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Analysis of Transportation Mode Choice in Bitung City Using Structural Equation Modeling

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Abstract: Transportation is the foundation of daily life and is vital to a region's economic and social development. Transportation is a crucial aspect of human life, facilitating connections between locations. Mode choice is a critical consideration in transportation planning, influenced by cost, travel time, and comfort factors. This study aims to analyze the characteristics of travelers in Bitung City Regency and the factors influencing their choice of transportation modes in 2024. The research involved distributing an online questionnaire to 200 respondents and gathering data on various latent variables, including Travel Cost, Travel Time, Vehicle Condition, and Comfort Level. The analysis used Structural Equation Modeling (SEM) with SPSS and AMOS software. The study revealed a significant gender disparity among the respondents, with men dominating the demographics at 60%. Most respondents were from the 26–35-year age group (40%), had a private status (35%), and had completed high school or vocational school (35%). Motorbikes were the most common regarding vehicle ownership, with 60% of respondents owning one. The SEM analysis revealed significant factors influencing transportation mode choice. Travel Time (WT) had a negative effect on Comfort Level (TK) and Vehicle Condition (KK), with t-values of -0.684 and -0.895, respectively, indicating that longer travel times reduce comfort and vehicle satisfaction. Vehicle Condition (KK) significantly influenced the preference for Online Transport (TO) and Conventional Ojek (OK) with t-values of 0.597 and 0.278, respectively. Comfort Level (TK) significantly impacted the preference for Public Transport (TU), Conventional Ojek (OK), and Online Transport (TO) with t-values of 0.728, 0.530, and 0.301, respectively. The findings of this research have practical implications, suggesting that enhancing travel time efficiency, vehicle conditions, and overall comfort can significantly influence

mode choice preferences. These insights can engage and interest transportation planners, policymakers, and researchers, guiding future transportation planning and policymaking in Bitung City Regency.

Keywords: *Transportation Mode Choice, Structural Equation Modeling (SEM), Route Selection, Transportation Planning, Bitung City*

INTRODUCTION

Transportation, which is the foundation of daily life, plays a vital role in a region's economic and social development. The transportation system's efficiency directly affects economic growth, population mobility, and regional connectivity [1]. In today's era of globalization, an integrated and sustainable transportation system is essential to address the challenges of urbanization and population growth [2]. The choice of transportation mode, which is the primary determinant of travel efficiency and comfort, is influenced by travel costs, travel time, and comfort level [3]. The choice of transportation mode is undoubtedly influenced by several factors, as travelers take various aspects into account when choosing the best option for their journey [4]. Common considerations that the public typically weighs when deciding on a mode of transport include travel expenses, distance, duration of the trip, fares, and other relevant factors[5]. According to Khisty C.J. (1998), decisions to select a mode are based on several factors, such as time, distance, efficiency, cost, safety, and comfort. This study employed Structural Equation Modeling (SEM) to analyze the relationships between the identified latent variables and transportation mode choice[6]. SEM is a multivariate statistical technique that allows for examining complex relationships among variables. The model was estimated using maximum likelihood estimation, and its adequacy was assessed through goodness-of-fit indices [7].

[1] Kenneth. Button, "Transport Economics," *Edward Elgar Publishing*, 2010.

[2] David Banister, "The Sustainable Mobility Paradigm," *Transport Policy 15.2*, 2008.

[3] and Luis G. Willumsen de Dios Ortúzar, Juan, "Modelling Transport.," *John Wiley & Sons*, 2024.

[4] and Semuel YR Rompis Kawengian, Erlangga, Freddy Jansen, "Model Pemilihan Moda Transportasi Angkutan Dalam Provinsi," *Jurnal Sipil Statik*, 2017.

[5] O.Z. Tamin, "Perencanaan Dan Pemodelan Transportasi.," *Institut Teknologi Bandung. Bandung*, 2008.

[6] and G. Lomax. Schumacker, E., "A Beginner's Guide to Structural Equation Modelling. 4th Edtn," 2016.

[7] Paul. Kline, "A Handbook of Test Construction (Psychology Revivals): Introduction to Psychometric Design," *Routledge*, 2015.

Bitung City, located at the northern tip of Sulawesi Island, is Indonesia's rapidly growing port city. Bitung Port, an essential route for the movement of goods and passengers, both local and international, is a critical player in the city's trade and logistics. Geographically, Bitung City is located at 1° 23' 23" - 1° 35' 39" N and 125° 1' 43" - 1 25° 18' 13" E. The area of the city is 313.5 km2, with a land area of 304 km2. Bitung City, most of whose residents are from the Sangir tribe, is a melting pot of various cultures with a strong influence from the North Nusa region. The city's identity is closely related to the rich heritage of the Sangir tribe. Bitung City is also an industrial center, especially the fishing industry. According to data from the Bitung City Central Statistics Agency (2024), the population of this city in mid-2024 was 214,724 people.

Understanding the factors that influence transportation mode choices is crucial because an individual's decision in choosing a mode of transportation not only impacts personal travel comfort and efficiency but also has broader implications for the transportation system as a whole. Factors such as cost, travel time, accessibility, and comfort are often key considerations for transportation users. On the other hand, this decision is also influenced by social, economic, and environmental aspects, such as the availability of infrastructure, government policies, as well as the impact on carbon emissions and traffic congestion. By understanding transportation mode choice patterns, the government and stakeholders can design more effective policies, such as improving public transportation, integrating modes, or providing incentives for sustainable transportation, which ultimately supports more efficient, inclusive, and environmentally friendly mobility.

Previous research by Agustia shows that commuters prefer Trans Metro Pasundan over DAMRI, with key factors influencing their decision including safety, comfort, cost, trip frequency, speed, and vehicle capacity.[8] Meanwhile, a study by Kristyanto used the Analytic Hierarchy Process (AHP) method to analyze transportation mode choices for students commuting to Tegal Boto Campus, University of Jember. The results indicated that time was the dominant factor (33%) in determining transportation mode choice, with motorcycles as the primary mode (32.7%). This choice is based on the flexibility of motorcycles, allowing students to reach the campus in a shorter time.[9] Both studies

[8] Virda Lusiana Agustia and Ria Haryatiningsih, "Analisis Preferensi Komuter Terhadap Pilihan Moda Transportasi Bandung Raya," *Jurnal Riset Ilmu Ekonomi Dan Bisnis*, 2024, 97–108.

[9] Alfin Kristyanto, Akhmad Hasanuddin, and Paksitya Purnama Putra, "Analisis Pemilihan Moda Transportasi Mahasiswa Universitas Jember Menuju Kampus," *BENTANG: Jurnal Teoritis Dan Terapan Bidang Rekayasa Sipil* 10, no. 1 (2022): 49–58.

demonstrate that transportation mode preferences are strongly influenced by a combination of efficiency, comfort, and travel time factors, which are relevant in understanding transportation choice patterns in various contexts.

Although research on factors influencing transportation mode choices has been widely conducted in various regions in Indonesia, there remains a significant research gap regarding the local context in Bitung City. This city has unique geographical, demographic, and economic characteristics, including its position as one of the main port cities in Eastern Indonesia, which can influence its community's transportation patterns. This study aims to fill that gap by providing a locally data-driven analysis that can offer new insights for more targeted transportation policy-making in Bitung City. The objectives of this research are : (1) To determine the characteristics of travelers when choosing transportation modes in Bitung City; (2) To determine the factors that influence the choice of transportation modes using Structural Equation Modeling (SEM) in Bitung City.

RESEARCH METHODS

Research Location

This research was conducted in Bitung City, excluding the islands around Bitung City.

Figure 1. Location of Bitung City

Data Collection

Primary data was collected from April to July 2024 through a structured questionnaire distributed to 200 road users in Bitung City. The questionnaire was designed to capture information on various aspects of transportation mode choice, including individual preferences, perceived congestion, cultural factors, and dependency. A simple random sampling technique was employed to ensure

a representative sample. According to [10], the Slovin formula was used to determine the number of samples in this study.

$$n = \frac{N}{1 + N(e)^2}$$

Description:
n = Sample size/number of respondents
N = Population size
e = Percentage of tolerance for sampling error accuracy that can still be tolerated; e = 0.1

Respondent Characteristics

The study analyzed respondent characteristics based on gender, age, occupation, educational background, and vehicle ownership. These characteristics provided insights into the demographics of the sample and their influence on transportation mode choice.

Research Variables

This study utilizes seven variables, categorized into two independent variables and five dependent variables. The independent variable, denoted as variable X, influences the dependent variable, variable Y.

Independent Variables/Free Variables (X) consist of:

1) Travel costs (X1)
2) Travel time (X2)

Dependent Variables/Dependent Variables (Y) consist of:

1) Vehicle conditions (Y1)
2) Comfort Level (Y2)
3) Online Transportation (Y3)
4) Conventional Motorcycle Taxis (Y4)
5) Public Transportation (Y5).

[10] Sugiyono, "Metode Penelitian Administrasi: Dilengkapi Metode R&D," *Bandung: Alfabeta*, 2017.

Measurement Scale

The research used the Likert scale to measure the value of the variable. According to [11], the Likert scale measures the attitudes, opinions, and perceptions of a person or group of people about social phenomena. In the study, the researcher specifically determined this social phenomenon, which is then referred to as the research variable. The measurement scale used in the study to measure the value of the variables is by using a Likert scale with 5 (five) gradations, namely: Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree.

Data Analysis

The data analysis in this study employs the Structural Equation Modeling (SEM) approach. [12] This method, a second-generation multivariate analysis technique, enables researchers to examine the relationships between complex variables, both recursive and non-recursive, providing a holistic view of the entire model. SEM allows for simultaneous testing of:

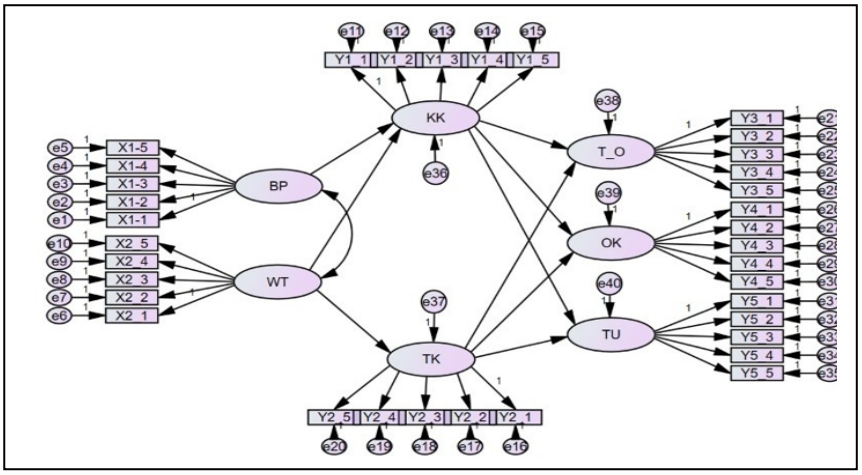
1) Measurement Model: The relationship (loading value) between indicators and constructs (latent).
2) Structural Model: The relationship between independent and dependent constructs.

Structural Equation Modeling (SEM) is a set of statistical techniques that enables the testing of a series of relatively complex relationships in a hierarchical or simultaneous manner. These relationships can involve one or more dependent/endogenous variables and one or more independent/exogenous variables. Additionally, there can be multiple independent/exogenous variables, with each dependent/endogenous and exogenous variable represented as a factor or construct derived from several directly observed indicators. SEM is often referred to as Path Analysis or Confirmatory Factor Analysis. As an analytical tool, SEM can address issues related to correlational regression and help identify the dimensions of a concept, making it a versatile combination of methods. Figure 2 below presents the structural diagram of this study along with its explanation.

[11] Sugiyono, "Metode Penelitian Kuantitatif, Kualitatif, Dan R&D," *Bandung: Alfabeta.*, 2016.

[12] and Anis Chariri. Ulum, Ihyaul, Imam Ghozali, "Intellectual Capital Dan Kinerja Keuangan Perusahaan; Suatu Analisis Dengan Pendekatan Partial Least Squares (PLS)," 2008.

Figure 2. Structural Diagram



BP = Travel Cost
WT = Travel Time
KK = Vehicle Condition
TK = Comfort Level
TO = Online Transportation
OK = Conventional Motorcycle Ojek
TU = Public Transportation

RESULTS AND DISCUSSION

Results

1. Phytochemical content of ethanol extract of durian (Durio zibethinus Murr) fruit seeds

Table 1. Phytochemical test of ethanol extract of durian fruit seeds

Secondary Metabolite Compounds	Reagents	Results
Alkaloids	Bouchardart	+
	Maeyer	+
	Dragendroff	+
	Wagner	+
Steroids and Triterpenoids	Salkowsky	-
	Lieberman-Burchad	-
Saponins	Aquadest+96% Alcohol	+

Flavonoids	FeCl3 5%	+
	Mg(s)+ HCl (p)	+
	10% NaOH	-
	H2O 4(p)	+
Tannins	FeCl3 1%	+
Glycosides	Mollish	+

The results of phytochemical testing on durian seed extract showed the presence of alkaloid compounds, saponins, flavonoids, tannins, and glycosides, which were detected positively using various reagents. However, steroidal and triterpenoid compounds were not detected in durian seed extract with the reagents used.

2. Measurement of blood sugar levels

Tabel 2 Mean and standard deviation of KGD

Group	Before	After	14 Days	Difference
	Mean±SD	Mean±SD	Mean±SD	Mean±SD
N	86,8±9,55	125,6±2,88	118,0±8,19	7,6±6,69
K+	83,6±5,32	381,4±57,39	136,6±12,10	244,8±53,28
K-	83,6±6,99	309,8±68,11	390,6±111,22	-80,8±72,88
P1	86,0±11,07	304,6±12,54	161,0±11,38	143,6±21,33
P2	88,6±7,89	282,2±18,23	189,8±13,70	92,4±28,30
P3	95,4±9,07	281,8±20,28	237,8±16,13	44,0±30,68

The mean blood glucose level (KGD) in the positive control group (K+) showed a significant increase, with a difference of 244.8 ± 53.28 mg/dL between after treatment and day 14. The negative control group (K-) experienced an increase that continued to increase until day 14, with a negative difference of -80.8 ± 72.88 mg/dL. Meanwhile, the P1, P2, and P3 treatment groups showed a more moderate decrease in blood glucose levels, with a difference of 143.6±21.33 mg/dL, 92.4±28.30 mg/dL, and 44.0±30.68 mg/dL on day 14, respectively. The normal group (N) showed little change with a difference of only 7.6±6.69 mg/dL.

3. Measurement of creatinine levels

Table 3. Creatinine mean and standard deviation

Group	Average	Standard deviation
N	0,54	0,064
K+	0,77	0,074
K-	1,38	0,100
P1	0,88	0,021
P2	0,91	0,007
P3	0,93	0,011

The results showed that the mean and standard deviation of creatinine in groups N, K+, K-, P1, P2, and P3 were 0.54±0.064; 0.77±0.074; 1.38±0.100; 0.88±0.021; 0.91±0.007; and 0.93±0.011. Group P1 is the group that has the smallest mean creatinine value compared to groups P2 and P3.

4. Measurement of ureum levels

Table 4. Mean and standard deviation

Group	Average	Standard deviation
N	30,0	2,550
K+	45,8	2,683
K-	55,4	3,209
P1	46,8	2,683
P2	49,0	1,225
P3	49,8	0,837

The results showed that the mean and standard deviation of ureum in groups N, K+, K-, P1, P2, and P3 were 30.0 ± 2.550; 45.8 ± 2.683; 55.4 ± 3.209; 46.8 ± 2.683; 49.0 ± 1.225; and 49.8 ± 0.837. Group P1 is the group that has the smallest mean ureum value compared to groups P2 and P3.

5. Histopathologic analysis of the kidney

Table 5. Mean and standardized kidney

Group	Average	Standard deviation
N	0	0
K+	0,2	0,447
K-	1,6	0,548
P1	0,2	0,447
P2	0,4	0,548
P3	0,6	0,548

The results showed that the mean and standard deviation of glomerular hypertrophy in groups K+, K-, P1, P2, and P3 were 0.2±0.447; 1.6±0.548; 0.2±0.447; 0.4±0.548; and 0.6±0.548, while group N showed no glomerular hypertrophy. Group P1 had the smallest mean glomerular hypertrophy compared to groups P2 and P3. There were significant differences in glomerular hypertrophy between group N and group K-, group K+ and group K-, and group K- and groups P1, P2, and P3 ($p<0.05$). However, between the other two groups no significant differences were found ($p>0.05$). Based on the results of the study, it can be concluded that P1 is the most effective treatment concentration in reducing glomerular hypertrophy, with the ability comparable to the K+ group ($p = 0.000$; $p>0.05$).

DISCUSSION

Based on the results above, it is known that the significant implications of each endogenous variable in this study, which are substantial in order from the largest to the smallest, are as follows:

1) The implications for the Vehicle Condition (KK) variable from the Travel Time (WT) variable are 82.99%, with a significant error determination of 17.1%, and they are significant.
2) The implications on the Public Transportation (TU) variable from the Comfort Level (TK) variable are 53.73%, with a significant error determination of 46.27%, which underscores the impact of the Comfort Level (TK) variable.
3) The implications for the Comfort Level (TK) variable from the Travel Time (WT) variable are 53.43%, with an error determination of 46.56%, and they are significant.
4) The implication on the Online Transportation (TO) variable from Vehicle Condition (KK) is 40.32% with an error determination of 59.68% and significant.

5) The implication on the Conventional Motorcycle Taxi (OK) variable from the Comfort Level (TK) is 25.02% with an error determination of 74.98% and significant.
6) The implication on the Online Transportation (TO) variable from the Comfort Level (TK) is 90.30% with an error determination of 90.70% and significant.
7) The implication on the Conventional Motorcycle Taxi (OK) variable from Vehicle Condition (KK) is 07.62% with an error determination of 92.38% and significant.

Based on the significant implications contained in the research variables, as explained above, it can be concluded that: the variables Travel Time (WT), Vehicle Condition (KK) and Comfort Level (TK) are the most influential factors in choosing transportation modes in Bitung City.

CONCLUSION

The results of this study obtained the characteristics of respondents in Bitung City based on gender dominated by men at 60%, more from the 26-35 year age group at 40%, with private status at 35%, with the last education being high school/vocational school at 35%, and based on vehicle ownership the majority of respondents own motorbikes at 60%. Based on the results of the Structural Equation Modeling (SEM) test, the factors that influence the selection of transportation modes in Bitung City Regency are Travel Time (WT), Vehicle Condition (KK), and Comfort Level (TK). Where the t-value of Travel Time (WT) against Comfort Level (TK) is -0.684, the t-value of Travel Time (WT) against Vehicle Condition (KK) is -0.895, the t-value of Vehicle Condition (KK) against Online Transportation (TO) is 0.597, the t-value of Vehicle Condition (KK) against Conventional Motorcycle Taxis (OK) is 0.278, the t-value of Comfort Level (TK) against Public Transportation (TU) is 0.728, the t-value of Comfort Level (TK) against Conventional Motorcycle Taxis (OK) is 0.530. The t-value of Comfort Level (TK) against Online Transportation (TO) is 0.301. This study indicates that Travel Time (WT), Vehicle Condition (KK), and Comfort Level (TK) are the main factors influencing transportation mode choice in Bitung City Regency. To attract public interest in using transportation modes, improvements in aspects such as travel route efficiency, vehicle cleanliness, and comfort are necessary. (TK) against Online Transportation (TO) is 0.301. The findings suggest that improving travel time efficiency, vehicle conditions, and overall comfort can significantly influence mode choice preferences, guiding future transportation planning and policymaking in Bitung City Regency.

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