Model for Selecting the Impact of Traffic Conclusion in Manado City Using Structural Equation Modeling

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Abstract: ***Population growth and increased development in urban activity centers that are not well organized will result in problems, one of which is transportation problems. Transportation problems such as traffic jams, delays are the result of movement generation that occurs at the same time so that there is a large traffic load on the roads leading to activity centers. Traffic jams have been getting worse lately. New Traffic Congestion Points are increasing day by day. Therefore, the Pattern of Selection of Road Network Routes Each road user chooses the right route on his way to his destination so that the travel time is minimum and the cost is the cheapest. This study aims to model the perception of road users regarding traffic congestion on route selection in the city of Manado with a Structural Equation Modeling (SEM) approach. The results showed that the route selection model due to traffic congestion in the city of Manado with the SEM approach was a fit model based on the Goodness of Fit (GoF) criteria. The indicator that makes a dominant contribution to the impact of congestion is the cultural aspect, namely the lack of awareness of traffic signs and non-compliance with applicable norms. The selection of the impact route from the selected congestion is the loading of many segments, namely the number of intersections traversed and the number of traffic signs.***

Keywords: Traffic Congestion, Route Selection, Structural Equation Modeling

1. Introduction

Manado City as the capital city of North Sulawesi Province with an area of 157.26 km^2, which is flanked in the north by North Minahasa Regency and the Mantehage Strait, in the south of Minahasa Regency, west of Manado Bay, east of Minahasa Regency [1], with considerable potential both in the field of the tourism and industrial sectors provide added value to various business and investment opportunities [2]. Thus the activities that occur as a result of the formation of activity centers / land use, such as; government administrative centers, settlements, schools, hospitals, entertainment facilities, shopping centers, tourism accommodation centers cause the generation of such a large movement which consequently affects the existing transportation system. The occurrence of a movement is caused by the fulfillment of needs that are available elsewhere. This means that the interrelationships between spatial regions play a very important role in creating movement. Transportation problems such as traffic jams, delays will occur as a result of movements or trips carried out so that there is a concentration of origin for movement generation at the same time and there is a large traffic load on the road to the center of activity in the city of Manado.

There are several things that are considered to be the cause of traffic jams in Manado, which are getting worse, including the increase in housing development, the stretching of the economic sector that continues to increase and the behavior of Manado residents in using transportation. The resultant between the increase in development and its results with the behavior of the community in carrying out this mobilization is an explosion of Traffic Congestion because from the beginning it was not anticipated by the local government. In addition, the cause of traffic congestion also comes from the pattern of people's behavior in mobilizing and the culture of society in general. The existing culture leads people to tend to use private vehicles because vehicles are not only viewed from a technical function but also a prestige function. People's culture of poor traffic is also shown by their non-compliance with applicable norms such as parking carelessly. The cause of Traffic Congestion which is also observed in Manado City is the mixing of all types of vehicles, both goods transporting vehicles and people in the role of arterial, collector and local road functions so that the road network does not function efficiently [3]. The application of route rules and operating times will be able to reduce traffic congestion which in turn will reduce traffic congestion. The number of roads in the Manado City area makes it possible for users to choose the best route based on their personal perception in order to avoid Traffic Congestion in achieving their travel destination.

Several studies related to traffic congestion and route selection, Izanloo et al. in 2017, traffic flow in cities is influenced by many factors, including land use (especially commercial land use due to the nature of trips). This phenomenon can be more effective when combined with accessibility and road connectivity factors [4]. Sompie in 2015, with a Structural Equation Modeling approach, showed that the choice of transportation mode on weekends was influenced by economic status, activity patterns and service satisfaction. Activity patterns had the greatest influence on transportation modes [5]. Ingram in 2022 states that when traveling, travelers are faced with uncertainty. On the one hand, travelers cannot accurately predict the characteristics (attributes) of a route because of the randomness of its characteristics. Referring to this type of uncertainty, describes an unexpected phenomenon as randomness. Randomness in various processes can be explained well by probability theory [6]. Wegener in 2004, points out that spatial development, or land use, determines the need for spatial interaction, or transportation. However, it is difficult to empirically isolate the impact of land use on transportation and vice versa because of the many flows that coincide with changes in other factors [7]. This poses a problem if the possible impacts of integrated land use and transport policies to reduce travel demand are to be predicted. Conder and Keith in 2002, developed an integrated land use and transportation model (MetroScope) [8]. This model is used to explore several regional growth management options and also to generate new regional transport forecasts and plans. Comparing the MetroScope results with previous estimates shows that an integrated transport and land use model can produce different results in terms of travel length, vehicle mileage, traffic congestion levels, mode and route choices, as well as work and household locations. This study aims to examine and analyze the model of the relationship between traffic congestion that occurs on roads with parameters of dependency, culture, and smoothness on route selection in the city of Manado using SEM.

2. Research Methodology

The data of this research is primary data which is taken directly by providing questionnaires through questionnaires to road users in Manado City. The sampling method used is simple random sampling. The research was conducted for 3 months, from March 2022 to May 2022. The object of the research took place in the administrative area of Manado City which consisted of 11 Districts. The research variables consist of 8 latent variables, namely: Traffic Congestion (X), dependency aspect (X1.1), cultural aspect (X1.2), fluency disturbance aspect (X1.3), Route Selection (Y), Route Shortest Load (Y1.1), Probable Loading (Y1.2), and Multiple Segment Loading (Y1.3).

Research using SEM allows a researcher to answer questions that are both regressive and dimensional (measuring the dimensions of a concept) [9]. Identification of the dimensions of a concept or construct (conducted by confirmatory factor analysis), and to measure the influence or degree of relationship between factors whose dimensions have been identified (performed by path analysis) [10]-[11]. The SEM model is structured based on the conceptual framework presented as follows.

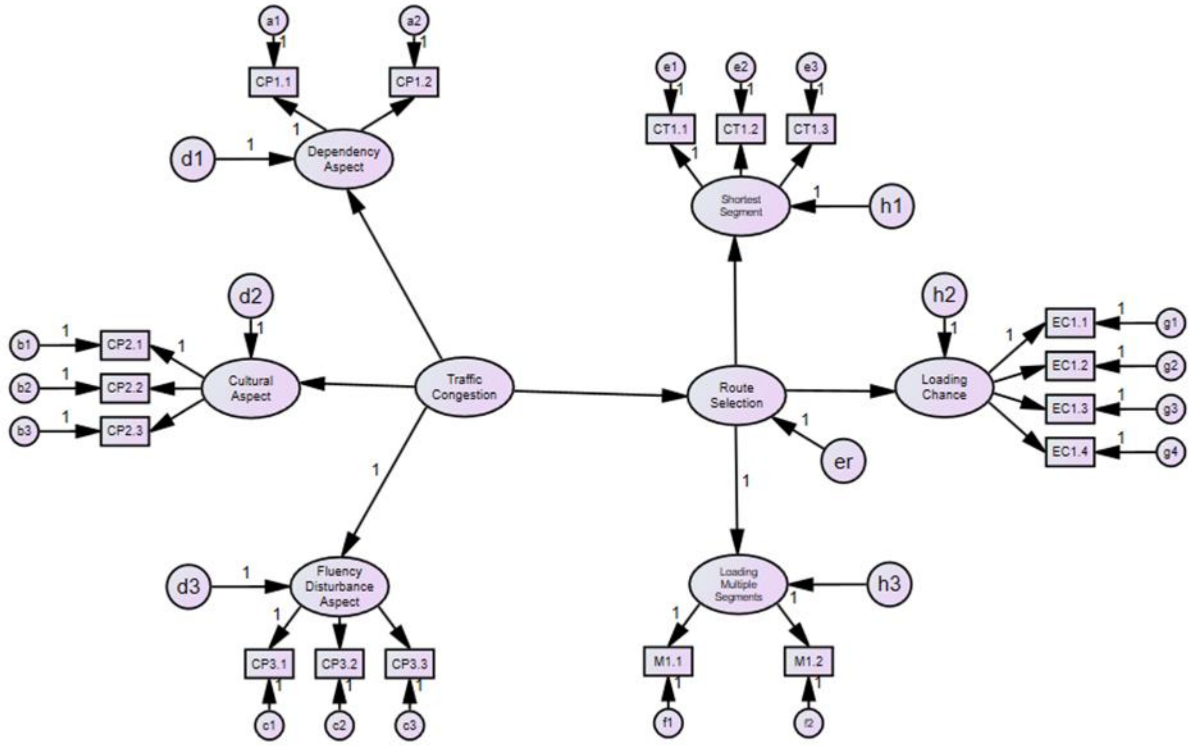

Figure 1: Conceptual Framework for Route Selection Based on Traffic Congestion in Manado City

The stages of analysis carried out are the evaluation of the measurement model, goodness of fit and evaluation of the structural model. Evaluation of the measurement model, namely convergent validity, is used to determine the correlation between each indicator and its latent variables. Convergent validity can be seen from the standardize loading factor (λ) value greater than 0.5 is still acceptable [12]. Composite reliability is an indicator block that measures a construct and can be evaluated with a measure of internal consistency [13]. Composite reliability can be accepted as a level of reliability if the coefficient of the latent variable is greater than 0.7. Evaluation of the structural model, namely testing the path coefficients between latent variables, using the T statistic, if the T statistic value is greater than the t table value, then the path coefficient is statistically significant [14].

3. Results and Discussion

Validity test is intended to determine whether the questions in the questionnaire are representative enough and Reliability is a measure of the internal consistency of the indicators of a variable that shows the degree to which each indicator indicates a general variable. Validity and reliability tests were carried out using confirmatory factor analysis, and the results are presented in Table 1 below.

Table 1: Convergent Validity Test, Discriminant Validity and Reliability of Latent Variable Traffic Congestion (X1) and Route Selection (Y)

First Order CFA				Second Order CFA			
Item	Loading	T-Statistic	C-R (AVE) [√AVE]	Indicators	Loading	T-Statistic	C-R (AVE) [√AVE]
CP1.1 (road capacity)	0.831	Referen	0.859 (0.753) [0.868]	dependency aspect (X1.1)	0.940	12.883	0.971 (0.919) [0.958]
CP1.2 (shoulder of the road)	0.904	17.489					
CP2.1 (lack of awareness of traffic signs)	0.862	Referen	0.901 (0.751) [0.867]	Cultural aspects (X1.2)	0.974	14.001	
CP2.2 (behavior patterns)	0.858	17.948					
CP2.3 (non-compliance with norms applicable)	0.880	18.843					
CP3.1 (slow vehicles)	0.779	Referen	0.899 (0.749) [0.866]	fluency disturbance aspects (X1.3)	0.961	Referen	
CP3.2 (stopping of public transportation or other vehicles)	0.883	15.746					
CP3.3 (vehicles entering and leaving land beside the road)	0.928	16.763					
CT1.1 (travel time)	0.921	Referen	0.941 (0.842) [0.917]	Shortest Route(Y1.1)	0.910	18.549	0.884 (0.723) [0.851]
CT1.2 (distance)	0.959	23.284					
CT1.3 (cost)	0.870	19.711					
EC1.1 (movement on arterial roads)	0.924	Referen	0.914 (0.726) [0.852]	Opportunity Loading (Y1.2)	0.641	10.792	
EC1.2 (collectors)	0.801	11.498					
EC1.3 (local)	0.856	12.441					
EC1.4 (road surface condition)	0.823	13.678					
M1.1 (number of intersections traversed)	0.950	Referen	0.882 (0.789) [0.888]	Loading of Multiple Segments (Y1.3)	0.965	Referen	
M1.2 (number of traffic signs)	0.822	18.694					

Table 1 shows that all loading values are greater than 0.5, the p-value in the error variance is 0 less than 0.05 and the composite reliability (C-R) value is greater than 0.7 and the AVE root value in each latent variable is greater than 0.5, it can be said that all latent variables and indicators are valid (convergent and discriminant) and reliable. Traffic Congestion (X) with an indicator of dependency aspect (X1.1) with a loading value of 0.940, cultural aspects (X1.2) with a loading value of 0.974, fluency disturbance aspects (X1.3) with a loading value of 0.961. route selection (Y) with the Shortest Route indicator (Y1.1) with a loading value of 0.910, Opportunity Loading (Y1.2) with a loading value of 0.641, and Loading of Multiple Segments (Y1.3) with a loading value of 0.965.

The dependency aspect indicator consists of 2 items, namely the road capacity (CP1.1) with a loading value of 0.831, the shoulder of the road (CP1.2) with a loading value of 0.904. The cultural aspect indicator (X1.2) consists of 3 items, namely lack of awareness of traffic signs (CP2.1) with a loading value of 0.862, behavior patterns (CP2.2) with a loading value of 0.858, and non-compliance with norms applicable (CP2.3) with a loading value of 0.880. The indicator of smoothness disturbance aspect (X1.3) consists of 3 items, namely slow vehicles (CP3.1) with a loading value of 0.779, stopping of public transportation or other vehicles (CP3.2) with a loading value of 0.883, and vehicles entering and leaving land beside the road (CP3.3) with a loading value of 0.928.

The indicator of the shortest route (Y1.1) consists of 3 items, namely travel time (CT1.1) with a loading value of 0.921, distance (CT1.2) with a loading value of 0.959, and cost (CT1.3) with a loading value of 0.870. The Probable Loading Indicator (Y1.2) consists of 4 items, namely movement on arterial roads (EC1.1) with a loading value of 0.924, collectors (EC1.2) with a loading value of 0.801, local (EC1.3) with a loading value of of 0.856, and the road surface condition (EC1.4) with a loading value of 0.823. The Loading Multi-Section Indicator (Y1.3) consists of 2 items, namely the number of intersections traversed (M1.1) with a loading value of 0.950, and the number of traffic signs (M1.2) with a loading value of 0.822.

After testing the validity and reliability on each latent variable, several prerequisites must be met in covariance-based structural modeling. The assumptions that must be met are normal multivariate, non singular and outliers [15].

a) Normality test

Normality of the data is one of the requirements in Structural Equation Modeling (SEM) [16]. Normality testing is emphasized on multivariate data by looking at the value of skewness, kurtosis, and statistically it can be seen from the Pearson Correlation between dj and q [17]. If a significance level of 5 percent is used, then the Pearson Correlation value between dj and q is more than 0.5 or p is smaller than = 0.05, which means that the data is normally distributed in multivariate manner. The Pearson Correlation between dj and q is 0.969 or p = 0.000 < = 0.05, so it can be said that the data has a normal multivariate distribution.

b) Singularity Test

Singularity can be seen through the determinant of the covariance matrix [18]. The value of the determinant equal to zero indicates an indication of the existence of a Singularity problem, so it cannot be used for research. The results of the study give the value of the Determinant of sample covariance matrix of .029. This value is close to zero, so it can be said that there is no singularity problem in the analyzed data.

c) Outliers

Outliers are observations that are far from other observations or appear to be extreme, both univariate and multivariate [19]. Outlier test results in this study are presented at the Mahalanobis distance or Mahalanobis d-squared [20]. The Mahalanobis value which is greater than the Chi-square table or p value < 0.001 is said to be an outlier observation. In this study, there were four data outliers, because they were still below 5 percent of the observations (250 x 5% = 13), so it can be said that there were no outliers.

Furthermore, the influence between latent variables is used for structural equation modeling in the form of a path diagram as follows:

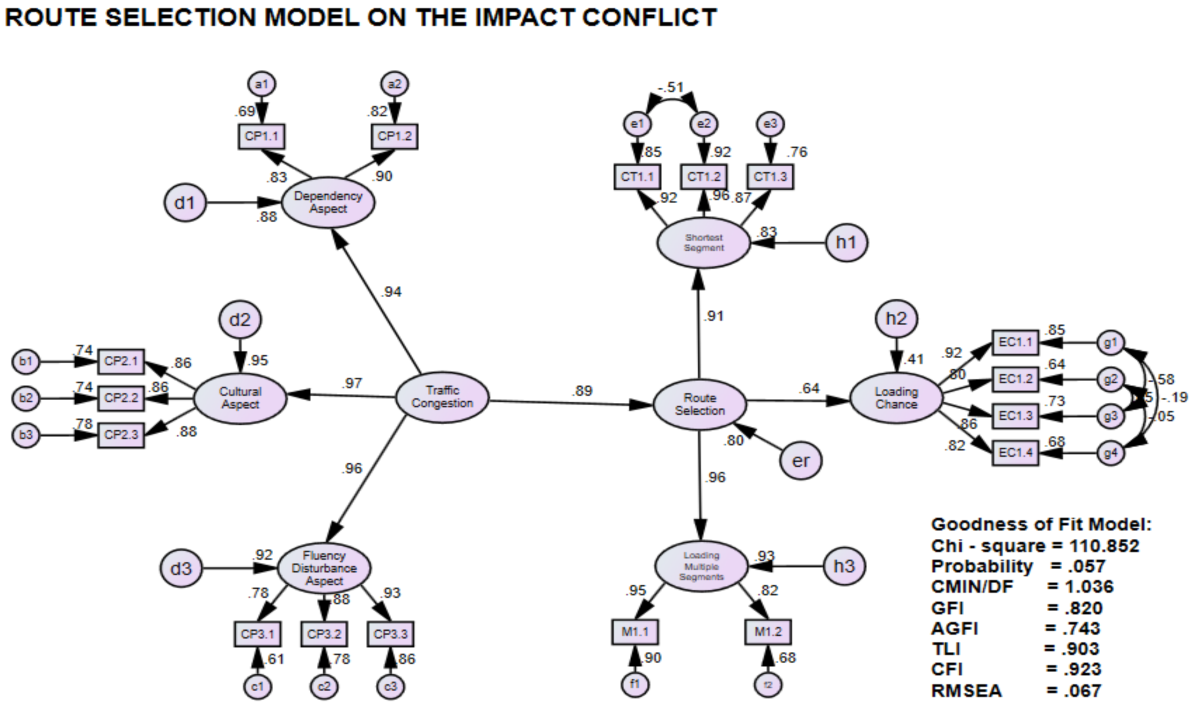

Figure 2: Path Diagram of Traffic Congestion Model on Manado City Route Selection

The structural equations in Figure 2 are as follows:

Route Selection = 0.89 P_Traffic Congestion (1)

The results of testing the complete model in Figure 2 with the complete AMOS program can be seen in the following table

Table 2: Route Selection Model Test Results

Criteria	Cut – Off Value	The calculation results	Information
Chi – Square	Expected small	110.852	$\chi 2$ withdf = 107 is 132.144 Good
Significance Probability	≥ 0.05	0.057	Good
RMSEA	≤ 0.08	0.067	Good
GFI	≥ 0.90	0.820	Marginal
AGFI	≥ 0.90	0.743	Marginal
CMIN/DF	≤ 2.00	1.036	Good
TLI	≥ 0.90	0.903	Good
CFI	≥ 0.90	0.923	Good

Table 2 shows that theeight criteria used to assess whether or not a model is appropriate or not, it turns out to be good and quite good. It can be said that the model is acceptable, which means that there is a match between the model and the data. The path coefficient tests in Figure 2 and the above equation in detail are presented in the following table.

Table 3: VarianceThe Results of Testing the Path Coefficient of the Manado Route Selection Model

Laten Variables	Coefficient	Critical Ration (C.R.)	Probability	Information
Traffic Congestion →Route Selection	0.894	13.690	0.000	Significant
Traffic Congestion ---→ Dependency Aspect	0.940	12.883	0.000	Significant
Traffic Congestion ---→Cultural Aspects	0.974	14.001	0.000	Significant
Traffic Congestion ---→ Fluency Disturbance Aspects	0.961	Referen	0.000	Significant
Route Selection ---→Shortest Route	0.910	18.549	0.000	Significant
Route Selection ---→Probability Loading	0.641	10.792	0.000	Significant
Route Selection ---→Multiple Segment Loading	0.965	Referen	0.000	Significant

From the appropriate models and those contained in Table 3, so that each path coefficient can be interpreted as follows.

a) Influence of Traffic Congestion (X) on The Route Selection (Y)

Traffic Congestion has a positive and significant effect on Route Selection. This can be seen from the path coefficient which is positive at 0.894 with a C.R. of 13,690 and obtained a significance probability (p) of 0.000 which is smaller than the significance level (α) which is determined at 0.05. Thus, Traffic Congestion has a direct effect on Route Selection by 0.894, which means that every time there is an increase in Traffic Congestion, it will increase Route Selection by 0.894.

b) Influence of Dependency aspect (X1.1)on The Traffic Congestion (X)

Dependency aspect contributes to Traffic Congestion of 0.940. This can be seen from the loading value which is positive at 0.940 with a C.R. of 12,883 and obtained a significance probability (p) of 0.000 which is smaller than the specified significance level (α) of 0.05. Thus the dependency aspect is a valid and significant indicator on the Traffic Congestion variable.

c) Influence of Cultural aspects (X1.2)on The Traffic Congestion (X)

Cultural aspects contribute to Traffic Congestion of 0.974. This can be seen from the loading value which is positive at 0.974 with a C.R. of 14.001 and obtained a significance probability (p) of 0.000 which is smaller than the significance level (α) which is determined at 0.05. Thus the cultural aspect is a valid and significant indicator on the Traffic Congestion variable.

d) **Influence of Fluency Disturbance Aspect (X1.3) on The The Traffic Congestion (X)**

Aspects of disturbance of smoothness contributed to Traffic Congestion of 0.961. This can be seen from the loading value which is positive at 0.961 and the significance probability (p) is 0.000 which is smaller than the significance level (α) which is determined at 0.05. Thus the smoothness aspect is a valid and significant indicator on the Traffic Congestion variable.

e) Influence of The Shortest Route (Y1.1) on The Route Selection (Y)

The Shortest Route contributes to the route selection of 0.910. This can be seen from the loading value which is positive at 0.910 with a C.R value. of 18,549 and obtained a significance probability (p) of 0.000 which is smaller than the significance level (α) which is determined at 0.05. Thus the Shortest Route is a valid and significant indicator on the route selection variable.

f) Influence of Probability loading (Y1.2)on The Route Selection (Y)

Probability loading contributes to route selection of 0.641. This can be seen from the loading value which is positive at 0.641, with a C.R. of 10,792 and obtained a significance probability (p) of 0.000 which is smaller than the specified significance level (α) of 0.05. Thus, Probability Loading is a valid and significant indicator on the route selection variable.

g) Influence ofLoading of Multiple Segments (Y1.3)on The Route Selection (Y)

Loading of Multiple Segments contributes to route selection of 0.965. This can be seen from the loading value which is positive at 0.965 and the significance probability (p) is 0.000 which is smaller than the significance level (α) which is determined at 0.05. Thus the Loading of Multiple Segments is a valid and significant indicator on the route selection variable.

4. Conclusion

The results of the study show that using the SEM approach, the route selection model based on traffic jams in the city of Manado is a fit model. The impact of traffic jams greatly affects route selection. The indicator that makes a dominant contribution to the impact of congestion is the cultural aspect, which includes a lack of awareness of traffic signs, behavior patterns, and non-compliance with prevailing norms. The selection of the impact route from the selected congestion is the Loading of Multiple Segments consisting of the number of intersections traversed and the number of traffic signs.

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