



HUB AND SPOKE AIRPORT NETWORKS IN SULAWESI ISLAND, INDONESIA BASED ON FREIGHT RATIO

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ABSTRACT

Demand of air transportation services keep increasing each year in line with the increasing of population and welfare. Sultan Hasanuddin International Airport Makassar (SHIAM) is the 4th busiest airport in Indonesia and the busiest airport in Sulawesi Island. This paper aims to analysis hub and spoke airport networks in Sulawesi Island based on the freight ratio. Based on freight ratio value, airport can be classified in four types i.e.: full passenger airport, freight interest airport, freight specialist airport, and mixed passenger and freight airport. The freight ratio analysis for domestic flight carried out for six airports and two for international flight. The results of the study show that the freight ratio value for domestic flight is 0.443-6.222 kg/passenger. SHIAM has the highest of freight ratio value for domestic flight and international flight and categorized as a mixed passenger and freight airport. Tampa Padang Airport in Mamuju, West Sulawesi categorized as a full passenger airport category. Sam Ratulangi International Airport in Manado, Djalaluddin Airport in Gorontalo, Mutiara Airport in Palu, and Haluoleo (Wolter Monginsidi) Airport in Kendari categorized as mixed passenger and freight airport category. Freight ratio value for international flight is 5.961 kg/passenger for Sam Ratulangi International Airport in Manado and 9.574 kg/passenger in Sultan Hasanuddin International Airport. Two airports includes in mixed passenger and freight airport category.

Keywords: hub and spoke, freight ratio, sultan Hasanuddin international airport, Sulawesi Island, airport network.

INTRODUCTION

Sultan Hasanuddin International Airport Makassar (SHIAM), originally named Kadieng Flying Field is the 4th busiest airport in Indonesia and the busiest airport in Sulawesi Island that serving 9,581,561 passengers and 68,860,884 kilograms of goods in 2017 [1]. Sultan Hasanuddin Airport serves the Eastern Indonesia area and South Sulawesi Province. Soekarno-Hatta International Airport (SHIA) in Cengkareng is the 1st busiest, Juanda International Airport in Surabaya, East Java is the 2nd busiest, and the Ngurah Rai International Airport in Denpasar, Bali is the 3rd busiest airport in Indonesia. In 1990, the Indonesian government Sultan Hasanuddin International Airport Makassar (SHIAM) as the third Indonesian hajj embarkation airport for Sulawesi region which also consists of West Sulawesi, Central Sulawesi, North Sulawesi, South East Sulawesi, Gorontalo, and South Sulawesi Province. Demand of air transportation services keep increasing each year in line with the increasing of population and welfare.

Hub and spoke network pattern has been introduced and developed in the aviation world in United States since the early 1980s, triggered by the enforcement of the Airline Deregulation Act (ADA) in 1978 [2]. Airline Deregulation Act promoted considerable deployment of the hub and spoke network structures for the airports and airlines operations worldwide, and contributed also to the overall costs' reduction both for passenger and air cargo traffic [3]. The Airline Deregulation Act of 1978 freed airlines from 40 years of economic regulation [4]. "An Hub is an airport where traffic is concentrated to foster connections, typically to

intercontinental long-haul destinations" [5]. All passengers in a pure point-to-point system board at flight origin and deplane at the destination. In the hub and spoke system, by contrast, all passengers except those whose origin or destination is the hub, transfer at the hub for a second flight to their destination. Each has advantages best suited for certain markets that make an eventual predominance of one system unlikely [6]. Li *et al.* [7] and Danesi [8] using a routing factor to analysis dual-hub airport network connectivity. Oktal and Ozger [9] stated that factors affecting hub location in cargo transportation are aircraft range and trip cost, runway availability, and cargo traffic continuity of an airport.

The advantages of application of hub and spoke in airport network are consolidation of passengers, decreased the number of routes, increase demand (frequent flights) and decrease costs [10]. As in the road transport, various ways have been done to reduce the transportation costs or generalized costs by applying congestion charges [11,12], identification of black spot locations to reduce accident costs [13] and road safety audit at black spot area [14]. Traffic to regional air express and airfreight hubs is likely to respond in complex ways to fuel costs [10]. The carrier can save the fixed cost by forming the hub-spoke network [15]. In contrast to road transport, on air transport the fuel cost is a very large component. On road transport, the components of transportation costs include vehicle operating costs, travel time costs, and externality costs (i.e.: congestion cost and accident costs). Vehicle operating cost can be decreased by improved road surface pavement [16, 17]. Accident costs can be decreased by reducing accident frequency and injury severity [18] and



determining the speed limit to reduce speeding [19-20]. Total accident cost in Purbalingga Central Java, Indonesia was estimated 0.38% of the gross domestic product [21].

Environmental externalities in aviation operation is resulted from the aircraft and ground support noise and emissions. Based on the passengers' movement, London's Heathrow Airport (LHR) is the busiest airport in United Kingdom. In aviation operation, the noise effects have significant impact on health of human and welfare [22]. Annual impacts of aircraft noise on residential property values in the United States amounts to US\$100-400 per person near an airport fence line [23]. Congestion spill-over from London's Heathrow Airport can impact air traffic in Birmingham and Manchester [24].

Discussions of airline competition analysis and network strategies in a hub and spoke system can be found in [25-27]. One of the efforts that can be done to perform the air transportation network is determine the hub and spoke airports. Hub and spoke airport networks enable carriers to supply transport services to many combinations of origin and destination zones at high frequencies and low costs. The disadvantage for the traveler is of course that they have to make a detour via the hub airport implying an extra stop. For many combinations of origin and destination zone, travelers can choose between more than one main carrier and airport [28,29]. Çiftçi and Sevklı [30] propose a multi-objective model for the selection of a newly constructed hub and spoke system. This model used to maximize aircraft utilization and revenue whilst reducing the commercially infeasible network detour factor. Unit passenger revenues and operating costs for the segments, distances between cities and hubs, expected load factors and flying times of segments. Factors that affect the network structure of an airline are as follows: number of hubs, potential traffic at the hub cities, and location of the hub in order to minimize flying costs, good airport facilities, good weather facilities and strategy of competitors [31].

Shao and Sun [32] using the network Data Envelopment Analysis (DEA) models to analyze the performance evaluation of China's air routes. Most air route's efficiency of freight transport was much lower than its deficiency of passenger transport, and the airports with many air routes have high efficiencies. DEA has been widely used in studies on the civil air aviation's efficiency analysis [32-34] and airport [35-37]. Dobruszkes et al. [38] stated that Low-Cost Carriers (LCCs) are increasing their operations from major airports, while generally continuing their growth and expansion strategy. Some authors have nevertheless analysed how LCCs are accommodated at large, traditional airports [39-43].

Three categories of airport are major hubs, secondary hubs, and secondary airport [44]. The characteristic of three categories of airport are follows:

A. Major hubs

This is where the leading scheduled carriers and strategic alliances will focus their traffic.

B. Secondary hubs

They have an attractive catchment area, function as feeder airports for mega-hubs, and have a hub function for small partners of a strategic alliance or for certain regions.

C. Secondary airports

They have an attractive catchment area, an important feeder function for the big hubs and offer a certain number of direct scheduled connections, although intercontinental flights are the exception here. Secondary airports do not have a hub function [44].

The number of hub flight is based on the number of spoke and inter-connected city [45]. Classification of airport as a hub or spoke can be classified based on the Freight Ratio (FR). Freight ratio is ratio between the number of cargo (kg) and the number of passenger boarding in the airport (passenger). Based on freight ratio value, airport can be classified in four types i.e.: full passenger airport, freight interest airport, freight specialist airport, and mixed passenger and freight airport. The classification of airport based on freight ratio is follows:

- a) Full passenger airport is airport with freight ratio value is very low.
- b) Freight interest airport is airport with freight ratio value between 30-100 kg per passenger.
- c) Freight specialist airport is airport with freight ratio value is more than 100 kg per passenger.
- d) Mixed passenger and freight airport is airport with freight value is 30 kg per passenger and the number of passenger boarding in the airport is high.

Hierarchy of airports in Indonesia as referred to KM Ministry of Transportation Republic of Indonesia No. 11 (2010) in article 9 (1) consists of hub airport and spoke airport [46]. Hub airport is an airport that has a broad coverage of various service airport serving the passenger and/or cargo and influence the development of the national economy or the provinces. Spoke airport is airports that has service coverage and affect the development of the local economy, destination airport and supporting infrastructure service local activities.

The aim of this paper is to evaluate the hub and spoke airport networks in Sulawesi Island, Indonesia based on freight ratio.

METHODS

Study location

The study location was in six airports in Sulawesi Island, Indonesia i.e.: Tampa Padang Airport in Mamuju, West Sulawesi; Djalaluddin Airport in Gorontalo, Mutiara Airport, Palu, Central Sulawesi; Sultan Hasanuddin International Airport, Makassar, South Sulawesi; Haluoleo (Wolter Monginsidi) Airport, Kendari, South East



Sulawesi, and Sam Ratulangi International Airport, Manado, North Sulawesi. The airport that is taken is the largest airport in each province. Six airports in Sulawesi Island, Indonesia are shown in Figure-1.

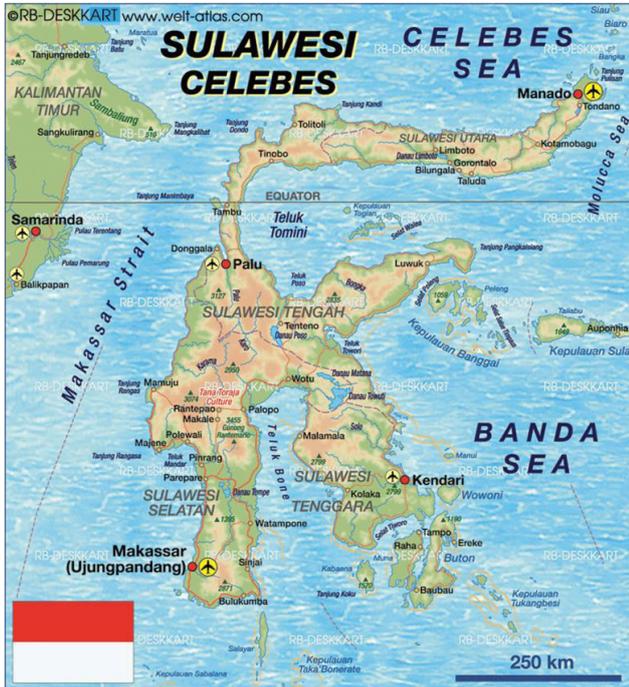


Figure-1. Six airports in Sulawesi Island, Indonesia.

Data collection and analysis approach

Based on the freight ratio value, an airport can be classified as a hub airport or a spoke airport. Freight ratio is ratio between the number of cargo and the number of passenger boarding in the airport. The unit of freight ratio is kg per passenger boarding. The formula of freight ratio as follows:

$$FR_i = \frac{\sum \text{Cargo}}{\sum \text{Passenger}} \quad (1)$$

With FR_i is the freight ratio of an airport i , \sum -cargo is the number of cargo in kg and \sum -passenger is the number of passenger boarding in the airport in people.

Based on the analysis result of freight ratio value, then an airport can be classified in four types i.e.: full

passenger airport, freight interest airport, freight specialist airport, or mixed passenger and freight airport.

Data collection

Data required includes the production data from six airports in Sulawesi Island, Indonesia comprises the number of passengers boarding (people), the number of cargo (kg) for domestic and international flights. Data of flight traffic consist of aircraft traffic, passengers, baggage, and cargo. Data production of each airport is obtained from the Directorate General of Civil Aviation, Ministry of Transportation Republic of Indonesia in 2017 [1], PT. (Persero) Angkasa Pura and Technical Executors Unit under Regional Office of Ministry of Transportation Republic of Indonesia.

RESULTS AND DISCUSSIONS

Freight ratio value for domestic flight

The freight ratio analysis for domestic flight in Sulawesi Island carried out for six airports. The airport that is taken is the largest airport in each province. Six airports in Sulawesi Island, Indonesia i.e.: Tampo Padang Airport in Mamuju, West Sulawesi; Djalaluddin Airport in Gorontalo, Mutiara Airport, Palu, Central Sulawesi; Sultan Hasanuddin International Airport, Makassar, South Sulawesi; Haluoleo (Wolter Monginsidi) Airport, Kendari, South East Sulawesi, and Sam Ratulangi International Airport, Manado, North Sulawesi.

The freight ratio value for domestic flight from six airports in Sulawesi Island between 0.443 to 6.222 kg per passenger. Sultan Hasanuddin International Airport Makassar (SHIAM) South Sulawesi has the highest of freight ratio value (6.222 kg per passenger) and categorized as a mixed passenger and freight airport because the freight ratio value is lower than 30 kg per passenger and the number of passenger boarding in the airport is high. Based on the freight ratio value, Tampo Padang Airport in Mamuju, West Sulawesi categorized as a full passenger airport because the freight ratio value is very low (0.443 kg per passenger). Sam Ratulangi International Airport in Manado, Djalaluddin Airport in Gorontalo, Mutiara Airport in Palu, and Haluoleo (Wolter Monginsidi) Airport in Kendari categorized as mixed passenger and freight airport category. The number of passengers boarding, number of cargo, and freight ratio value for domestic flight from six airports in Sulawesi Island, Indonesia is shown in Table-1.

**Table-1.** Freight ratio value for domestic flight from six airports in Sulawesi Island, Indonesia.

Airport, City	Number of passengers boarding (people)	Number of cargo(kg)	Freight ratio (kg per passenger)	Category airport
Sam Ratulangi, Manado	930,517	5,378,145	5.780	Mixed passenger and freight airport
Djalaluddin, Gorontalo	381,082	2,295,757	6.024	Mixed passenger and freight airport
Mutiara, Palu	672,698	3,075,858	4.572	Mixed passenger and freight airport
Tampa Padang, Mamuju	48,494	21,488	0.443	Full passenger airport
Sultan Hasanuddin, Makassar	8,436,271	52,491,364	6.222	Mixed passenger and freight airport
Haluoleo (Wolter Monginsidi), Kendari	662,468	3,123,571	4.715	Mixed passenger and freight airport

The result of freight ratio analysis in Sulawesi Island, Indonesia is similar with the freight ratio in Kalimantan Island [29]. Freight ratio value for domestic flight from five airports in Kalimantan Island, Indonesia at 0.945 to 7.002 kg per passenger. Syamsuddin Noor Airport in Banjarmasin has the highest of freight ratio value and categorized as a mixed passenger and freight airport. Supadio Airport in Pontianak categorized as a full passenger airport. Tjilik Riwut Airport, Sultan Aji Muhammad Sulaiman Sepinggian Airport, and Juwata Airport categorized as a mixed passenger and freight airport category.

Freight ratio value for international flight

There are two airports in Sulawesi Island, Indonesia that serve international flight i.e.: Sam Ratulangi International Airport in Manado, North Sulawesi and Sultan Hasanuddin International Airport in Makassar, South Sulawesi. The number of passengers boarding, number of cargo, and freight ratio value for international flight from two airports in Sulawesi Island, Indonesia is shown in Table-2.

Table-2. Freight ratio value for international flight from two airports in Sulawesi Island, Indonesia.

Airport, City	Number of passengers boarding (people)	Number of cargo (kg)	Freight ratio (kg per passenger)	Category airport
Sam Ratulangi, Manado	27,532	164,111	5.961	Mixed passenger and freight airport
Sultan Hasanuddin, Makassar	102,630	982,607	9.574	Mixed passenger and freight airport

From Table-2, the freight ratio value for international flight from two airports in Sulawesi Island between 5.961 to 9.574 kg per passenger. Sultan Hasanuddin International Airport in Makassar, South Sulawesi has the highest of freight ratio value 9.574 kg per passenger and categorized as a mixed passenger and freight airport because the freight ratio (FR) value is < 30 kg per passenger and the number of passenger boarding in the airport is height. Sam Ratulangi International Airport in Manado, North Sulawesi categorized as mixed passenger and freight airport category with the freight ratio value 5.961 kg per passenger. The freight ratio value

for domestic flight and international flight in Sulawesi Island, Indonesia can be seen in Figure-2.

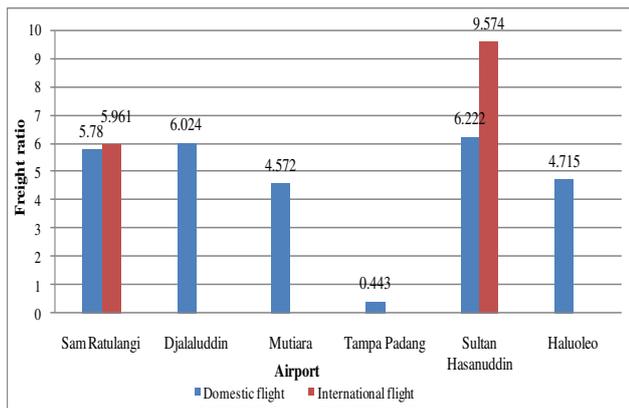


Figure-2. Freight ratio value for domestic flight and international flight in Sulawesi Island.

Hierarchy and stages of development

Based on KM Ministry of Transportation Republic of Indonesia No. 11, 2010 [46], hierarchy and stages of the development of six airports in Sulawesi Island, Indonesia is shown in Table-3. Sultan Hasanuddin International Airport in Makassar and Sam Ratulangi International Airport in Manado is primary hub, Djalaluddin Airport in Gorontalo, Mutiara Airport in Palu, and Haluoleo (Wolter Monginsidi) Airport in Kendari are secondary hub, and Tampa Padang Airport in Mamuju is a tertiary hub. Based on the stage of development of airport, Sam Ratulangi Airport includes in stabilization of primary airport; Sultan Hasanuddin Airport include in development of primary airport.

Table-3. Hierarchy and stages of development from six airports in Sulawesi Island, Indonesia.

Airport, City	Number of passengers boarding (people)	Number of cargo (kg)	Hierarchy of airport	Stages of development
Sam Ratulangi, Manado	958,049	5,542,256	Primary hub	I-Stabilization of primary airport
Djalaluddin, Gorontalo	381,082	2,295,757	Secondary hub	I-Stabilization of secondary airport
Mutiara, Palu	672,698	3,075,858	Secondary hub	I-Stabilization of secondary airport
Tampa Padang, Mamuju	48,494	21,488	Tertiary hub	IV-Stabilization of tertiary airport
Sultan Hasanuddin, Makassar	8,538,901	53,473,971	Primary hub	I-Development of primary airport
Haluoleo (Wolter Monginsidi), Kendari	662,468	3,123,571	Secondary hub	II-Stabilization of secondary airport

Desire line of airfreight cargo in Indonesia is shown in Figure-3 [47]. From Figure-3, there are seven airports with the number of cargo is very high, two airports in Sumatra Island i.e.: Kualanamu International Airport, Deli Serdang, North Sumatra and Hang Nadim International Airport, Batam; two airports in Java Island i.e.: Soekarno-Hatta International Airport, Jakarta and

Juanda International Airport Surabaya, East Java; one airport in Bali Island i.e.: Ngurah Rai International Airport, Denpasar; one airport in Sulawesi Island i.e.: Sultan Hasanuddin International Airport, Makassar, South Sulawesi and one airport in Kalimantan Island i.e.: Sultan Aji Muhammad Sulaiman (Sepinggan) International Airport, Balikpapan in East Kalimantan.

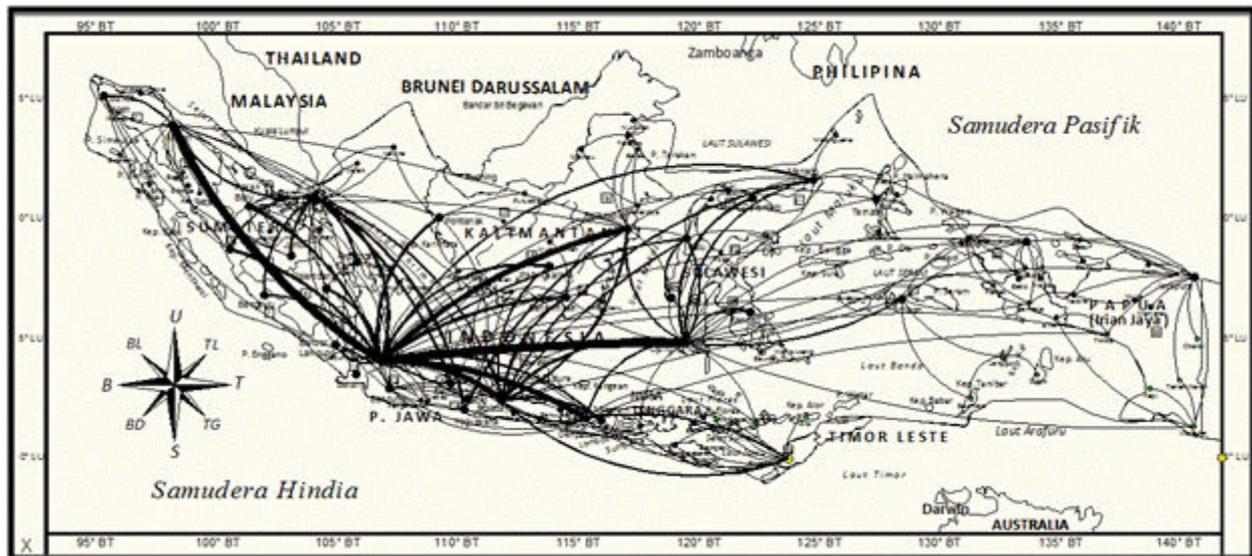


Figure-3. Desire line of airfreight cargo in Indonesia year 2011 [47].

From Figure-3, Soekarno-Hatta International Airport (SHIA) is a central hub because all of the spoke cities in Indonesia fly into SHIA. There are route flights from SHIA to all cities in Indonesia. This result is in line with the findings of Sugiyanto *et al.* [48], based on Herfindahl-Hirschmann Index (HHI), the amount of domestic cargo hub is required for distribution logistics or cargo in Indonesia are two airports the first is Soekarno-Hatta International Airport in Cengkareng and the second is Juanda International Airport in Surabaya, East Java. The percentage of cargo volume in Soekarno-Hatta International Airport is 38.229% for domestic flight and 88.162% for international flight [49]. In Sumatra Island, based on Herfindahl-Hirschmann Index (HHI) there are two hub airports for the domestic flight i.e.: Kualanamu International Airport in Deli Serdang, North Sumatra and Hang Nadim International Airport in Batam. Beside as a hub airport for domestic flight, Kualanamu International Airport in Deli Serdang, North Sumatra as a hub for international flight in Sumatra Island [50].

CONCLUSIONS

Based on the results, the following conclusion can be drawn:

- The freight ratio value for domestic flight from six airports in Sulawesi Island, Indonesia between 0.443 to 6.222 kg per passenger.
- Sultan Hasanuddin International Airport Makassar (SHIAM) has the highest of freight ratio value and categorized as a mixed passenger and freight airport. Tampa Padang Airport in Mamuju categorized as a full passenger airport. Sam Ratulangi International Airport in Manado, Djalaluddin Airport in Gorontalo, Mutiara Airport in Palu, and Haluoleo (Wolter Monginsidi) Airport in Kendari categorized as mixed passenger and freight airport category.

- The freight ratio value for international flight from Sam Ratulangi International Airport in Manado is 5.961 and 9.574 kg/passenger for Sultan Hasanuddin International Airport in Makassar. Two airports are categorized as a mixed passenger and freight airport.

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