio, boost nett export into 10% of the gross domestic product and raise research and development budget to 2% of the gross domestic product. Indonesia is also trying to develop five manufacturing sectors with regional competitiveness including food and beverage, textile, automotive, chemistry and electronic. In dealing with Industry Revolution 4.0, Indonesia made a commitment to revitalise manufacturing industries.

Also in 'Making Indonesia 4.0', Indonesia set ten national priorities, such as improvement of goods and materials flow, redesign of industries' zone, accomodation of sustainable standards, empowerment of micro to middle level businesses, development of national digital infrastructures, attracting interest of foreign investors, enchancement of human resources' qualities, development of innovations, incentive for technological investations, and harmonisation of rules and policies. The implementation of strategies in 'Making Indonesia 4.0' is expected to boost gross domestic product growth by 1-2% each year which will accumulate into 5-7% in 2030. It is also expected to raise the number of available jobs as much as seven to nine million, both in the manufacturing sector or non-manufacturing sector, in 2030 as a consequence of increasing export demands.

According to the Constitution of Republic of Indonesia Number 20 Year 2003, about the National Education System, vocational high-school education in Indonesia is directed to mastering certain skills in industry. Students will be taught related skills to the vocational program chosen. In order for the graduates to be a skilled workforce, they are taught both the theory and practical approach. Link and match are programs from Indonesia's Ministry of Industy which aims to connect Vocational High Schools to related industries.

Based on official data from Indonesia's Ministry of Education and Culture in January 2018, there were 13,710 Vocational High School in Indonesia with the total number of teachers amounting to 292,212 teachers. As much as 57% schools are concentrated within Java Island. Within the same year, there were 1,300,521 Vocational High School's graduates and 1,721,547 Vocational High School's new students which made the total number of Vocational High School's students in January 2018 reach 4,904,031 students.

However, Vocational High School has the lowest enrolment compared to other educational levels which amounts to 8.92%. This fact is able to impact the national economy. According to projection from Indonesia's National Development Planning Agency, in 2025-2030, Indonesia will experience a phase known as demography bonus. This is the phase where people of productive age dominate the entire population of Indonesia. As 28.2% of Indonesia's workforces are composed of Vocational High School's graduates or equal, Vocational High School's high unemployment rate might compromise the potential benefit of the demography bonus. In the International, Vocational Education and Training (VET) system in Germany, in contrast, shows a much higher proportion of youth participation (Anderson & Bowman, 1965). Also, the problem lies with exuberant claims of advocates who wrongly think that vocational education is more likely to reduce youth unemployment, prevent youth unemployment from being alienated and cause them to not engage in anti-social activities (Wallenborn & Heyneman, 2009). These social claims about the virtues of vocational education were common to all colonial authorities as well to the leaders of the

independent countries in the 1960s (Heyneman 1971, 1972). Claims that vocational education was more 'practical' were endemic in the United States as a counter to the social influences on youth of the 1960s (Heyneman 1976, 1978).

Prior research states that quantity expansion or increasing the number of Vocational High School's students does not contribute to decreasement of unemployment but even increases it (Slamet PH, 2016). On the other hand, according to Indonesia's Ministry of Education and Culture, one reason for Vocational High School's low enrolment rate are mismatches of vocational program with industry in the area. It means that it requires an accurate planning to establish Vocational High Schools rather than just increasing the quantity. The research conducted aims to show general conception about Indonesia's distribution of middle to big industry and its workforces in Indonesia, cluster Indonesia's provinces based on it's industrial concentrations, and recommend vocational programs based on it's industrial concentrations.

Methods

Data is secondary data from Indonesia's Ministry of Industry. Data collected is from the company directory which lists all middle to big industry in Indoneisa. Available information from the directory includes company name, company address, commodity and workforces. It was then sorted by provinces and commodities.

Fuzzy C-Means based on the fuzzy concept. The theory was first introduced by Lotfi Zadeh (1965) and first named as fuzzy set. Bezdek introduced Fuzzy C-Means (FCM) clustering method in 1981. FCM is an unsupervised clustering algorithm that is applied to a wide range of problems connected with feature analysis, clustering and classifier design. FCM is a data clustering technique in which a data set is grouped into clusters with every data point in the data set related to every cluster, and it will have high degree of belonging to that cluster and another data point that lies far away from the centre of a cluster, which will have a low degree of belonging to that cluster (Branco,

Evsukoff, & Ebecken, 2005; Cox, 2005; Ghosh & Dubey, 2013; Pavel & Jiri, 2007; Siler & Buckley, 2005)). Within the fuzzy concept, validity is measured by a distinct criterion compared to other methods of clustering. In this research, there are three criteria to measure validity.

- Partition Coefficient Index (PCI)

  The value of PCI evaluates only the degree of memberships without considering the value of observations which commonly contains geometric information. It's value range is from 0 to 1, while the greater value indicates a better quality of the resulting clusters (Bezdek, 2013).

- Partition Entropy Index (PEI)

  The value of PEI evaluates the randomness of observations within clusters and range from 0 to 1. The lesser value indicates a better quality of the resulting clusters (Bezdek, 2013).

- Modified Partition Coefficient Index (MPCI)

  PCI and PEI tend to become monotonic against the number of clusters. MPCI is able to remove that drawback and range from 0 to 1. The greater value indicates a better quality of the resulting clusters (Dave & Bhaswan, 1992).

Results and Discussion

Even though Indonesia's industries have decent achievements, it's achievements are not distributed evenly across all provinces. This fact could be further absorbed in **Figure 1**, where there are huge gaps in the number of middle to big industries between provinces. Most of the industries are concentrated within Java Island, where it could reach thousands of middle to big industries, except for Yogyakarta with 437 industries. While the other provinces don't reach 500 industries

except for Riau Archipelago and South Sumatra. The gaps could be further attested by observing the difference between provinces with the highest number of industries, Western Java with 8,923 industries and provinces with the lowest number of industries, North Maluku with 12 industries.

The number of industrial workforces is proportional to number of industries in each provinces of Indonesia. The gaps between provinces in Java Island and the other provinces could still be observed ini **Figure 2**. The gaps could be further attested by observing the difference between provinces with the highest number of industrial workforces, West Java with 2,269,137 workforces and provinces with the lowest number of industrial workforces, Norh Maluku with 583 workforces.

Based on **Figure 3** and **Figure 4,** it can be seen that manufacture of food and beverages, textile is the manufacture with the most labour and number of companies. Both types of industries are included in five manufacturing sectors with regional competitiveness developed by the Indonesian's Ministry of Industry. Other industries included in the 5 manufacturing sectors are machinary, chemical and electronic. The result from Fuzzy C-Means divides Indonesia's provinces into eight clusters based on its industrial concentrations. Eight clusters are considered the best number of clusters based on the criteria of PCI, PEI and MPCI, which can be found in **Table 1**. Based on centroid values, the characteristics of each cluster can be inferred, as in **Table 2**. Each province is included into one of the eight clusters based on their highest degree of membership. For membership of each cluster can be observed in **Figure 5** and **Table 3**. Based on clustering results, it could be recommended for the following vocational programs for each cluster in **Table 4** and **Table 5**.

Conclusion

There are gaps in industrial concentration between provinces in Java Island and the other provinces. Provinces in Java Island could have more than 1,500 industries and absorbs more than

a million workforces, except for Jakarta and Yogyakarta. While the other provinces don't reach 500 industries, except for Northern Sumatra and Riau Archipelago. From the five manufacturing sectors which are developed to have regional competitiveness, two of them are manufacture of food and beverages and manufacture of textiles. They have high concentrations, compared to other manufactures. Three other manufactures are developed; they are machinary, chemical, and electric. The manufacture of electricity is still relatively low when it is compared to the other manufactures.

Based on the result of the analysis, it has eight clusters with different manufacturing characteristics. From eight clusters, the fifth cluster has medium to high concentration that it is lower than the other cluster. In contrast to the first cluster, the second cluster, fourth cluster, seventh cluster and eighth cluster begin to develop manufacture of food and beverages. The eighth cluster has medium to high concentration that it is almost more superior to the other clusters in all types of manufactures. The seventh cluster has medium to high concentration except in the manufacture of electricity. The fourth cluster has medium to high concentration except in the manufacture of coal and petroleum. Based on the clustering, it could be recommended that vocational programs should be based on industrial concentrations. It is done to better assure that Vocational High School's graduates may earn jobs that match with the skills they were taught in their provinces.

Recommendation

Based on the conclusion, some suggestions from the author are:

1. Considering manufacturing in other fields such as agrarian, maritime, arts and tourism in grouping and mapping Indonesian territory, in further research to explore the needs of human resources in Indonesia, especially for Vocational High Schools.
2. Grouping and mapping at the district or city level in Indonesia, in further research as recommendations to determine Vocational High School programs in each district or city.

3. Develop training with the system 3-in-l in area with low medium-high concentrations of manufacturing such as cluster one, cluster three and cluster five.
4. Pay more attention with low medium-high consentrations manufacturing such as cluster one, cluster three and cluster five in the link and match program.
5. Pay more attention to manufacturing that the number of companies is fewer in the link and match the program.
6. Facilitating and the development and education of Vocational High Schools that matches with medium-high concentrations of manufacturing in the area.
7. Encouraging medium-high concentrations of manufacturing equality in all regions of Indonesia.

Appendix

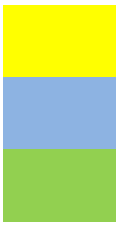
Table 1. Validity of Clusters

Criterion	Values
PCI	0.8888642
PEI	0.3591484
MPCI	0.8729876

Table 2. Cluster Characteristics

Explanation	K1	K2	K3	K4	K5	K6	K7	K8
Manufacture of food and beverages								
Manufacture of tobacco products								
Manufacture of textile and related products								
Manufacture of wood and products of wood								
Printing and reproduction of recorded media								
Manufacture of coal and petroleum								
Manufacture of chemicals and chemical products								
Manufacture of rubber and plastics								
Manufacture of metal and metal products								

Explanation	K1	K2	K3	K4	K5	K6	K7	K8
Manufacture of electronic component and equipment communication								
Manufacture of machinery								
Manufacture of furniture								
Other manufacturing								



High Consentration
Medium Consentration
Low Consentration

Table 3. Clustering of Indonesia's Provinces Based on its Industry Concentration

Cluster	Cluster Colour	Membership of Cluster
1	Blue	North Sumatera, Lampung, Riau
2	Purple	Banten
3	Pink	Riau Archipelago
4	Green	West Java
5	Maroon	Aceh, West Sumatera, Jambi, South Sumatera, Bengkulu, Bangka Belitung Archipelago, DI Yongyakarta, Bali, West Nusa Tenggara, East Nusa Tenggara, West Kalimantan, Central Kalimantan, South Kalimantan, East Kalimantan, North Kalimantan, North Sulawesi, Central Sulawesi, South Sulawesi, Southeast Sulawesi, Gorontalo, West Sulawesi, Maluku, North Maluku, West Papua, Papua
6	Grey	DKI Jakarta
7	Yellow	Central Java

8	Red	East Java

Tabel 4. Recommendations of Vocational Programs in for Cluster 1 until Cluster 5

Cluster	Recommendations of Vocational Programs
1	Cullinary Art, Crop Agribusiness Pruduction, Farm Agribusiness Production, Aquatic Agribusiness Production, Agro Engineering, Agricultural Agroindustry
2	Cullinary Art, Crop Agribusiness Pruduction, Farm Agribusiness Production, Aquatic Agribusiness Production, Agro Engineering, Agricultural Agroindustry, Fashion, Textile Craft, Leather Craft, Textile Technology, Wood Construction Engineering, Furniture Engineering, Finishing Work Engineering, Wood Craft, Forest Processing, Mining Geology, Bio Fuel Technology, Oil Engineering, Chemical Industry, Chemical Analyst, Pharmacy, Industrial Pharmacy, Steel Construction Engineering, Welding Engineering, Metal Manufacturing Engineering, Metal Casting Engineering, Metal Craft, Metal Instrumentation, Glass Instrumentation, Electrical Engineering, Software Engineering, Computer Network Engineering, Broadcasting Technology, Colling and Air Conditioning Engineering, Telecommunication, Electricity Engineering, Mechanical Engineering Production, Machine Drawing Engineering, Industrial Mechanical Maintenance Engineering, Shipping Engineering, Aircraft Technology, Automotive Engineering.

3	Mechanical Engineering Production, Machine Drawing Engineering, Industrial Mechanical Maintenance Engineering, Shipping Engineering, Aircraft Technology, Automotive Engineering.
4	Cullinary Art, Crop Agribusiness Pruduction, Farm Agribusiness Production, Aquatic Agribusiness Production, Agro Engineering, Agricultural Agroindustry, Fashion, Textile Craft, Leather Craft, Textile Technology, Wood Construction Engineering, Furniture Engineering, Finishing Work Engineering, Wood Craft, Forest Processing, Multimedia, Graphics, Electricity Engineering, Chemical Industry, Chemical Analyst, Pharmacy, Industrial Pharmacy, Steel Construction Engineering, Welding Engineering, Metal Manufacturing Engineering, Metal Casting Engineering, Metal Craft, Metal Instrumentation, Glass Instrumentation, Electrical Engineering, Software Engineering, Computer Network Engineering, Broadcasting Technology, Colling and Air Conditioning Engineering, Telecommunication, Electricity Engineering, Mechanical Engineering Production, Machine Drawing Engineering, Industrial Mechanical Maintenance Engineering, Shipping Engineering, Aircraft Technology, Automotive Engineering.
5	Recommendation for Vocational High Schools programs for cluster 5 are according to the potential in each region.

Tabel 5. Recommendations of Vocational Programs for Cluster 6 until Cluster 8

Cluster	Recommendations of Vocational Programs
6	Cullinary Art, Crop Agribusiness Pruduction, Farm Agribusiness Production, Aquatic Agribusiness Production, Agro Engineering, Agricultural Agroindustry, Fashion, Textile Craft, Leather Craft, Textile Technology, Wood Construction Engineering, Furniture Engineering, Finishing Work Engineering, ,Wood Craft, Forest Processing, Multimedia, Graphics, Electricity Engineering, Chemical Industry, Chemical Analyst, Pharmacy, Industrial Pharmacy, Steel Construction Engineering, Welding Engineering, Metal Manufacturing Engineering, Metal Casting Engineering, Metal Craft, Metal Instrumentation, Glass Instrumentation, Electricity Engineering, Mechanical Engineering Production, Machine Drawing Engineering, Industrial Mechanical Maintenance Engineering, Shipping Engineering, Aircraft Technology, Automotive Engineering.
7	Cullinary Art, Crop Agribusiness Pruduction, Farm Agribusiness Production, Aquatic Agribusiness Production, Agro Engineering, Agricultural Agroindustry, Fashion, Textile Craft, Leather Craft, Textile Technology, Wood Construction Engineering, Furniture Engineering, Finishing Work Engineering, Wood Craft, Forest Processing, Mining Geology, Bio Fuel Technology, Oil Engineering, Chemical Industry, Chemical Analyst, Pharmacy, Industrial Pharmacy, Stone and Concrete Engineering, Plumbing and Sanitation Engineering, Ceramic Craft, Industrial Waste and Waste Processing Engineering, Steel Construction

Engineering, Welding Engineering, Metal Manufacturing Engineering, Metal Casting Engineering, Metal Craft, Metal Instrumentation, Glass Instrumentation, Electrical Engineering, Software Engineering, Computer Network Engineering, Broadcasting Technology, Colling and Air Conditioning Engineering, Telecommunication, Electricity Engineering, Mechanical Engineering Production, Machine Drawing Engineering, Industrial Mechanical Maintenance Engineering, Shipping Engineering, Aircraft Technology, Automotive Engineering.

8 Cullinary Art, Crop Agribusiness Production, Farm Agribusiness Production, Aquatic Agribusiness Production, Agro Engineering, Agricultural Agroindustry, Fashion, Textile Craft, Leather Craft, Textile Technology, Wood Construction Engineering, Furniture Engineering, Finishing Work Engineering, Wood Craft, Forest Processing, Mining Geology, Bio Fuel Technology, Oil Engineering, Chemical Industry, Chemical Analyst, Pharmacy, Industrial Pharmacy, Stone and Concrete Engineering, Plumbing and Sanitation Engineering, Ceramic Craft, Industrial Waste and Waste Processing Engineering, Steel Construction Engineering, Welding Engineering, Metal Manufacturing Engineering, Metal Casting Engineering, Metal Craft, Metal Instrumentation, Glass Instrumentation, Electrical Engineering, Software Engineering, Computer Network Engineering, Broadcasting Technology, Colling and Air Conditioning Engineering, Telecommunication, Electricity Engineering, Mechanical Engineering Production, Machine Drawing

Engineering, Industrial Mechanical Maintenance Engineering, Shipping Engineering, Aircraft Technology, Automotive Engineering.

Appendix

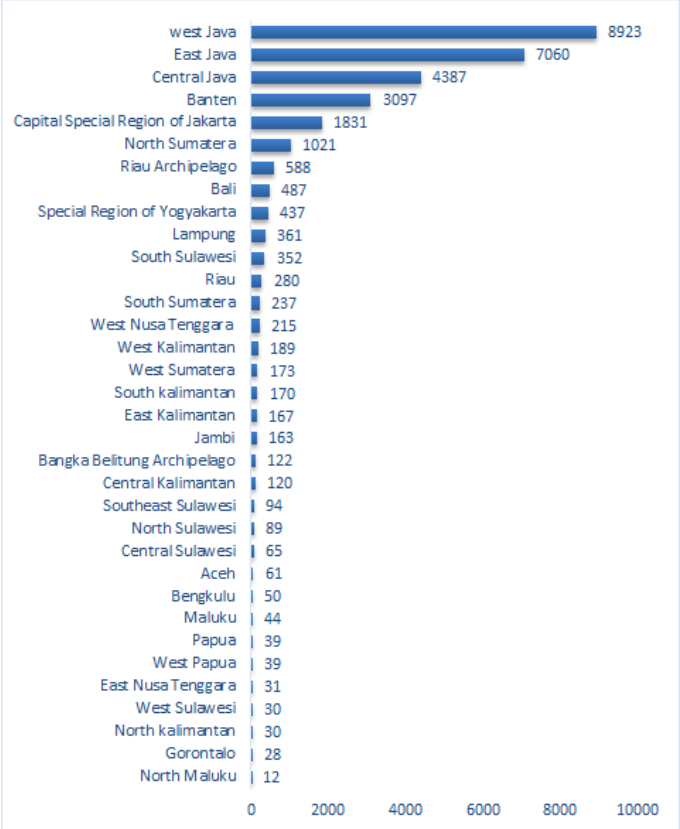


Figure 1. The Number of Middle to Big Industries in Indonesia Based on Provinces

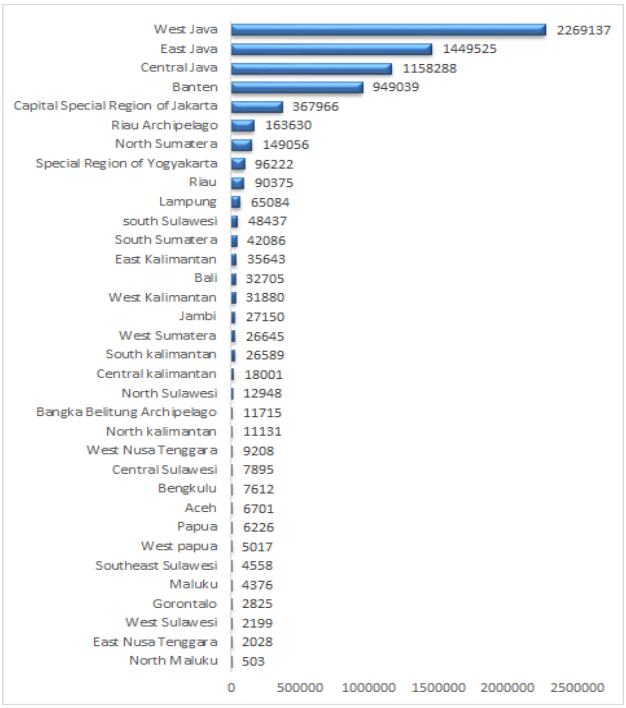


Figure 2. The Number of Workforces of Middle to Big Industries in Indonesia Based on Provinces

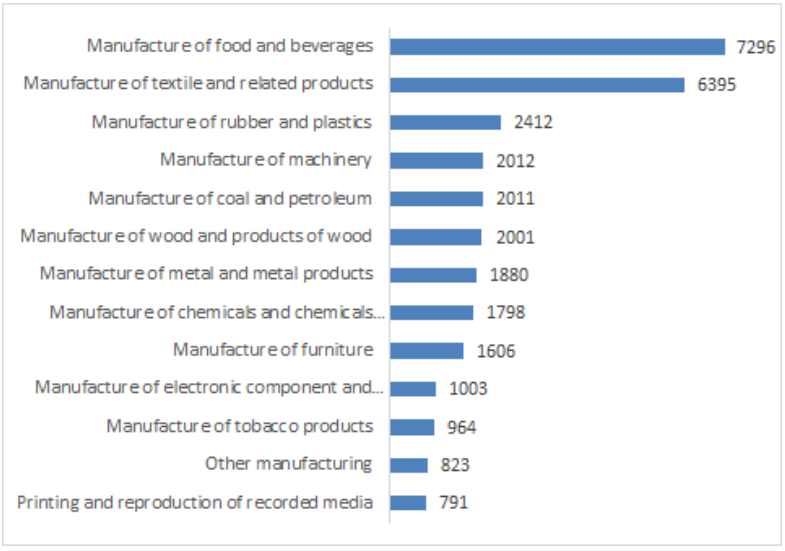


Figure 3. The Number of Middle to Big Industries in Indonesia Based on Commodities

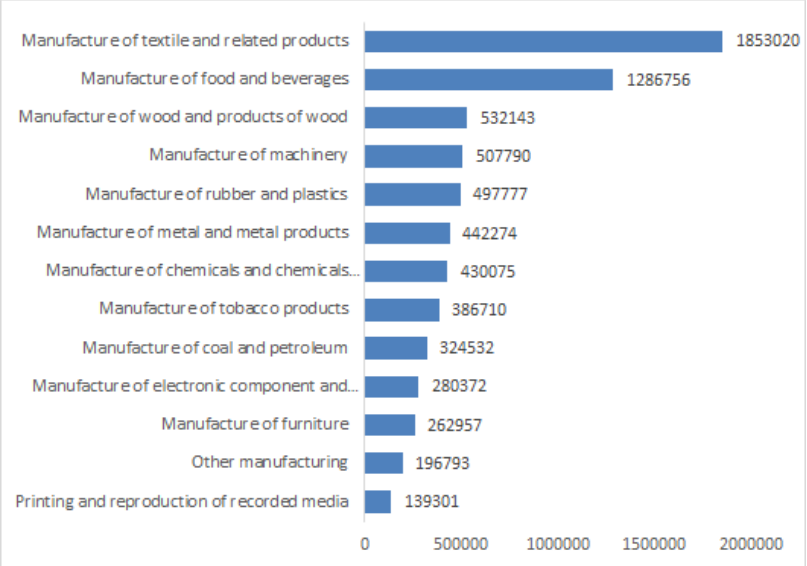


Figure 4. The Number of Workforces in Middle to Big Industries in Indonesia Based on Commodities

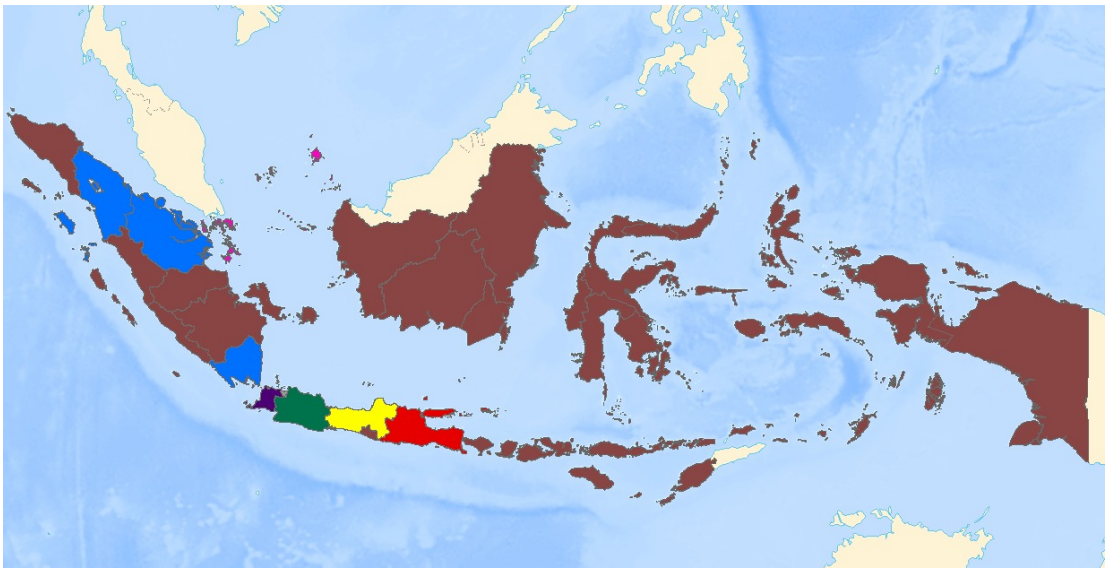


Figure 5. Clustering of Indonesia's Provinces Based on its Industry Concentration

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