FREIGHT TRANSPORT MODE CHOICE USING A BINARY LOGIT MODEL

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ABSTRACT
This study provides the first description of freight mode choice using the SARBAGITA area in Bali as a case study. A binary logit model was built to analyze the important factors influencing the choice between pick-up/box cars and medium/large trucks. This study found that the odds that drivers aged between 31 and 40 years old, elementary school as driver educational qualification, transported mining results, transported forest products and travel distance will use pick-up/box cars were 3.82, 6.54, 8.78, 18.08, and 1.05 times more likely than these of medium and large trucks. Meanwhile, the odds that freight transport vehicles owned by private, driver income was equal to regional minimum wage, and an average weight of transported goods were less than 5 tons will use pick-up/box cars were 34%, 28%, and 1% less likely than these of medium and large trucks.

Keywords: fatal road accidents; logistic regression; motorcycle

INTRODUCTION
The choice of transport mode is determined by the interaction between transport and shipping companies (Holguıin-Veras et.al., 2011). In the case of private fleets, shippers also act as logistics carriers. Freight transport is often restricted from moving on certain road networks. Movement restrictions can affect the efficiency and effectiveness of logistics transport. The more efficient and effective the logistics transportation method, the lower the price of raw materials. Logistics transport is closely linked to the road network, especially in delivery destination areas (Kalahasthi, et.al, 2022).

Understanding the factors that influence the decision to use freight vehicle type(s) (Khakdaman et al., 2022) is important to support infrastructure planning decisions and key analysis in urban road traffic. These factors include place of origin and destination, type of transport, and type of industry. The shipping line and the carrier are responsible for making decisions about the choice of mode and type of vehicle. The shipper produces the goods, and the carrier is responsible for transporting and delivering the goods.Bali Province, as a strategic province in terms of logistics distribution, especially towards eastern Indonesia, has many infrastructure-related logistics distribution issues that have not been researched. The main parameter involved in logistics distribution is the travel time of goods. These parameters are related to factors such as the behavior of logistics transport operators, the infrastructure of the road network, and the choice of logistics transport mode. Therefore, it is necessary to study how a logistics/transportation company chooses the type of vehicle to transport goods in urban areas and the impact of logistics traffic flow on urban traffic efficiency.

Therefore, this study aims to analyze the choice behavior of freight/logistics vehicles in urban areas of Bali province. The purpose of this study is to analyze the choice behavior of freight vehicles in the urban area of Bali province, which is useful in enriching the logistics database and estimating the transportation system model. The benefits that can be achieved through practical application include contributing to stakeholders (executive and legislative at the provincial and district/city levels) in improving regulations related to the system. In addition, the transport system implementing logistics policy may contribute to logistics transport management and operations agencies in the context of improving the quality and technology of transport modes in the logistics transport system in Bali.

METHOD

Research on the characteristics of logistics transportation in Bali Province covers a wide region or area and a wide research period, as well as sectoral aspects that cannot possibly be studied in their entirety, so it is necessary to limit the scope of the research as follows:

a. Research on the characteristics and needs of logistics transportation was carried out in urban areas in Bali Province, namely the SARBAGITA area
b. The logistics transportation modes that operate and pass on this route are all types of vehicles used to transport goods across roads in the SARBAGITA area.
c. Types of logistics vehicles in the context of behavior in choosing logistics transportation modes include light/medium vehicles (pick up) and heavy logistics transport vehicles with an axle load of 2 (two) axles up to >2 (two) axles (3, 4, and 5). as) operates and passes through the SARBAGITA Region.
d. This study limits the research object to the characteristics of the logistics transport system in 3 (three) characteristic aspects, which are goods, operators, and the mode of transport used.

Data collection on freight traffic was carried out on arterial roads in the SARBAGITA region, specifically Jl. Bypass Ngurah Rai towards Kuta, Sanur, and Nusa Dua. This stretch was chosen, among other reasons, because it carries traffic with a high proportion of freight and reflects mixed traffic conditions. Road segments are selected based on the presence of different traffic conditions such as intensity (traffic/capacity ratio), traffic distribution and composition, and vehicle weight percentage. The location is not close to the intersection so it is prone to traffic jams. This is avoided because the idea is to observe uninterrupted traffic flows. Additionally, road segments selected based on physical and geometrical characteristics can support this type of research. While road selection is often based on physical, environmental, and traffic conditions, road section selection is based on more specific requirements, specifically straight and flat road sections (no slopes). Traffic data includes traffic volume and speed data for each mode, specifically heavy vehicles, light vehicles, and motorcycles. Road geometry data includes road width, lane width, effective road width, curb width, curb width at barriers, road slope, and side obstacle data. The collection of traffic data on the site is performed by marking reference lines on road segments. Video cameras were placed on the left and right sides of the road to record the convoy passing through the observation point.

Model Development

The pick-up/box cars and medium & large trucks were employed as the binary predictor variables in this study. These independent variables are shown in Table 1, following the research objective to characterize the logistics transport system based on 3 (three) aspects, which are goods, operators, and the mode of transport used. Study variables and their coding are shown in Table 1.

Table 1.
Variables selected for the study

No.	Variable Description	Classifications and Coding	Variable Title
1.	Type of goods delivered	1 = Mining results 2 = Agricultural products 3 = Fisheries 4 = Industrial product 5 = Forest products 6 = Electronic and automobile products 7 = Construction Materials	GoodsType
2.	Average driving speed	1 = < 40 km/hour 2 = 40-60 km/hour 3 = 60-80 km/hour 4 = 80-100 km/hour	Speed
3.	Educational qualification	1 = Elementary school 2 = Junior high school 3 = Senior high school 4 = Vocational	Education
4.	Driver's age	1 = 17-20 years 2 = 21-30 years 3 = 31-40 years 4 = 41-60 years	Age
5.	The average weight of goods delivered	1 = < 5 ton 2 = 5-10 ton 3 = 11-15 ton 4 = 16-20 ton	GoodsWeight
6.	The average cost of freight delivered	1 = < Rp. 10 million 2 = Rp. 11-25 million 3 = Rp. 26-50 million 4 = Rp. 51-75 million	GoodsCost
7.	Income per month	1 = < Regional minimum wage 2 = Equal to Regional minimum wage 3 = > Regional minimum wage	Income
8.	Vehicle ownership used to deliver goods	1 = Private 2 = Owned by the company	FrOwnership
9.	A driving license for the freight vehicle	1 = Available 2 = Not Available	DrivLic

The entry method of logistic regression was followed using SPSS version 15. The Omnibus Tests of both motorcycle and motor vehicle fatal accidents model coefficients are analyzed to assess whether data fit the model as shown in Table 2. It shows the Chi-square difference tests for the specified model relative to a null model which contains only an intercept and no independent variables. In Table 2, the specified model is significant ($p < 0.05$) so it is concluded that the independent variables improve on the predictive power of thenull model.

Table 2.
Omnibus tests of model coefficients

	Chi-square	degree of freedom	Sig.
Step	262.118	27	.000
Block	262.118	27	.000
Model	262.118	27	.000

Table 3 contains the two pseudo R^2 measures that are Cox & Snell and Nagelkerke. The former measure frequently does have a maximum of less than one. It is therefore usually betterto assess Nagelkerke's measure as this divides Cox and Snell by the maximum to give a measure that does range between zero and one. In this example, the model explains 64% of the variance in thedependent variable. In addition, in Table 3 Hosmer-Lemeshow

(H-L) test shows the significance of both developed logistic regression models (p-value > 0.05). Meanwhile, Table 4 gives the overall percentage of cases that are correctly predicted by the full model. The overall percentages have increased by 34% for the null and full models from 63.7 to 85.6 respectively.

Table 3.
Goodness of fit

Pseudo R^2 Test	-2 Log likelihood	Cox & Snell R^2	Nagelkerke R^2
	282.937	.467	.640
Hosmer and Lemeshow Test (H-L Test)	Chi-square	Degree of freedom	Sig.
	4.624	8	.797

Table 4.
Classification accuracy

Null Model		Predicted		
		Pick-up & Car Box	Medium & Large Trucks	Percentage Correct
Observed	Pick-up/Box Cars	265	0	100.0
	Medium & Large Trucks	151	0	.0
			Overall Percentage	63.7
Full Model		Predicted		
		Pick-up & Car Box	Medium & Large Trucks	Percentage Correct
Observed	Pick-up/Box Cars	244	21	92.1
	Medium & Large Trucks	39	112	74.2
			Overall Percentage	85.6

RESULT AND DISCUSSIONS

The model results as shown in Table 5 indicate that driver age between 31 and 40 years old, driver qualification (passing elementary school), transported mining and forestry products, and travel distance were positively related to freight mode transport choice. On the other hand, privately owned freight transport vehicles, driver income less than and equal to regional minimum wage, and transported goods < 5 tons were negatively related to freight mode transport choice. This indicated that several factors including driver age between 31 and 40 years old, driver qualification (passing elementary school), transported mining and forestry products, and travel distance were more likely to influence transporting goods using pick-up/box cars than medium and large trucks. Meanwhile, several factors consist of privately owned freight transport vehicles, driver income less than and equal to regional minimum wage, and transported goods < 5 tons were less likely to influence transporting goods using pick-up and car-box than medium and large trucks.

The odds that drivers aged between 31 and 40 years old, elementary school as driver educational qualification, transported mining results, transported forest products, and travel distance will use pick-up/box cars were 3.82, 6.54, 8.78, 18.08, and 1.05 times more likely than these of medium and large trucks. Previous research in Ethiopia also shows that the type of goods transported significantly influences the choice of freight transport vehicle (Reda, et.al, 2023).

Meanwhile, the odds that freight transport vehicles owned by private, driver income was equal to regional minimum wage, and the average weight of transported goods were less than 5 tons will use pick-up/box cars were 34%, 28%, and 1% less likely than these of medium and large trucks. Previous studies (Hensher, et.al, 2023; Jourquin, 2023) have taken into account the weight of each type of goods shipped and found that the observed weight significantly influences the choice of transportation options.

Table 5.
Model results of freight transport mode choice

Variables	β	Sig.	Exp (β)
Age (17-20 years old)	.687	.495	1.987
Age (21-30 years old)	-.123	.815	.884
Age (31-40 years old)	1.340**	.007	3.818
Age (41-60 years old)	-	-	-
Education -Elementary School	1.878**	.021	6.541
Education – Junior High School	.828	.249	2.289
Education – Senior High School	1.041	.136	2.831
Education – Vocational	-	-	-
Driving License (Available)	.745	.386	2.107
Driving License (Not Available)	-	-	-
Freight Transport Ownership (Private)	-1.085**	.022	.338
Freight Transport Ownership (Company)	-	-	-
Income (< Regional Minimum Wage)	-2.155**	.004	.116
Income (= Regional Minimum Wage)	-1.265**	.034	.282
Income (> Regional Minimum Wage)	-	-	-
Transported Goods (Mining Results)	2.172**	.013	8.775
Transported Goods (Agriculture)	.675	.241	1.964
Transported Goods (Fishery)	-1.021	.390	.360
Transported Goods (Industrial Products)	-.187	.833	.829
Transported Goods (Forest Products)	2.895**	.000	18.082
Transported Goods (Electronic and Automobile Products)	-1.785	.460	.168
Transported Goods (Construction Materials)	-	-	-
Transported Goods Weight (< 5 tons)	-4.615**	.002	.010
Transported Goods Weight (5 - 10 tons)	-1.973	.178	.139
Transported Goods Weight (11 - 15 tons)	-1.261	.433	.283
Transported Goods Weight (16 - 20 tons)	-	-	-
Transported Goods Cost (< Rp. 10 million)	-2.698	.062	.067
Transported Goods Cost (Rp. 11 - 25 million)	-2.767	.057	.063
Transported Goods Cost (Rp. 26 - 50 million)	-1.312	.401	.269
Transported Goods Cost (Rp. 51 - 75 million)	-	-	-
Travel Distance	.050**	.012	1.051
Travel Time	-.001	.913	.999
Average Speed (< 40 km/hour)	1.337	.196	3.809
Average Speed (40 - 60 km/hour)	.056	.953	1.057
Average Speed (60 - 80 km/hour)	.635	.518	1.887
Average Speed (80 - 100 km/hour)	-	-	-
Constant	2.054	0.409	7.796

Note: Bold figures are significant at 95%. The large constant coefficient in the model indicated that there will besome other factors, for instance, economic conditions that may be impacted on freight transport mode choices.

CONCLUSIONS

This study applies logistic regression techniques to study freight transportation mode choices in Bali. Discrete choice random utility models are used because they offer significant advantages in modeling freight demand. This study shows that driver age, education level, mining and forestry products, and distance traveled are important factors and positively influence the choice of pick-up/box cars instead of medium/large trucks. Meanwhile, ownership of a freight vehicle, driver's income, and goods weight negatively affect the choice of pick-up/box cars over medium/large trucks.

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