Time Behavior Properties of Freight Transportation in South Sulawesi-Indonesia using Polynomial Regression Model

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Abstract: The present paper attempts to understand time behavior properties of freight transportation in South Sulawesi Province, Indonesia. This study focuses on three time attributes, i.e. arrival time, departure time, and travel time of the freight transport, where the number of trips of the time attributes is modeled using polynomial regression approach. The study conducts a freight transport survey using account and interview methods on seven areas in the capital city of the province. The modeling results show that the trip number related to the time behavior properties of each truck category mostly follow the polynomial model in orde-6. Further, the distributions of trucks have two peak-hour periods related to the departure and arrival time properties. In addition, travel time property is dominated by 15 – 30 minutes. The results provide an expectation in revising the demand model in order to explore the choice models of the time attributes in further studies.

Keywords: Time behavior, freight transportation, polynomial regression model

1. INTRODUCTION

Nowadays, the one main focus in Indonesia's master plan for 2011 – 2025 on enhancing and expansion of economy development is the development of freight transportation infrastructures (MP3EI, 2011). Regarding this, Indonesia government has been encouraging in studies on the development concepts of the freight transportation infrastructures. For example, studies on characteristics or behaviors of freight transport stake holders, demand models of inner and inter island freight transports, finances of the freight transport infrastructures, etc.

In context of the study needs on the freight transportation in Indonesia, many previous studies have been conducted. However, most of them were conducted for freight transport characteristics in Java, Sumatera, and Kalimantan islands. For instances, Ridwan (2012) in case Java island, Syahminan et al. (2011a; 2011b; and 2012) for freight transport in Sumatera island, and Mahmudah, et al. (2012) for characteristics of the freight transport in Kalimantan island. Only a few previous researches have focused on freight transport characteristics in Sulawesi island particularly in South Sulawesi Province. Two last previous researches only focused on the container terminal (Idrus et al., 2012) and container port (Dewa et al., 2012) characteristics of the Makassar Port, South Sulawesi, Indonesia.

In order to contribute on the development of the freight transportation South Sulawesi Province, the present study attempts to grasp the time behavior properties of freight transportation in the Province such arrival time, departure time and travel time using

polynomial regression approach.

2. THE STUDY METHODS

2.1 The Study Object

The object of this study focuses on freight transportation which has been operating in Makassar City, the capital city of South Sulawesi Province. The study locations in the city consist of seven locations survey at the road network in the city as shown in Figure 1.

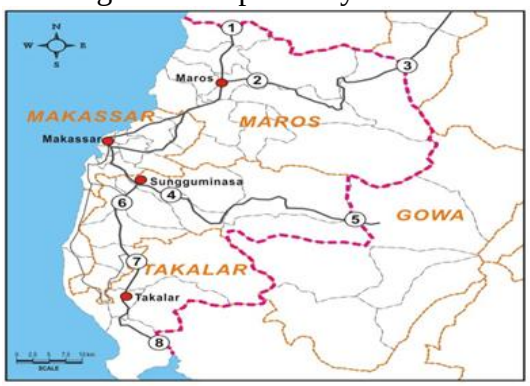
2.2 The Study Location

The freight transport survey in this study consists of an account survey of the fright transport flow on the roads in the city, and an interview survey for the freight transport origin-destination. In the last survey, the characteristics of the freight transport such as commodity types, loading quantity and capacity of vehicles, departure time, arrival time, travel times, etc. are involved in the questionnaire of the survey. Both surveys were conducted during 24 hour survey from 06:00 am until 06:00 am on the next day, in 2 – 3 June, 2004.

There are seven survey locations for account and interview surveys. The first location (L-1) at the gate of Hatta Port, the second location (L-2) at the gate of Parangloe storage in Jl. Dr. Ir Sutami, the third location (L-3) at the gate of the inter-city transportation terminal in Daya, the fourth location (L-4) at the west gate of Sutami expressway, the fifth location (L-5) at the main gate of Makassar Industries Area (MIA), the sixth location (L-6) at the gate of container area in Hasanuddin airport, and the seventh location (L-7) at the gate of Soekarno Port. Those locations are chosen due to many vehicles of the freight transport which passing in the road network at the locations.

The survey method of the vehicle account of the freight transport at the seven locations was conducted in similar to traffic account survey for the traffic conventional survey. Mean while, the interview method of the origin-destination survey was conducted through stop the vehicles of the freight transport on the road sides, then the surveyor interviews the freight transport operator using a sheet questionnaire. The map of the survey locations and the interview survey method are visualized in Figure 1a and Figure 1b respectively.

a. The interview survey method



b. The map of the survey locations

Figure 1. The survey locations and the interview method

2.3 Data Analysis Methods

The data from the survey are extracted in tables and classification regarding the time periods,

commodity types, transit capacity, and operational time attributes (such departure time, arrival time, and travel time). The extraction results are described visually in histogram shapes. Then, the data could be analyzed in order to grasp the characteristics and time behavior properties of the freight transport.

Particularly, the distribution results of the three time attributes such departure time, arrival time, and travel time of the freight transport are analyzed using the simple time-series model approach, i.e. the polynomial regression model. This model approach develops a relationship between on response variable (Y) and one independent variable (X) which has various degree on the X variable. The model has error (ε_i) which assumed in normal distribution. The general form of the polynomial model is expressed in Equation (1) as follows.

$$Y = \beta_0 + \beta_1 X^1 + \beta_2 X^2 + \ \ldots \ + \beta_n X^n + \ \varepsilon_i \tag{1}$$

where,

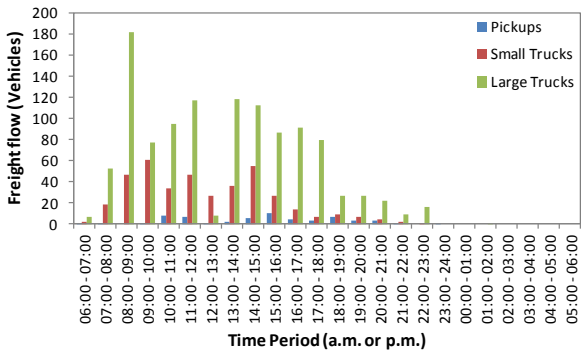
β_n : parameter of X^n that should be estimated, and
β_0 : a constant of the model.
X^n : a vector of observed variables that represent relevant attributes to Y.

3. THE RESULTS

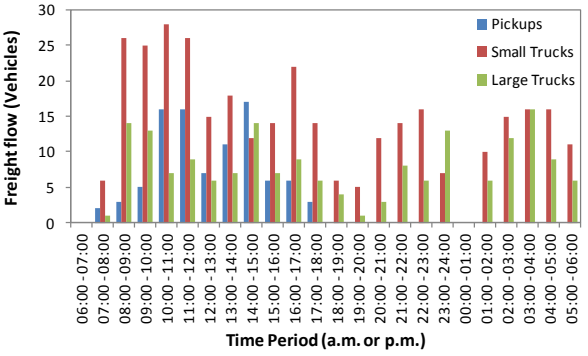
3.1 The Flow Rate of the Freight Transportation

Number of data from the vehicle account survey for the freight transport which conducted in the 7 locations are 224 data at the L-1, 236 data at the L-2, 635 data at the L-3, 116 data at the L-4, 194 data at the L-5, 163 data at the L-6, and 214 data at the L-7. Regarding the compilation results of the survey data, we present the distribution phenomena of the freight transport in Makassar, South Sulawesi Indonesia as sown in Figure 2. Figures 2a until 2f visualize the volume of the freight transport flow of each survey location, L-1 until L-7, respectively.

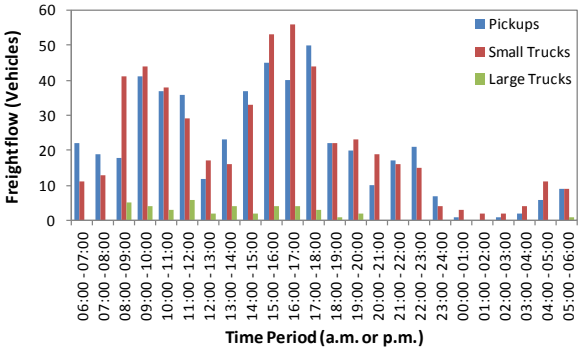
Figure 2 shows that there are 3 vehicle types which used in operating freight transport in South Sulawesi, i.e. pickups, small trucks (2 axle loads), and large trucks (equal or more than 3 axle loads). The small trucks dominate the freight transport vehicles in mostly locatotions, however, in certain location domination of the large trucks is also available (such L-1). Meanwhile, the pickup types are also significant in number of flow at all locations, after the small truck number. The largest volume of the small trucks for the freight transport achieves 160 trucks per-hour which occurs at the L-4 location. As well as, the pickups are 120 vehicles per-hour at the similar location. In addition, the largest volume of the large trucks is 180 trucks per-hour which occurs in L-1 location. Regarding the survey flow rate of the freight transport at the seven locations, the freight transport operates mostly 24 hour, except in location L-1 which the freight transport only operate until 23:00 pm, and at the L-5 until 18:00 pm. In both locations, the land use activities only open until the time periods. Furthermore, Figure 2 shows the fluctuiation of the flow rate of the freight transport during the time observation, 24 hours. The flow rate distributions show that have 2 until 3 peak hour periods. Regarding the high flow rate of the freight transport for the both modes, small trucks and large trucks, we analyzed the time behavior characteristics of the two modes further in the following section.



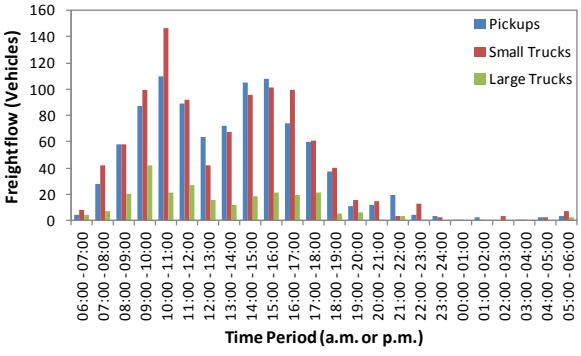
a. L-1 location



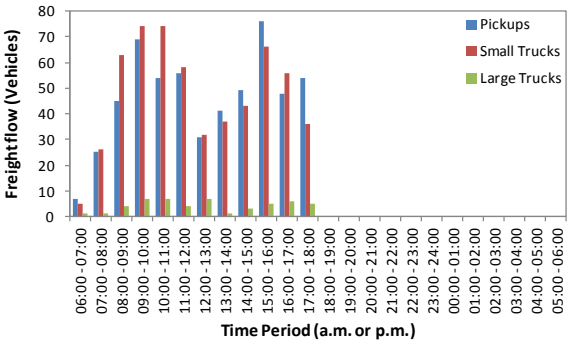
b. L-2 location



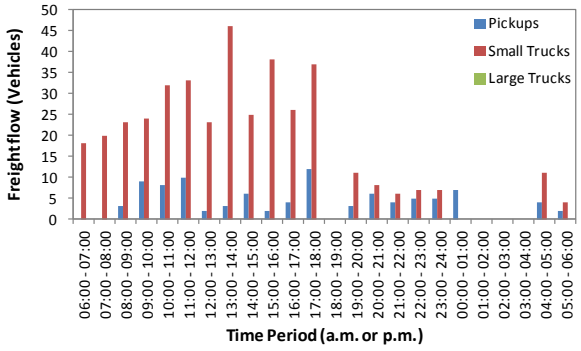
c. L-3 location



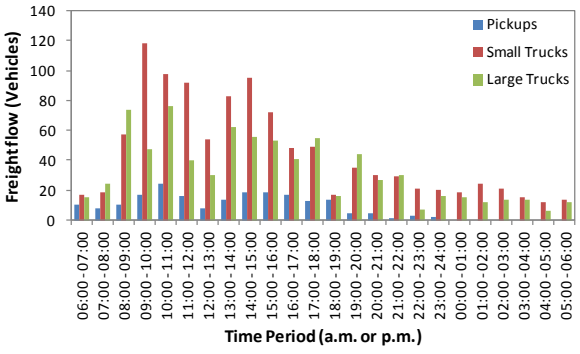
d. L-4 location



e. L-5 location



f. L-6 location



g. L-7 location

Figure 2. The flow rate of the freight transportation in South Sulawesi

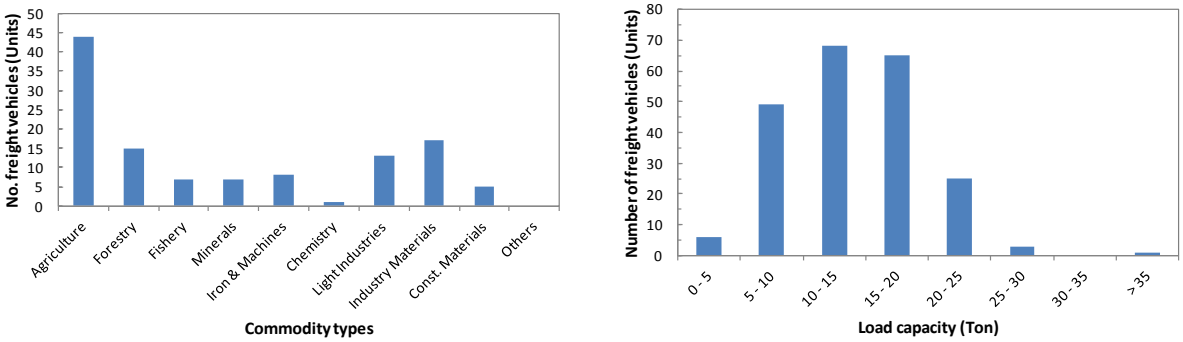
3.2 The Commodity and Mode Characteristics of the Freight Transport

Regarding the analysis results of the survey data, we present the commodity characteristics and the load capacity of the trucks in Figure 3 only for the result of the location L-1 (the gate

of the Hatta port).

Figure 3a shows that there are 9 commodity types in operating freight transport in South Sulawesi. The nine types are agriculture commodities, forest commodities, mining materials, iron and machine, chemistry materials, light industries and electronics goods, industry materials, and construction materials. Further, Figure 3a shows that the agriculture commodities are the largest portion in the freight transportation in South Sulawesi. Meanwhile, chemistry materials are minor in operating the freight transport in the area.

Figure 3b shows that the vehicles of the freight transport have major load capacity about 10 – 15 tons and 15 – 20 tons. The second major of the load capacity of the freight vehicles is 5 – 10 tons. However, it is also available significantly trucks which have load capacity until 20 – 25 tons. In addition, the trucks which have the smallest load capacity (0 – 5 tons) are minor in the locations, as well as for the largest load capacity (> 25 ton).



a. Commodity types b. Load capacity

Figure 3. The Commodities and modes of freight transportation in location-1 (L-1)

3.3 The Time Attributes of the Freight Transport and Its Distribution Model

Particularly, this study focused on the behavior of the time attributes of the freight transportation in operating in the South Sulawesi Province. The time attributes which analyzed in this study are departure time, arrival time, and travel time for the small and the large trucks as dominant mode at the locations. Figure 4a, Figure 4b, and Figure 4c show the characteristics of the three time attributes of the freight transport in the L-1 location, respectively.

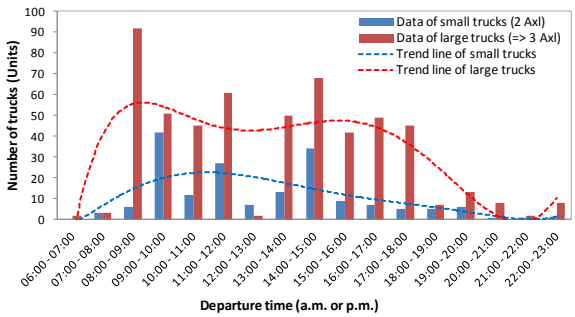
Figure 4a shows that both trucks have similar distribution phenomena of their departure time attribute. In this regard, the departure time distributions have 2 peak hour periods, i.e. morning peak period, and afternoon peak period. The morning peak period occurs at 08:00 – 09:00 am for the large trucks, and at 09:00 – 10:00 am for the small trucks. In the other side, the afternoon peak period occurs at 14:00 – 15:00 pm for both modes.

Figure 4b shows the similar phenomena for the arrival time attribute. The morning peak period occurs at the same time with the departure time attribute for both truck types. Meanwhile, the afternoon peak period occurs faster than the departure time's peak period. In this regard, the afternoon peak period occurs at 13:00 – 14:00 am for both modes.

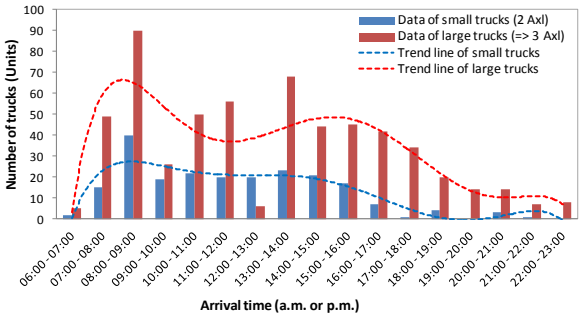
The travel time attribute of the small and large trucks are dominated by 15 until 30 minutes traveling as shown in Figure 4c. The figure also shows the availability of travel time variation about 30 – 45 minutes, 45 – 60 minutes, and around 2 hours. Domination of the short travel time in this case due to the road network infrastructure to and from the location study (L-1, Hatta Port) is facilitated by an expressway. The other reason is that mostly commodities of the freight transport at the location are origin from the storage and container yard which located near from the port.

As the main purpose of this studi, we presented the modeling results of the three time

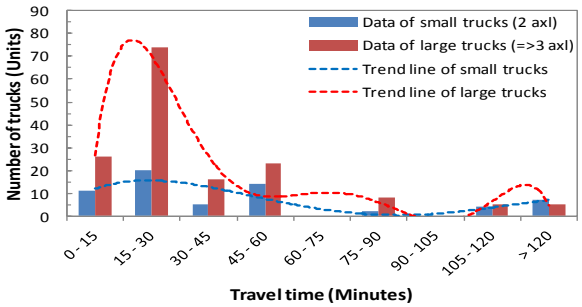
attributes using the polynomial regression model approach as shown in Table 1 and visualized in Figure 4 as the broke lines.



a. Departure time



b. Arrival time



c. Travel time

Figure 4. Brands of the motorcycle sampling

Table 1. Distribution model of time attribute of the freight transportation

Time attributes	The modeling resultsHasil Pemodelan	
	The modeling equation	R^2
Departure time	ST = $0.0001t^6 - 0.0063t^5 + 0.1284t^4 - 1.1789t^3 + 3.8827t^2 + 3.8103t - 8.8145$	0.4501
	LT = $-0.0003t^6 + 0.0201t^5 - 0.5672t^4 + 7.5756t^3 - 50.399t^2 + 155.73t - 121.33$	0.5438
Arrival time	ST = $-0.0005t^6 + 0.0272t^5 - 0.5918t^4 + 6.3231t^3 - 34.713t^2 + 90.765t - 61.552$	0.8440
	LT = $-0.001t^6 + 0.0617t^5 - 1.4257t^4 + 16.092t^3 - 91.266t^2 + 236.72t - 156.86$	0.6231
Travel time	ST = $-0.04756t^4 + 1.14266t^3 - 8.84576t^2 + 22.7986t - 3.0556$	0.6385
	LT = $-0.0774t^6 + 2.4748t^5 - 31.304t^4 + 198.21t^3 - 649.85t^2 + 1003.4t - 496.22$	0.8969

ST: Samll Trucks; LT: Large Trucks

Table 1 present the polynomial model of the three time attributes of the freight transport operation. The table shows that the polynomial model in orde-6 superior on the model distributions. Only one model has polynomial equation in orde-4, i.e. distribution model of the travel time of the small trucks. The significant levels of the models vary from good significant until its significant level of the model is acceptable. In this regard, the R2 values of the models vary from 0.45 until 0.89. These modeling results give a chance in revising and development a distribution model of the time attributes of the freight transport using behavior approach of the freight transport operator in further. So that, we can result a more reliable model on basis the operator behavior actually.

5. CONCLUSIONS

Some important indicators of the freight transportation system in Makassar city, a capital city

of South Sulawesi Province in Indonesia such flow rate of the freight vehicles, commodity types, load capacity of trucks, and three time attributes, i.e. departure time, arrival time, and travel time, have been elaborated in this study.

The flow rate of the goods for small and large trucks, and also pickup vehicles showed the significant potency in the development of the freight transportation system in South Sulawesi. Its indicated by the commodity demand of the freight transport is available in the large number of the agriculture commodities, forest commodities, etc. in South Sulawesi Province. However, the condition of the truck modes has given prospects to develop and improve the road network infrastructure of the freight transport in the area in the future.

Specifically, the modeling results of the three time attirubtes of the freight transport operation in South Sulawesi, also have given a chance in revising and developing the better models for the prediction models of the departure time, arrival time, and travel time based on the stake holder behaviors of the freight transport in the further studies in the future.

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