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MODELLING OF TRIPS ASSIGNMENT ANALYSIS FOR ROADS NETWORK SYSTEM BASED ON TRANSPORTATION NEEDS OF EXSPORT COMMODITY

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ABSTRACT

High economic growth requires an increase in export commodity trade. The distribution of export commodities must be supported by improving the service of a good and smooth road network system. Production of export commodities in export commodity producing zones requires good distribution services to increase the competitiveness of export commodities. The trips assignment analysis model of freight transportation is an analysis of loading in the road screen system to get the effect of the production of export commodity movements on road network system services. The purpose of modeling is to find an overview of the movement and transportation needs of road freight to the production volume of export commodity producing zones. The road network system that is built is simulated by loading the volume of traffic generated from the production of freight vehicles from the export commodity production zone. The destination origin matrix method is based on gravity modeling with the generation and pull of movement developed with traffic volume data obtained from traffic counting data surveys. He least squares method and the Jordan g aus elimination method with the Newton Raphson method are used in modeling and calibration applications on matrices that result from movement between zones. The results of the modeling are a simulation model of movement in the network system created in a computing system based on the determination of nodes and links that are designed in a virtual road network system in Central Java Province. The resulting model was validated with the results of traffic counting data traffic movements by producing a significance test of the R2 model of 0.92. So the results of modeling trips assignment analysis on the road network system based on export commodities have significance for determining the routes used efficiently on the transportation needs of freight transportation on an efficient road network system that results from modeling.

Keywords: trips assignment, road network system, export commodities.

1. INTRODUCTION

The development of export commodity production zones has increased significantly in Indonesia's economic development. Central Java Province is one that has a stable and positive growth rate in the development of production and distribution of export commodities. The generating and attracting of export commodity movements in Central Java Province has greatly encouraged the national movement system to increase the distribution of export commodity transportation movements. [1-7]

The road network system is the main infrastructure of transportation infrastructure in encouraging the acceleration of the distribution of commodity goods. Central Java Province was built with a road network system that connects the corridor zone of the northern lane and the corridor zone of the southern lane with the connecting lane that has adequate road capacity. The network system is underway being formed by the national road network system and the provincial road network system and the district or city network system with integration on the route links that are connected between zones or districts. Trip modeling assignment analysis is a systematic study of the road network in measuring the performance of road network system services and the distribution of movements in the road network system. The performance parameters of the road network system that are analyzed are estimated based on traffic flow generated from commodity production zones especially export commodities.

Trip assignment analysis can be used for route selection and determination of the transportation needs of the most expensive road goods related to vehicles transporting export commodities on the road network system. [1-7]

Analysis of the overall performance of road services is an approach in solving the trips model of the road network system assignment. So the study of the trip assignment analysis model is the basis for estimating transportation needs in the road network system in accordance with export commodity production. The movement of export commodities requires an efficient and effective distribution channel in the road network system in the destination zone of the commodity goods destination. The direction of distribution movement of the trip assignment analysis model will direct the movement according to the level of congestion experienced by the road network system. Simulation trips assignment resulting analyzes will show an extensive network of roads system burdened by a large volume of traffic in accordance with the capacity of the road or in excess of

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the capacity of the specified path on the roads and streets built network system. A road network system with excess volume will cause low levels of road service and slow travel speeds. The level of road service indicated by the level of VC ratio of the road section will be indicated on each link that connects between zones on the road network system that is built in the Central Java province. [1-7] [8] [10-16]

With the use of trip analysis analysis generated, a transportation needs approach is obtained to determine the right mode and network in the movement system to improve an efficient distribution system in the movement of export commodity goods. The transportation demand model based on traffic on the road network system that has been optimized for the movement distribution produces a good level of accuracy in the prediction of modes and transportation needs in accordance with production volumes based on commodity production zones. Thus, sustainable development in the regional transportation system can be predicted well according to their needs [9-13]. The transportation problem depends on the condition of the road and how to overcome it gradually and continuously so that it can be passed by motorized vehicles, including concrete construction which is arranged in a mixed form [17-21].

2. MODELLING TRIP ASSIGNMENT ANALYSIS FOR ROAD NETWORK SYSTEM

The modeling of trips assignment analysis is the development a distribution movement model based on gravity modeling. By combining traffic data transportation needs are estimated based on movements between zones. The resulting combination is the origin destination matrix with its parameters. With basic equations (1) [14-16]

$$T_{id} = \sum_{k=1}^{K} T_{id}^{k} \tag{1}$$

with T_{id}^{k} is the movement of each export commodity movement destination k from the zone of origin i to destination zone d with the definition of the equation shown in equation (2) [14]

$$T_{id}^{k} = b_{k}.O_{i}^{k}.D_{d}^{k}.A_{i}^{k}.B_{d}^{k}.f_{id}^{k} \tag{2}$$

$\hat{V}$ total flows on certain roads is the sum of the movement between the zones within the study area that use these roads, shown in equation (3). [14-16]

$$\hat{V}_{l} = \sum_{i=1}^{N} \sum_{d=1}^{N} T_{id}.p_{id}^{l} \tag{3}$$

By substituting equation (2) to equation (3), the basic equation for the transportation demand estimation model with traffic flow data is shown on equation (4) [14-16]

$$V_{l} = \sum_{k=1}^{K} \sum_{i=1}^{N} \sum_{d=1}^{N} \left(b_{k}.O_{i}^{k}.D_{d}^{k}.A_{i}^{k}.B_{d}^{k}.f_{id}^{k} p_{id}^{l}. \right) \tag{4}$$

Traffic flow with other modes of travel between zones indicated an equation (5) [14-16]

$$V_{l}^{m} = \sum_{i=1}^{N} \sum_{d=1}^{N} T_{id}^{m}.p_{id}^{lm} \tag{5}$$

By using gravity models as a transportation model indicated equation (6) [14-16]

$$F_{id} = \mu \frac{m_{i}.m_{d}}{d_{id}^{2}}$$

Analogy equation (6) models specific gravity for the transport system shown in equation (7) [14]

$$T_{id} = k \frac{O_{i}.D_{d}}{d_{id}^{2}} \tag{7}$$

With the limitation of the model the equation is shown (8)

$$\sum_{d=1}^{N} T_{id} = O_{i} \qquad \sum_{i=1}^{N} T_{id} = D_{d} \tag{8}$$

Balancing factor A_{i}^{m} and B_{d}^{m} shown the equation (9) [14]

$$A_{i}^{m} = \left[\sum \left(B_{d}^{m}.D_{d}^{m}.f_{id}^{m} \right) \right]^{-1}$$
$$B_{d}^{m} = \left[\sum \left(A_{i}^{m}.O_{i}^{m}.f_{id}^{m} \right) \right]^{-1} \tag{9}$$

Transportation of freight with various types and types of freight vehicles with simple mode selection using the logit-multinomial model is shown by the equation (10) [1-7] [8] [16]

$$T_{id}^{k} = T_{id}.\frac{\exp\left(-\beta.C_{id}^{k}\right)}{\sum_{m=1}^{M} \exp\left(-\beta.C_{id}^{m}\right)} \tag{10}$$

Estimating the modeling with a combination of the distribution of movement with the choice of modes as the transportation needs of freight transport is shown in equation (11) [1-5] [14-16]

VOL. 15, NO. 21, NOVEMBER 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

$$V_l^k \sum_{i-1}^{N} \sum_{d=1}^{N} \left[O_i^k . D_d^k . A_i^k . B_d^k . f_{id}^k . p_{id}^{lk} . \frac{exp(-\beta . c_{id}^k)}{\sum_{m=1}^{M} exp(-\beta . c_{id}^k)} \right] \quad (11)$$

2.1 The Least Squares Estimation Method for Calibrate Model

The use of this method is done to calibrate the parameters of the unknown transportation model so as to minimize the difference in the number of squares between the results of the assessment of observations, shown the equation (12) [14-16]

$$\text{Minimize} \quad S = \sum_{l=1}^{L} \left[\frac{(\hat{V}_l - V_l)^2}{\hat{V}_l} \right] \quad (12)$$

To get the parameter value is unknown (β) is done by making the first derivative (S) of these parameters with 0 (zero). With a negative exponential resistance function, the parameter value t is obtained with equation (13) [14-16]

$$\frac{\partial S}{\partial \beta} = f = \sum_{l=1}^{L} \left[\frac{2}{\hat{V}_l} \left\{ (V_l - \hat{V}_l) . \left(\frac{\partial V_l}{\partial \beta} \right) \right\} \right] = 0 \quad (13)$$

Where:

$$V_l = \sum_{l=1}^{N} \sum_{d=1}^{N} \left[T_{id} . p_{id}^l \right] \quad (14)$$

$$\frac{\partial V_l}{\partial \beta} = \sum_{l=1}^{N} \sum_{d=1}^{N} \left[\frac{\partial T_{id}}{\partial \beta} . p_{id}^l \right] \quad (15)$$

$$\frac{\partial^2 V_l}{\partial \beta^2} = \sum_{l=1}^{N} \sum_{d=1}^{N} \left[\frac{\partial^2 T_{id}}{\partial \beta^2} . p_{id}^l \right] \quad (16)$$

$$V_l^k = \sum_{i=1}^{N} \sum_{d=1}^{N} \left[O_i^k . D_d^k . A_i^k . B_d^k . f_{id} . p_{id} . \frac{exp(-\beta . C_{id})}{\sum_{m=1}^{M} exp(-\beta . C_m)} \right]$$

Based on a simultaneous equation of 13 with one unknown β parameter, the Calibration Technique with Newton-Rophson Method is combined with the Gauss-Jordan elimination technique to find the value of the β parameter. [14-16]

2.2 Barriers Function in Calibration

The resistance function is shown equation Negative exponential barrier function shown equation (17)

$$F_{id} = exp^{(-\beta C_{id})}$$
$$\frac{\partial F_{id}}{\partial \beta} = -C_{id} . exp^{(-\beta C_{id})} \quad (17)$$
$$\frac{\partial^2 F_{id}}{\partial \beta^2} = (C_{id})^2 . exp^{(-\beta C_{id})}$$

Barrier function rank (18)

$$F_{id} = C_{id}^{-\beta}$$
$$\frac{\partial F_{id}}{\partial \beta} = -(log_e C_{id}) . C_{id}^{-\beta}$$
$$\frac{\partial^2 F_{id}}{\partial \beta^2} = (log_e C_{id})^2 . C_{id}^{-\beta} \quad (18)$$

Barriers function Tanner (19)

$$F_{id} = C_{id}^{-\beta} . exp^{(-\beta C_{id})}$$
$$\frac{\partial F_{id}}{\partial \beta} = -(C_{id} + log_e C_{id}) . \left(exp^{(-\beta C_{id})} \right) . \left(C_{id}^{-\beta} \right)$$
$$\frac{\partial^2 F_{id}}{\partial \beta^2} = (C_{id} + log_e C_{id})^2 . \left(exp^{(-\beta C_{id})} \right) . \left(C_{id}^{-\beta} \right) \quad (19)$$

Using m = m + 1, and setting the value of βm with equation 13. The initial repetition of t obtained by the value of h is required until β converges (h value reaches a value very small or close to zero). [14-16]

3. DETERMINATION OF ROAD NETWORKS AND TRAFFIC DATA COUNTING

Analysis of the road network system in Central Java determines road transportation services as a distribution of movement due to the production of the generation and attraction of the movement export commodity in Central Java.

Determination of the road network based on the existing condition of the road network in Central Java with the status of national and provincial roads and the status underneath it with accuracy based on the functional road. The data described in the previous chapter is used to validate traffic modeling based on traffic volume in the road network system. Data obtained from secondary data and traffic counting in each zone of the road network based on the type of goods vehicle has been defined in the previous section. The location of the traffic counting model validation is shown Figure-1 [1-7, 11-16].

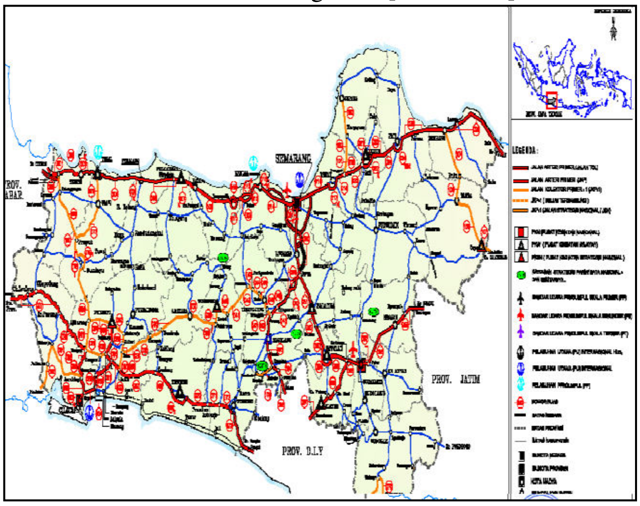

Figure-1. Map of the central java road network with link number.

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4. METHODOLOGY

Analysis approach modeling the trips assigment analysis of a road network system on export commodities is shown by the flowchart diagram of the analysis stage shown in Figure-2.

4.1 Test Model for Trips Assignment Analysis

Correlation Test

The correlation coefficient is a measure of how close the relationship between variables in the model. [1-12]

Correlation Test

$$r = \frac{N\sum_{i=1}^{n}(X_iY_i) - \sum_{i=1}^{n}(X_i)\sum_{i=1}^{n}(Y_i)}{\sqrt{\left[\sum_{i=1}^{N}(X_i)^2 - \left(\sum_{i=1}^{N}(X_i)\right)^2\right]\left[N\sum_{i=1}^{N}(Y_i)^2 - \left(\sum_{i=1}^{N}(Y_i)\right)^2\right]}} \quad (20)$$

Determination Test

$$R^2 = 1 - \frac{\sum_{i=1}^{N}\sum_{d=1}^{N}(\hat{T}_{id} - T_{id})^2}{\sum_{i=1}^{N}\sum_{d=1}^{N}(\hat{T}_{id} - T_1)^2} \qquad i \neq d \quad (21)$$

4.2 Estimated Flowchart Modeling of Trips Assignment Analysis Road Network Systems in Central Java

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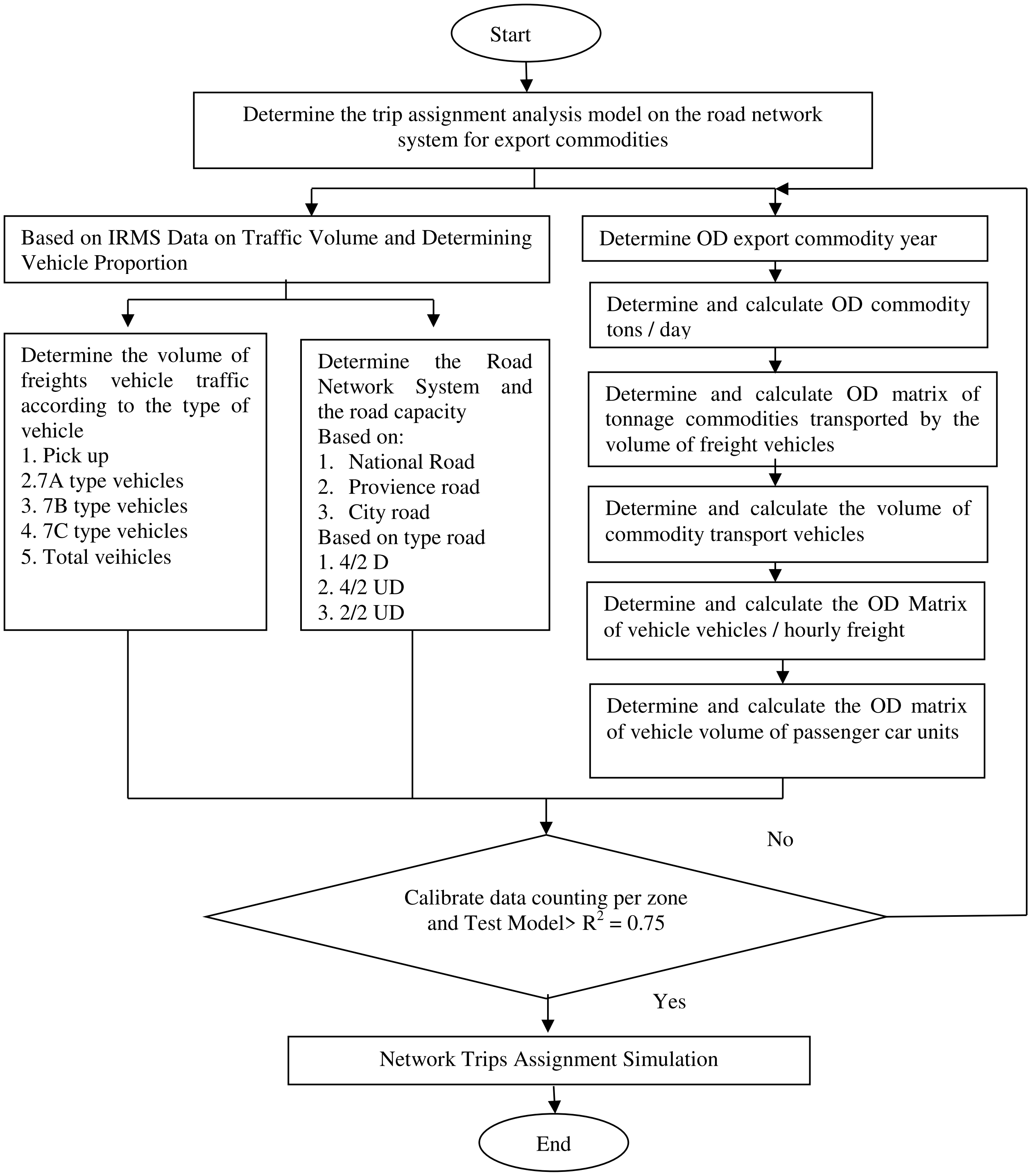

Figure-2. Flowchart modeling trip assignment analysis of road network systems in central java with no link.

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5. RESULTS AND DISCUSSIONS

The results of the trip assignment modeling analysis of the road network system due to the movement of the export commodity system are based on the volume of movement of export commodity freights, divided by the volume of frights vehicles by the type of freight vehicle with a carrying capacity according to the type of vehicle. The trip assignment model analyzes the road network system according to the type of freight vehicle shown in the Figures (3) - (5) [1-7, 8, 9, 17]

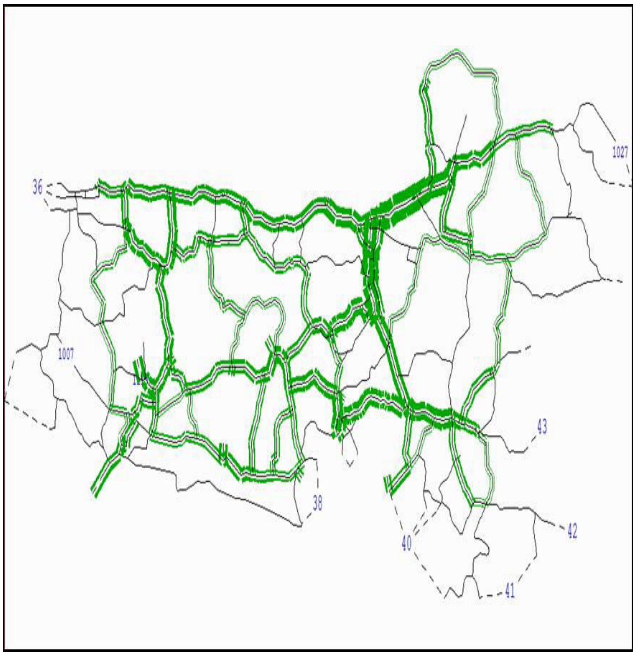

Figure-3. Simulation of trips assignment analysis road network of pickup vehicles.

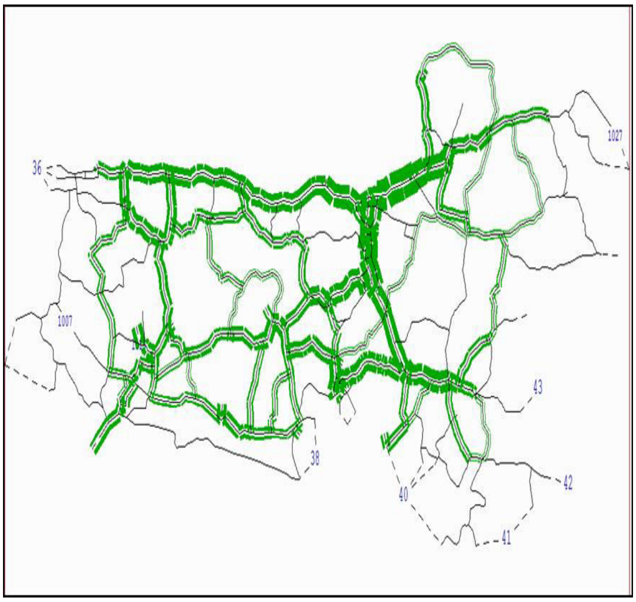

Figure-4. Simulation of trips assignment analysis road network of 7A vehicles.

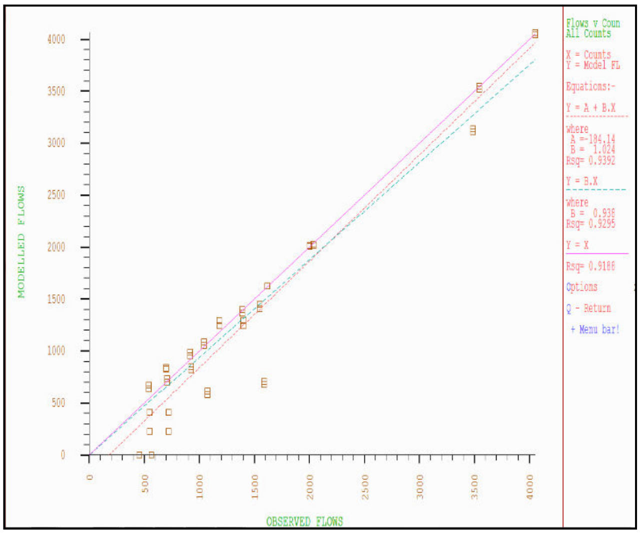

Figure-5. Simulation of trips assignment analysis road network of total vehicles.

Based on the modeling analysis shows that modeling trips assignment analysis on the road network system to the traffic volume of the existing data shows the value of the validation test which shows 0.92 that the resulting model meets the requirements of the modeling rules so that the modeling can be well received. [1-7, 10, 11, 12]

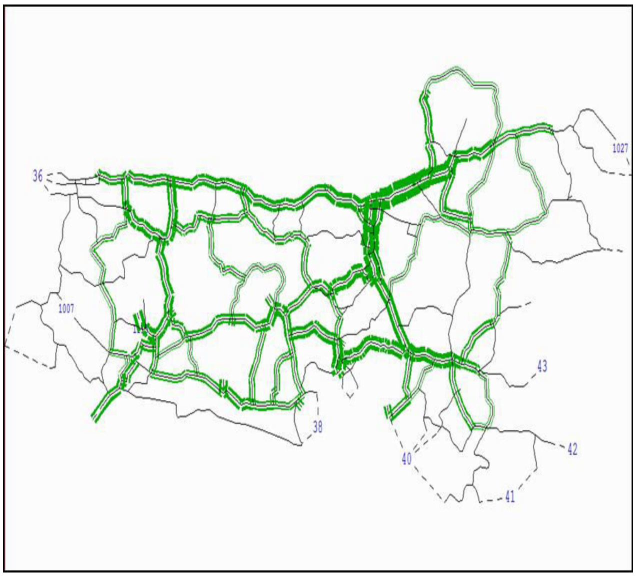

Figure-6. Validation of trips assignment analysis in the road network by the existing volume.

6. CONCLUSIONS

Based on the results of data analysis and modeling it can be concluded that:

- The movement of transportation of export commodity road goods in the road network system in Central Java Province is more dominant by pickup type vehicles.
- Vehicles with a larger type of freight operator use more vehicles with type 7 A vehicles. Type 7 A vehicles are

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vehicles that tend to be used more by export commodity transport operators.

- Trips assigment of freight vehicles in the road network system is being carried out in the middle of the northern lane.
- The connecting lane corridor also shows a fairly congested road network system. This shows that industries that produce export commodities are dominant in the corridor of the road.
- Comparison of the proportion of vehicles transporting goods in the total volume of vehicles on the road network system assignment trips in central Java has a significant contribution with the proportion of 40% of the total vehicles in the road network system.

Nomenclatures	
A_B C_{id} F_{id}	Atraction the movement to zone B Travel costs from the home zone i to the destination zone d Barrier function
$f(C_{id})$	Barrier function of travel cost
$O\frac{k}{i}$ T_{id} $T\frac{k}{id}$	Total movements for each destination or commodity k generated by the zone of origin i Total movement that moves from the origin zone i to the destination zone d within the study area The total movement that moves from the origin zone i to the destination zone d using the commodity k
$T\frac{r}{id}$ V_A	The total movement that moves from the origin zone i to the destination zone d using route r Traffic volume in condition A
Vi,V_l $\frac{V_M}{W}$	Estimated traffic results and observations on sectionsi traffic flow generated by the all-or-nothing trips assigment technique with the cost of the segment from the last repetition results Maximum capacity or current
R^2 S	Coefficient of determination Saturated current
$\sum_{k=1}^{K}$	Used to add all variables that have a value of k, starting from k = 1 to k = K
α,β	Coefficient of function

REFERENCES

[1] Akbardin J., *et al*. 2019. The Trips Assignment Influence of Freight Vehicle Network System on the Need for Fuel Consumption in Internal-Regional. Journal of Physics: Conference Series, 1364_012047.

[2] Akbardin J., *et al*. 2019. Modeling study of generating-trip transportation in the border zone area based on conditions of transportation's infrastructure a case study in the Central Java Province-Indonesia International. Journal of Scientific and Technology Research. 8-12.

[3] Akbardin J., *et al*. 2019. Application of gravity theory on the inter-regional zones activity build upon generating inland fisheries product result in Central Java. Journal of Physics: Conference Series. 1280 022068.

[4] Akbardin J., *et al*. 2018. The Influence of Freight Generation Production Characteristics of the Internal-Regional Zone Commodities on Sustainable Freight Transportation Highway Network System. Matec Web Conference.

[5] Akbardin J., *et al.* 2018. The Influence of Highway Transportation Infrastructure Condition toward Commodity Production Generation for the Resilience Needs at Regional Internal Zone. E3S Web Conference.

[6] Akbardin J., *et al*. 2018. The distribution system simulation model of each zone freight transportation movement based on unlimited the gravity model algorithm. IEEE explore.

[7] Akbardin J., *et al*. 2018. Development of gravity theory application in the internal regional inter-zone commodity movement distribution with the origin zone movement generation boundary, Journal of Physics: Conference Series.

[8] Bennett, C. R. dan Peterson, William D. O. 2000. Higway Development and Management-4-Volume Five - Aguide to Calibtation and Adaptation. The World Road Association (PIARC), Paris dan The World Bank, Washington, D.C.

[9] Cassetta E. 2001. Tranportation System Engineering: Theory and Methods, Kluwer Academic Publishers, Dordrecht, the Nederlands.

[10] Guelat J., M. Florian and T. G. Crainic 1990. A Multimode Multiproduct Network Assigment Model for Srategic Planning of Freight Flows. Transportation Science. 24(1): 25-39.

[11] Ham H., T. J. Kim and D. Boyce. 2005. Implementation And Estimation Of Combined Model

Of Inter Regional, Multimodal Commodity Shipments And Transportation Network Flows. Transportation Research part B. 39(1): 65-79.

[12] Holguin-Veras J. and Thorson E. 2000. Trip length Distributions in Commodity-based and Trip-Based Freight Demand Modelling, Transportation Research Record. 1707, pp. 37-48.

[13] Lakshmanan T. R. dan Anderson W. P. 2002. Transportation Infrastructure, Freight Services Sector And Economic Growth. A white paper prepared for US. Department of Transportation Federal Highway Administration.

[14] Nielsen O. A. 2004. A Stochastic Multimodal Freight Transport Assigment Model with Random Coeefisients, Proc. World Conference on Transport Research Society (WCTRS) D02 paper 1431 Istambul.

[15] Patriks son M. 1994. The Traffic Assignment Problem: Model and Methods. VSP, Utrecht, Netherlands.

[16] Tamin Ofyar Z. 2003. Perencanaan dan Pemodelan Transportasi, Soal dan Aplikasi, penerbit ITB, Bandung. (Indonesian).

[17] Syaiful Syaiful. 2017. Engineering model of traffic and transportation safety with pattern of cooperation between sustainable region in Bogor, MATEC Web Conf. 138(2017) 07008 DOI: https://doi.org/10.1051/matecconf/201713807008