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Strategic Ports Activities Analysis in Indonesia by using Agglomerative Clustering Method

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Abstract: Sea transportation is very important and strategic for Indonesia. It is because Indonesia is an archipelagic country with most of its coverage is sea. Therefore, sea is very important in connectivity among islands. One entity in sea connectivity is port. Indonesia has 25 strategic ports that are spread from Sumatera in the West and Papua in the East. One method to analyze the sea transportation activity is by analyzing the ports activity. In this research, we observe and analyze the activity of these 25 strategic ports in Indonesia. Rather than manually, we use computational technology by using clustering method. In this researcher, we use agglomerative clustering method which it is a part of hierarchical clustering method that use bottom-up approach. The port activity parameters that are observed include: cargo loading and unloading, ship call and passenger arrival and departure. We use 2017 data that was published by central bureau of statistics of Indonesia in late of 2018. There are several findings through this research. First, there is significant disparity among strategic ports which is most of them are at low performance or activity. Second, the ports activities strengthen argument that export commodities of Indonesia are dominated by natural resources and raw materials. In the other side, import commodities of Indonesia are dominated by end or cosumer products. Most of industrial products that are supplied by local industry are used to fulfill domestic demand. In passenger activitiy, Batam becomes the most strategic connection between Sumatera, Singapore and Johor.

Key words: Sea port, clustering, agglomerative method, Indonesa, maritime, import commodities

INTRODUCTION

Indonesia is a very big archipelagic country. It consists of more than 18,000 islands that extent from West (95°E) to East (141°E) (Hall, 2009). It means that horizontal length of Indonesia is approximately 5,000 km (Hall, 2009). As an archipelagic country, most of its coverage area is sea. Its total land area is approximately 2 million km^2 and the total sea area is approximately 3 million km^2 (Anonymous, 2004). It has eight major cities, 5 are in the island of Java (Jakarta, Surabaya, Bandung, Tangerang and Semarang) while the others are outside the island of Java (Medan, Palembang, Makassar) (Anonymous, 2004).

As an archipelagic country, sea is very important in Indonesia. Sea plays significant role in transportation of people or goods, so that, controlling and optimizing sea area can boost economical strength. Historically, the two biggest kingdoms in Indonesia which are kingdom of Sriwijaya (863-1225 AD) and kingdom of Majapahit (1293-1389 AD) were maritime kingdom that had strong maritime power to control their sovereignty (Pariwono *et al*., 2005). Indonesian sea also plays strategic role in international trade, especially, connection between Asia and Europe. During Ming Dinasty of China, its emperor has sent its ever largest fleet which it consisted of more than 300 vessels (Pariwono *et al*., 2005; Gavin, 20004). This fleet traveled for Asia expedition and visited Java and Sumatera. This fleet was led by grand eunuchs Cheng Ho as the principal envoys with Wang Ching-hung as assistant envoys (Duyvendak, 1939).

Indonesian sea became more important in international trade during colonial period. In this period, Dutch United India Company or wellknown as VOC was the most significant and successful player in international trade in Indonesia. This company was created in 1602 (Gelderblom *et al*., 2013) in order to force back the Portuguese fleet that has been established earlier and became the largest Asiatic company in 1800 (Gaastra, 2007). Its first operation in Indonesia was in the islands of Mollucas and Banda with most significant product was fine spice such as: nutmeg, mace, cinnamon and clove (Gaastra, 2007). There after, VOC became the biggest competitor of the English East India Company (EIC) in

international trade. Meanwhile, in the end of 17th century, trade and shipping between Asia and Europe became very intensive. Indian textile, Arabian coffee and Chinese were popular commodities (Gaastra, 2007). Besides international trade, by controlling the sea and trade monopoly, VOC then also held inter island trade in the island of Indonesia. In 1619, VOC conquered Javanese port town of Jaccatra (Jakarta). This conquest gave VOC a permanent harbour, warehouse and other facilities to run its operational (Niemeijer, 2007). Then, this port town was called as Batavia. This condition made Batavia as hub between VOC in Asia with the royal Netherland (Niemeijer, 2007). This condition continued until the Dutch Indies took over Indonesia from VOC. Batavia still became the central government of Dutch Indies. After Indonesia got its independence in 1945, Batavia was renamed as Jakarta and became the capital city of Indonesia until now. This long process makes Jakarta as the central economy of Indonesia and Tanjung Priok becomes the most important port in Indonesia.

Based on its historical process, sea plays significant role in Indonesia, especially, in economical aspect. Current government of Indonesia realized this condition. President Joko Widodo announced the Sea Toll which is the government's medisparityroject with its vision is to build and integrate marine logistic in Indonesia (Wicaksana, 2017). This project is designed to accelerate the sea transportation in Indonesia through its main ports such as: Belawan, Tanjung Priok, Tanjung Perak, Makassar and Sorong. Unfortunately, despite of this ambition, there are problems in infrastructure in Indonesia that must be solved, especially, sea port. In 2014 global competitiveness index rankings, in quality of port infrastructure category, Indonesia sat on 89th position and it was worse than Sindisparityore, Malaysia and Thailand (Bui, 2014). This condition made Singapore remained an important hub in Asia.

Based on this fact, to improve the Indonesian ports, these ports condition must be evaluated and analyzed. Basically, government of Indonesia holds and publishes the sea transportation statistics every year. The problem is most of this informastion is presented in tabular and lacks of deep analysis.

Based on this problem, in this research, we analyzed this port statistic information, so that, better perspective can be found. We analyze it by using agglomerative clustering method which it is part of hierarchical clustering method. Related to the sea toll program that held by government of Indonesia, in this research, we focus on the strategic ports only.

MATERIALS AND METHODS

In this research, we collect official data from Sea Transportation Statistics. We use data from year 2017 because this data was launched in November 2018. This data is provided by Central Bureau of Statistic of Indonesia. Sea transportation data that is used in this research includes loading, unloading, ship call and passenger. This data then is stored in database. In this research, we use MySQL database.

Before we explain the clustering work, there is definition about several specific terms that, we use in this research. This definition is based on sea transportation statistics 2017 book. Domestic shipping is shipping from one port to another port in Indonesia. These ports are conducted regularly and consistently or irregularly and inconsistently. International shipping is shipping between port in Indonesia and port in other countries. Strategic port is a port that is equipped with modern port facilities and has high ship movement traffic. Ship call is ship arrival at a port for docking or berthing. Gross Tonage (GT) is total volume of all rooms in a ship. This volume does not include tunnel, axle of propellers and chain locker. Loading is process to load cargo to the ship. Unloading is process to unload cargo from the ship.

The strategic port clustering process is process to load the strategic port data to the clustering application, to group this data and to show the clustering result. The clustering application is developed by using PHP language. This clustering process is shown in Fig. 1. In this research, we use agglomerative method as alternative of the k-means method that was used in our previous researches by Kusuma (2019a, b). The agglomerative method is part of hierarchical clustering method that uses bottom-up approach. Both agglomerative method and k-means method (Aprilia *et al*., 2018) is quantitative clustering process.

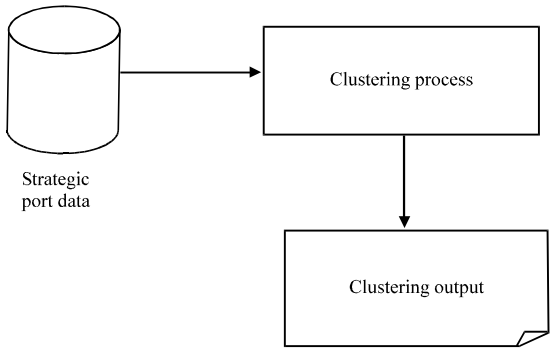

Fig. 1: Strategic port clustering process

There are differences between agglomerative method and k-means method. Agglomerative method uses deterministic approach. Meanwhile, k-means method uses combination between deterministic and stochastic approaches. Stochastics approach is used in k-means method, especially, during initial centroids determination. In k-means method, iteration stops after the cluster's members are stable, so that, there is not any member shifting. Meanwhile, in agglomerative method, iteration stops after the number of clusters is equal to the intended number of clusters.

The iteration process of agglomerative clustering method is shown in Eq. 1. In Eq. 1, variable A represents the action that will be taken after an iteration finish. There are two options stop or continue. The iteration stops only, if the current number of clusters (n_c) is equal to the intended number of clusters(n_{e_intent}):

$$A = \begin{cases} \text{stop}, n_c = n_{c\_intent} \\ \text{continue, else} \end{cases} \quad (1)$$

Basically, agglomerative clustering process can be divided into two steps. First step is initial clustering process. The second step is the iteration to find the proper cluster composition. The agglomerative clustering main algorithm is shown in algorithm 1. In algorithm 1 it is shown that there are four processes that are in the iteration process finding nearest cluster, acquiring these clusters, reclustering and calculating new clusters or centroids. As it is shown in Fig. 1, the iteration process still continues as long as the number of clusters is still higher than the intented number of clusters.

In the initial clustering step, all nodes (p) are viewed as cluster. It is means that the number of clusters is equal to the number of nodes. In this research, the node represents the port. So, the port is represented as a set of ports $\{p_1, p_2, p_3, \ldots, p_{np}\}$ where, n_p is the number of ports. Meanwhile, cluster (c) can be represented as a set of clusters $\{c_1, c_2, c_3, \ldots, c_{nc}\}$ where, n_c is the number of clusters. Based on this concept, the number of members (n_{member}) of every cluster is only one.

Algorithm 1; Agglomerative clustering main algorithm:

```
begin
 set_initialcluster()
 while nc>nc intent do
 begin
  find_nearestcluster()
  cluster_acquisition()
  reclustering()
  calculate_new_centroid()
 end
end
```

The first step inside the iteration process is finding two clusters that are most similar to each other. In this research, this concept is interpreted as finding two clusters that their locations are the nearest among clusters. This process is determined by using Eq. 1 and 2. In this research, link is introduced. Link (l) is a connection between two clusters. This link is unidirectional. Type of links is many-to-many. It means that every cluster has connection with all other clusters in the cluster set. In Eq. 1, it is shown that the selected link (l_{sel}) is link that has the lowest distance. In Eq. 2, the link distance is the Eucledian distance between two clusters: cluster i(c_i) and cluster j(c_j):

$$\begin{aligned} l_{esl} &= l \mid \min\left(d\left(l_k\right)\right) \wedge l \in L \\ d\left(l_k\right) &= \| c_i - c_j \| \end{aligned} \quad (2)$$

After link candidate is selected which it means that clusters with the nearest distance is found, the next step is the acquisition of this cluster (c_j) by another cluster (c_i). This process is shown in Eq. 3. In the acquisition process because c_j is acquired by c_i then all members of c_j become members of c_i. Then cluster c_j will be eliminated:

$$p.c = c_i \mid \forall p.c = c_j \quad (3)$$

The third step is reclustering. In reclustering, the old cluster or cluster that has not been used anymore will be deleted. This cluster (c_j) is cluster that its members have moved to its nearest neighbor (c_i). After that, the remained clusters will be reindexed.

The last step in the iteration process is calculating new centroids. This process is determined by using Eq. 4. In Eq. 4, cluster or centroid is indexed by k. The new centroid value is calculated based on the average value of its members:

$$C_K = \frac{\sum_{n_{member}} (c_K) p \mid p.c = c_k}{n_{member}(c_K)} \quad (4)$$

This agglomerative model is then implemented into clustering application. This application is developed by using PHP language, so that, it is a web based application. In this research, we cluster data of year 2016 and 2017. Data that is clustered is shown in Table 1. We use five clusters for every clustering work.

Table 1: Strategic port clustering list

Cluster No.	Process (2016, 2017)
1	Cargo loading of domestic voyage
2	Cargo unloading of domestic voyage
3	Cargo loading of international voyage
4	Cargo unloading of international voyage
5	Domestic and international ship call
6	Domestic and international passengers arrivals
7	Domestic and international passengers departure

RESULTS AND DISCUSSION

In this study, we will discuss the clustering result. The analysis focuses on the distribution and disparity among clusters. Output parameters that are observed in every cluster include number of ports, average score, total score and port list.

The first clustering result that is analysis is the cargo loading of domestic voyage. The analysis is used to observe the domestic goods distribution among regions in Indonesia. We use data from years 2016 and year 2017. The result of clustering data of year 2016 is shown in Table 2. Meanwhile, the result of clustering data of year 2017 is shown in Table 3.

Table 2 and 3 show that the disparity in cargo loading of domestic voyage among strategic ports in Indonesia is very wide. This condition occurs both in year 2016 and year 2017. As it is shown in in both tables, there are 15 ports in the first cluster. Other clusters are distributed into cluster two to cluster five. It means that 60% of strategic ports in Indonesia are in the first cluster or have the very low activities in loading domestic voyage compared with the ports in the higher clusters. In average cargo loading aspect, performance of ports in the first cluster is also very low compared with performance of ports in the higher cluster. In 2016, the average cargo loading of ports in the first cluster is only 15.1% of the second cluster. Meanwhile, in 2016, the average cargo loading of the ports in the first cluster is only 4% of the ports in the fifth cluster. This condition does not change significantly in year 2017. In 2017, the average cargo loading of the ports in the first cluster is still 15.5% of the ports in the second cluster. In 2017, the average cargo loading of ports in the first cluster falls to only 3.3% of the ports in the fifth cluster.

In total cargo loading aspect, the disparity among clusters is also wide. In 2016, the total cargo loading of ports in the first cluster is 30.3% of the ports in the fifth cluster. This ratio in 2017 falls to only 12.4%. This condition occurs because in 2017, there are 4 ports in the fifth cluster compared to only 2 ports in 2016. These additional ports are Banten and Balikpapan.

The second clustering is cargo unloading of domestic voyage in 2016 and 2017. Cargo unloading of domestic voyage represents the number of goods that comes from other region of Indonesia to this port and then is distributed into this region. The result of year 2016 is shown in Table 4. Meanwhile, the result of year 2017 is shown in Table 5.

Table 4 and 5 show that the disparity in domestic cargo unloading among clusters is very wide. Meanwhile, in cargo unloading aspect, the distribution of ports is better than in cargo loading aspect. In 2016, there are 10 ports in the first cluster and 10 ports in the second cluster Meanwhile, in 2017, there are 12 ports in the first cluster and 9 ports in the second cluster. This condition shows that there is increasing in number of members in the second cluster.

Table 2: Clustering result of cargo loading of domestic voyage, 2016

Ports list	Cluster No.	No. of ports	Average cargo loading (units)	Total cargo loading (units)
Lhokseumawe, Belawan, Pekanbaru, Tanjung Pinang, Batam, Tanjung Emas, Benoa, Tenau,Pontianak, Samarinda, Bitung, Ambon, Sorong, Jayapura, Biak	1	15	507	7.609
Teluk Bayur, Palembang, Makassar	2	3	3.351	10.0520
Dumai, Tanjung Perak, Banjarmasin	3	3	6.174	18.5230
Banten, Balikpapan	4	2	8.734	17.4670
Panjang, Tanjung Priok	5	2	12.540	25.0800

Table 3: Clustering result of cargo loading of domestic voyage, 2017

Ports list	Cluster No.	No. of ports	Average cargo loading (units)	Total cargo loading (units)
Lhokseumawe, Belawan, Pekanbaru, Palembang, Tanjung Pinang, Batam, Tanjung Emas, Benoa, Tenau, Pontianak, Samarinda, Ambon, Sorong, Jayapura, Biak	1	15	374	5.603
Bitung	2	1	2.410	2.410
Teluk Bayur, Dumai, Makassar	3	3	4.578	13.735
Tanjung Perak, Banjarmasin	4	2	7.106	14.211
Panjang, Tanjung Priok, Banten, Balikpapan	5	4	11.332	45.329

Table 4: Clustering result of cargo unloading of domestic voyage, 2016

Ports list	Cluster No.	No. of ports	Average cargo loading (units)	Total cargo loading (units)
Lhokseumawe, Pekanbaru, Palembang, Tanjung Pinang, Benoa, Tenau, Pontianak, Ambon, Sorong, Biak	1	10	767	7.666
Belawan, Teluk Bayur, Dumai, Panjang, Batam, Tanjung Emas, Tanjung Perak, Samarinda, Makassar, Jayapura	2	10	3.968	39.677
Tanjung Priok, Balikpapan, Bitung	3	3	10.133	30.399
Banten	4	1	29.538	29.538
Banjarmasin	5	1	76.589	76.589

Table 5: Clustering result of cargo unloading of domestic voyage, 2017

Ports list	Cluster No.	No. of ports	Average cargo loading (units)	Total cargo loading (units)
Lhokseumawe, Dumai, Pekanbaru, Palembang, Tanjung Pinang, Benoa, Tenau, Pontianak, Ambon, Sorong, Jayapura, Biak	1	12	975.00	11.701
Belawan, Teluk Bayur, Panjang,Batam, Tanjung Emas, Samarinda, Makassar	2	7	4.699	32.896
Tanjung Priok, Tanjung Perak, Balikpapan, Bitung	3	4	9.824	39.296
Banten	4	1	35.008	35.008
Banjarmasin	5	1	78.711	78.711

Table 6: Clustering result of cargo loading of international voyage, 2016

Ports list	Cluster No.	No. of ports	Average cargo loading (units)	Total cargo loading (units)
Lhokseumawe, Pekanbaru, Palembang, Batam, Tanjung Emas, Tanjung Perak, Benoa, Tenau, Pontianak, Bitung, Makassar	1	11	412.00	4.529
Belawan, Teluk Bayur, Panjang, Tanjung Pinang, Tanjung Priok, Banten	2	6	3.614	21.685
Dumai, Balikpapan	3	2	11.942	23.884
Samarinda	4	1	16.936	16.936
Banjarmasin	5	1	51.455	51.455

Table 7: Clustering result of cargo loading of international voyage, 2017

Ports list	Cluster No.	No. of ports	Average cargo loading (units)	Total cargo loading (units)
Lhokseumawe, Belawan, Pekanbaru, Palembang, Batam, Tanjung Emas, Tanjung Perak, Benoa, Tenau, Pontianak, Bitung, Makassar, Ambon, Sorong, Jayapura, Biak Teluk	1	16	371.00	5.930
Bayur, Panjang, Tanjung Pinang, Tanjung Priok, Banten	2	5	3.754	18.768
Dumai, Samarinda	3	2	7.420	14.840
Balikpapan	4	1	9.242	9.242
Banjarmasin	5	1	69.525	69.525

In average cargo unloading aspect, the analysis is as follows. In 2016, the average cargo unloading in the ports in the first cluster is only 1% of the fifth cluster. In 2017, this value increases to 1.2%. Both in 2016 and 2017, the average cargo unloading of ports in the fourth cluster is still less than in the fifth cluster.

In total cargo unloading aspect, the distribution is more equal. In 2016, the total cargo unloading of ports in the first cluster is 10% of ports in the fifth cluster. Meanwhile, this disparity is reduced in 2017. In 2017, total cargo unloading of ports in the first cluster is 14.9% of in the fifth cluster.

The third clustering is cargo loading of international voyage in 2016 and 2017. International cargo loading represents the export size of Indonesia. So, analyzing the international cargo loading of these strategic ports is important to analyze the export potentials in regions in Indonesia. The clustering result of year 2016 is shown in Table 6. Meanwhile, the clustering result of year 2017 is shown in Table 7.

Table 6 and 7 show that in 2016 and 2017, the number of ports in cluster three to cluster five does not change, except Samarinda and Balikpapan. Meanwhile, there is dynamic in cluster one and cluster two. In 2016, total ports in cluster one and cluster two is 17 ports. Meanwhile, there are 21 ports totally in cluster one and cluster two. Based on this condition, there are 5 ports in Indonesia that started to run export in 2017.

In average cargo loading, the disparity among clusters is very wide. This condition occurs both in 2016 and 2017. In 2016, the average cargo loading of ports in cluster one is only 0.8% of in cluster five. Meanwhile, in 2017, the average cargo loading of ports in cluster one is 0.5% of in cluster five. So, it can be said that this disparity is wider in 2017 than in 2016. Comparing the average internationl cargo loading in the third cluster to the fifth cluster between 2016 and 2017, it is indicated there is some cargo shifting from ports in cluster three and cluster four to cluster five.

In total cargo loading aspect, the disparity among clusters is wide. In 2016, the total cargo loading of ports in the first cluster is 0.8% of ports in the fifth cluster. Meanwhile, in 2017, the total cargo loading of ports in the first cluster fall to 0.5% of ports in the fifth cluster. So, the disparity in international cargo loading among ports in 2017 is wider than in 2016.

The fourth clustering is cargo unloading of international voyage in 2016 and 2017. International cargo unloading represents the import size of Indonesia. So, analyzing the international cargo unloading of these strategic ports is important to analyze the import consumption in regions in Indonesia. The clustering result of year 2016 is shown in Table 8. Meanwhile, the clustering result of year 2017 is shown in Table 9.

Table 8 and 9 show that in international cargo unloading aspect, the disparity among clusters is wide. In

Table 8: Clustering result of cargo unloading of international voyage, 2016

Ports list	Cluster No.	No. of ports	Average cargo unloading (units)	Total cargo unloading (units)
Lhokseumawe, Teluk Bayur, Dumai, Pekanbaru, Palembang, Batam, Benoa, Tenau, Pontianak, Banjarmasin, Samarinda, Bitung, Sorong, Biak	1	14	176	2.461
Belawan, Panjang, Tanjung Pinang, Tanjung Emas, Makassar	2	5	2.202	11.012
Balikpapan	3	1	6.173	6.173
Tanjung Perak	4	1	8.110	8.110
Tanjung Priok, Banten	5	2	17.673	35.346

Table 9: Clustering result of cargo unloading of international voyage, 2017

Ports list	Cluster No.	No. of ports	Average cargo unloading (unit)	Total cargo unloading (units)
Lhokseumawe, Teluk Bayur, Dumai, Pekanbaru, Palembang, Panjang, Tanjung Pinang, Batam, Tanjung Emas, Benoa, Tenau, Pontianak, Banjarmasin, Samarinda, Bitung, Makassar, Ambon, Sorong, Jayapura, Biak	1	20	429	8.579
Belawan, Balikpapan	2	2	4.400	8.799
Tanjung Perak	3	1	6.960	6.960
Tanjung Priok	4	1	15.643	15.643
Banten	5	1	24.397	24.397

Table 10: Clustering result of domestic and international ship call, 2016 (Unit)

Ports list	Cluster No.	No. of ports	Average ship call	Total ship call
Lhokseumawe, Belawan, Teluk Bayur, Dumai, Palembang, Panjang, Tanjung Emas, Benoa, Tenau, Pontianak, Balikpapan, Bitung, Makassar, Ambon, Sorong, Jayapura, Biak	1	17	3.130	53.215
Pekanbaru, Banten	2	2	9.619	19.238
Tanjung Priok, Tanjung Perak	3	2	13.872	27.743
Tanjung Pinang, Banjarmasin, Samarinda	4	3	22.648	67.945
Batam	5	1	97.121	97.121

Table 11: Clustering result of domestic and international ship call, 2017 (Unit)

Ports list	Cluster No.	No. of ports	Average ship call	Total ship call
Lhokseumawe, Belawan, Teluk Bayur, Dumai, Palembang, Panjang,Tanjung Emas, Benoa, Tenau, Pontianak, Balikpapan, Bitung, Makassar, Ambon, Sorong, Jayapura, Biak	1	17	2.938	49.947
Banten	2	1	9.423	9.423
Tanjung Priok, Tanjung Perak, Samarinda	3	3	13.176	39.528
Pekanbaru, Tanjung Pinang, Banjarmasin	4	3	20.858	62.575
Batam	5	1	82.167	82.167

number of ports by adding number of ports in cluster one and two, there are 19 ports in 2016 and there are 22 ports in 2017. Overall, in 2016, there are 23 strategic ports that run import activity. Meanwhile, in 2017, there are 25 strategic ports that run import activity.

In average cargo unloading aspect, the disparity among clusters is wide. In 2016, the average cargo unloading of ports in the first cluster is 0.9% of ports in the fifth cluster. In 2016, the average cargo unloading of ports in the fourth cluster is 45.9% of porst in the fifth cluster. There is difference in 2017, in 2017, the average cargo unloading of ports in the first cluster is 1.7% of ports in the fifth cluster. Meanwhile, the average cargo unloading of ports in the fourth cluster is 64.1% of ports in the fifth cluster. So, it can be said that import disparity among ports in 2016 were reduced in 2017.

In total cargo unloading aspect, the disparity in 2017 is smaller than in 2016. In 2016, the total cargo unloading of ports in the first cluster is 6.9% of ports in the fifth cluster. Meanwhile, in 2017, the total cargo unloading of ports in the first cluster is 35.2% of ports in the fifth cluster.

The fifth clustering is domestic and international ship calls in 2016 and 2017. The ship call indicates how busy or the load of the ports. The ship call clustering result that is presented in unit is shown in Table 10 for 2016 and Table 11 for 2017. Meanwhile, the ship call clustering result that is presented in GT is shown in Table 12 for 2016 and Table 13 for 2017.

Table 10 and 11 show that in domestic and international ship call aspects, there is significant disparity among ports in Indonesia. Most of ports are in the first cluster. Number of strategic ports in the first cluster is 68% of the total strategic ports in Indonesia. Meanwhile, there is dynamic in cluster two to cluster four. In both years, Batam is the only port in the fifth cluster. In the average ship call, generally, there is declination in ship call from 2016-2017. This declination occurs in all clusters.

Table 12: Clustering result of domestic and international ship call, 2016 (GT)

Ports list	Cluster No.	No. of ports	Average ship call	Total ship call
Lhokseumawe, Teluk Bayur, Pekanbaru, Palembang, Panjang, Tanjung Pinang, Benoa, Tenau, Pontianak, Bitung, Ambon, Sorong, Jayapura, Biak	1	14	7.552	105.729
Belawan, Dumai, Batam, Tanjung Emas, Makassar	2	5	28.930	144.651
Tanjung Perak, Banten, Balikpapan, Samarinda	3	4	63.031	252.124
Banjarmasin	4	1	91.404	91.404
Tanjung Priok	5	1	120.269	120.269

Table 13: Clustering result of domestic and international ship call, 2017 (GT)

Ports list	Cluster No.	No. of ports	Average ship call	Total ship call
Lhokseumawe, Teluk Bayur, Pekanbaru, Palembang, Tanjung Pinang, Benoa, Tenau, Pontianak, Bitung, Ambon, Sorong, Jayapura, Biak	1	13	7.508	97.604
Belawan, Dumai, Panjang, Batam, Tanjung Emas, Makassar	2	6	30.276	181.656
Banten, Balikpapan, Samarinda	3	3	50.959	152.878
Tanjung Perak, Banjarmasin	4	2	92.507	185.014
Tanjung Priok	5	1	142.604	142.604

Table 14: Clustering result of domestic and international passengers arrivals, 2016

Ports list	Cluster No.	No. of ports	Average passenger arrival	Total passenger arrival
Lhokseumawe, Belawan, Teluk Bayur, Pekanbaru, Palembang, Panjang, Banten, Pontianak, Banjarmasin, Samarinda, Bitung, Biak	1	12	33.145	397.745
Dumai, Tanjung Priok, Tanjung Emas, Tenau, Balikpapan, Ambon, Sorong, Jayapura	2	8	183.657	1,469.253
Tanjung Perak, Benoa, Makassar	3	3	347.300	1,41.900
Tanjung Pinang	4	1	751.591	751.591
Batam	5	1	4,403.888	4,403.888

Table 15: Clustering result of domestic and international passengers arrivals, 2017

Ports list	Cluster No.	No. of ports	Average passenger arrival	Total passenger arrival
Lhokseumawe,Belawan,Teluk Bayur, Pekanbaru, Palembang, Panjang, Banten, Pontianak, Banjarmasin, Samarinda, Bitung, Biak	1	12	26.746	320.955
Dumai, Tanjung Priok, Tanjung Emas, Tanjung Perak, Tenau, Balikpapan, Makassar, Ambon, Sorong, Jayapura	2	10	185.376	1.853,760
Benoa	3	1	391.217	391.217
Tanjung Pinang	4	1	905.035	905.035
Batam	5	1	4.492,826	4.492,826

Analysis of the average ship call (unit) is as follows. In 2016, the average ship call of ports in the first cluster is 3.2% of the ports in the fifth cluster. Meanwhile, in 2017, the average ship call of ports in the first cluster is 3.6 of ports in the fifth cluster. In total ship call aspect, the lowest total ship call is not held by cluster with the lowest average number of ship calls.

Table 12 and 13 show that the disparity in ship call among clusters in 2016 is smaller than in 2017. Basically, there is small dynamic in number of members in every cluster between 2016 and 2017. Meanwhile, both in 2016 and in 2017, Tanjung Priok is still the only port in the fifth cluster.

In average ship call aspect in 2016, the average ship call of ports in the first cluster is 6.3% of the ports in the fifth cluster. Meanwhile, in 2017, the average ship call of ports in the first cluster is reduced to 5.2% of ports in the fifth cluster. The reason is there is increasing in ship call in Tanjung Priok. Meanwhile, the ship call in ports in the first cluster tends to stagnant.

The sixth clustering is the passenger arrivals. Passenger arrival indicates the people mobility that enters the port, both form other domestic ports and international ports. The result of passenger arrival 2016 is shown in Table 14. Meanwhile, the result of passenger arrival 2017 is shown in Table 15.

Based on data in Table 14 and 15, Batam is still port with the highest passenger arrival both in 2016 and in 2017. Meanwhile, Tanjung Pinang is the second highest passenger arrival port both in 2016 and 2017 and it stands in the fourth cluster. The disparity between Batam and other ports is significant high. In 2016, the passenger arrival in Tanjung Pinang is only 17% of passenger arrival in Batam. Meanwhile, in 2017, the passenger arrival in Tanjung Pinang is 20.6% of passenger arrival in Batam. It is because there is increasing in passenger arrival in Tanjung Pinang while in Batam, the passenger arrival is stagnant. Unfortunately, there is reduction in average passenger arrival in the first cluster. From 33,145 arrivals in 2016, this value is down to 26,746 arrivals in 2017.

Table 16: Clustering result of domestic and international passengers departures, 2016

Ports list	Cluster No.	No. of ports	Average passenger departure	Total passenger departure
Lhokseumawe, Belawan, Teluk Bayur, Pekanbaru, Palembang, Panjang, Banten, Pontianak, Banjarmasin, Samarinda, Bitung, Jayapura, Biak	1	13	38.690	502.965
Dumai, Tanjung Priok, Tanjung Emas, Tanjung Perak, Benoa, Tenau, Balikpapan, Ambon, Sorong	2	9	223.535	2,011.817
Makassar	3	1	482.177	482.177
Tanjung Pinang	4	1	756.843	756.843
Batam	5	1	4.353,896	4,353.896

Table 17: Clustering result of domestic and international passengers departures, 2017

Ports list	Cluster No.	No. of ports	Average passenger departure	Total passenger departure
Lhokseumawe, Belawan, Teluk Bayur, Pekanbaru, Palembang, Panjang, Tanjung Priok, Tanjung Emas, Banten, Tenau, Pontianak, Banjarmasin, Balikpapan, Samarinda, Bitung, Sorong, Jayapura, Biak	1	18	63.669	1.146,050
Dumai, Tanjung Perak, Makassar, Ambon	2	4	270.259	1.081,036
Benoa	3	1	394.390	394.390
Tanjung Pinang	4	1	922.996	922.996
Batam	5	1	4.543,672	4.543,672

In total passenger arrival aspect, it shows that Batam is very dominant among other ports. The sum of passenger arrival from all other ports still cannot outnumber the passenger arrival in Batam. Based on this condition, passenger mobility in sea transportation is concentrated in Batam.

The seventh clustering is the passenger departures. Passenger departure indicates the people mobility that leaves the region from related port both to other domestic ports and international ports. The result of passenger departure 2016 is shown in Table 16. Meanwhile, the result of passenger departure 2017 is shown in Table 17. Similar to condition in passenger arrival, in passenger departure, Batam still becomes the port with the highest passenger departure. Meanwhile, Tanjung Pinang still becomes the port with the second highest passenger departure. By observing the port distribution, the number of ports in the first cluster is very dominant compared with the number of ports in other clusters.

In average passenger departure, in the first cluster, there is increasing in 2017 compared with 2017 data. In the third cluster, Benoa replaces Makassar as the only one port in the third cluster. Meanwhile, in 2017, Makassar falls into the second cluster. The disparity in 2017 is also smaller than the disparity in 2016. In 2016, the average passenger departure of ports in the first cluster is 0.9% of ports in the fifth cluster. Meanwhile, in 2017, the average passenger departure of ports in the first cluster is 1.4% of ports in the fifth cluster.

In total passenger departure, the condition is similar to passenger arrivals. Batam is very dominant among other strategic ports in Indonesia. The sum of passenger departure of all other ports still cannot outnumber the passenger departure of Batam. This condition occurs both in 2016 and 2017.

Based on the clustering result and quantitative analysis, in this study, we will discuss the qualitative analysis. Besides that, we also connect the clustering result with other aspects such as geographic, demographic and economic. This comprehensive analysis is needed to get findings in this research.

In domestic cargo loading, it is shown that Panjang and Tanjung Priok dominate the maritime domestic connectivity, especially, in transporting goods. After that, there are Banten and Balikpapan. As, we know that Jakarta is the capital city of Indonesia and also the economic epicentrum of Indonesia. Industrialization in Indonesia is centralized in Jakarta and cities around it such as Tangerang, Bekasi, etc. Industry in West Java and Banten is also massive. Meanwhile, Banten and Tanjung Priok are the only ports that can be used by these provinces (DKI Jakarta, Banten and West Java) to distribute goods that are produced in these provinces. Meanwhile, Panjang as its location is in Lampung is port in Sumatera that its location is the closest to the island of Java. So, it is shown that product connectivity between Java and Sumatera is significant high. Meanwhile, there are three provinces outside the island of Java that its domestic cargo loading is high Dumai, Balikpapan and Banjarmasin. These provinces are well known for their natural resources oil, palm otil, timber and minerals, especially coal. Unfortunately, connectivity to the East part of Indonesia is low. It is shown that the domestic cargo loading in Tanjung Perak as port that connects the island of Java to the East part of Indonesia is not dominant enough.

In international cargo loading, it is shown that ports in the third to the fifth clusters are Dumai, Balikpapan, Samarinda and Banjarmasin. As it is mentioned before are provinces that produce natural resources massively. In the other side, ports that are related with the center of industry in Indonesia (Tanjung Priok, Tanjung Perak and Banten) are in the first or second cluster. This condition strengthens statement that industry in Indonesia is not strong enough. Raw materials and natural resource still dominate the export commodities in Indonesia rather than industrial product.

In the other side, when we look deeper in the international cargo unloading part, Tanjung Priok, Banten, and Tanjung Perak are very dominant. It means that these three provinces are the most significant gateway for imported products in Indonesia. These three provinces are also in the island of Java which its population is very high compared with population outside the island of Java. It means that imported commodities of Indonesia are dominated by end products or cosumer products.

In ship call aspect, both in unit based or GT based clustering, strategic ports in the first cluster is visited by small vessels in small frequency. It shows that economic disparity in Indonesia is very wide. In unit based clustering, Batam dominates in vessel visit. Meanwhile, in GT based clustering, Tanjung Priok dominates the vessels visit. It means that visitation characteristic in Batam is small or medium vessels in high frequency. Meanwhile, visitation characteristic of Tanjung Priok is big vessels in medium frequency.

This condition is supported by the geographic aspect in both ports. Tanjung Priok is encircled with wide industrial area. So, cargo vessel is dominant in Tanjung Priok. Meanwhile, when we look deeper in passenger mobility (arrival and departure), Batam is the most dominant port among other ports. The geographical aspect cannot be ignored. Batam is the nearest port of Indonesia to Singapore or Johor (Malaysia). Therefore, Batam becomes the most significant gateway for people connectivity from Indonesia, especially, Sumatera to Singapore and Johor.

CONCLUSION

In this research, we have clustered and analyzed the situation of 25 strategic ports in Indonesia. This research shows that there is significant performance disparity among ports in Indonesia. Most of strategic ports in Indonesia are still under performed (low cargo, low visit, low passenger). Connectivity between Java and Sumatera is very high compared with other connectivities in Indonesia. This research also shows that export commodities of Indonesia are dominated by natural resources and raw materials. Meanwhile, the import commodities of Indonesia are dominated by end products or consumer products.

This research is part of implementation of computational technology in economic and development studies, specifically, in transportation study. In the future, air and land transportation are also important to be analyzed and computational technology is very powerful tool rather than manual work.

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