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Development of Road Freight Transportation Distribution Model Based on Vehicle Transportation Inter Zone Requirement

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Abstract

The distribution of road transport goods has the characteristics determined from the commodity and supply chain system of the commodity to be transported. Leading export commodities have an important role in regional economic growth and the drivers of national economic stability. Coffee commodity is one of the main export commodities that have significant economic value in international trade. To support the economic value of better coffee commodities, a more efficient distribution system is needed from the distribution system of coffee commodity production and trade in the coffee commodity production zone to the destination zone. The revenues of coffee commodities are estimated to be based on demographic variables, the condition of road infrastructure and transport vehicles. Production zones of coffee commodity crops have characteristics that develop according to the condition of road infrastructure in the zone. Interactions between production zones use gravity modeling with the loading of transport networks based on the goods traffic in accordance with the dominant characteristics used in transporting the commodities. The development of a freight transportation distribution model with the Breadth-First Search algorithm has the objective to consolidate the interaction of goods transport supply and demand within a zone to determine the efficiency of the traffic load on the road network system. So that the time of coffee commodities distribution will be faster in the destination zone in accordance with the volume of commodity production and the number of available transport vehicles.

Keywords: Transportation of Goods, Commodity of export, coffee commodity, Breadth-First Search algorithm

1. Introduction

The development of a very high demand for goods transportation in a zone in distributing goods production has an important role in the development of sustainable transportation.

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Transportation of road-based goods is transported based on commodity goods to be sent to destination. The destinations is based on dominant production of commodities produced from commodity zone movements generation. Superior goods export of coffee commodities is one of the main commodities produced in the production zone in Central Java Province. Production of coffee commodities that increase in accordance with the growing needs of coffee commodities export. The rise of coffee commodity movements is distributed based on the supply and demand needs of the coffee commodities to the intermediate zone before the delivery of coffee commodities export destinations. Internal - regional road network in Central Java Province has a role to distribute production of commodity movement. The movements are in accordance with demand in the zone in need. Capacity and level of road service will affect the travel time in distributing and supporting the traffic movement in accordance with the required road network operations. A road network that has a good level of service will encourage increased production and distribution of commodity-producing zones. Road capacity in road network system in Central Java Province requires adjustment to traffic volume due to the development of goods commodity movement. By knowing the service level of road network system through model estimation of road network system loading due to production of coffee commodity movement revival. Analysis of network system loading will determine the changes in the system of traffic flow movement and the speed of the network system distribution in serving the traffic movement

1.1. Research Objective

This study has specific objectives:

- Model on the rising commodity movements of coffee export commodities in the regional internal of Central Java Province.
- Knowing the distribution model on superior commodity movement of coffee export in the regional internal of Central Java Province.
- Knowing the loading of road network system due to the export commodities movement in the province of Central Java Province.
- Develop distribution model on loading of road network system using Breadth-First Search computing algorithm

1.2. Research Boundary

This research was conducted in Central Java Province with road network system according to the use of national road and provincial road on loading of road network system.

2. Gravity Model

Generating movement is the number of moves generated by an origin zone (Oi) and the number of moves that are attracted to each destination zone (Dd) included in the study area

2.1. Generation and Atraction

The generation and attraction of movement is a modeling stage that estimates the number of movements coming from a zone or land use and the number of moves that are attracted to a land use or zone. The generation and attraction of movement is shown diagrammatically in Figure 1. The Trip Generation model is used to predict the number of traffic generated for a given zone characteristic condition. The movement generating is the number of moves generated by an origin zone (Oi) and the number of moves that are interested in each destination zone (Dd) contained in the study area. The amount of movement from the origin zone is also called Trip Production.

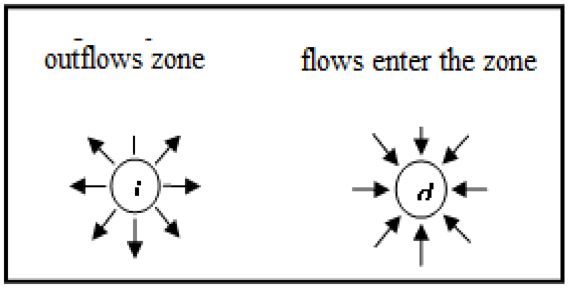

Fig 1. Generation and Attraction Movement

2.2. Modeling of Freight Transportation

Gravity model that gives the formula of freight transportation total volume based on the commodity type transported from one place to the other place is as follows (equation 1)

$$T_{idk} = \frac{S_{ik} . D_{dk} \, f_{id}}{\sum D_{dk} \, . \, f_{id}} \quad (1)$$

Where:
T_{idk} = the number of k commodity produced in the i region and sent to the d region
S_{ik} = the total amount of shipments on k commodity from the i region
D_{dk} = the total amount of demand on k commodity in d region
f_{id} = the friction/ barriers factor (= 1 / $d_{id}\lambda$)
λ = parameter

This model uses the gravity concept introduced by Newton developed from the gravity law analogy.

$$F_{id} = G \, . \frac{m_i . m_d}{d_{id}^2} \quad (2)$$

with G as the gravitational constant of the movement attraction, as well as distance, time, or cost as an accessibility measurement. Thus, for transportation purposes, the GR model is formulated as: (Equation 3)

$$T_{id} = k \, . \frac{O_i . O_d}{d_{id}^2} \quad (3)$$

In which k is a constant
So, in mathematical equation, GR model can be formulated as below:

$$T_{id} = O_i . D_d . A_i . B_d \, . \; f \, (C_{id}) \quad (4)$$

2.3. Modelling of Transportation based on Traffic Flow

$\hat{V}$ 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 (5).

$$\hat{V}_l = \sum_{i=1}^{N} \sum_{d=1}^{N} T_{id} \cdot p_{id}^{l} \tag{5}$$

Commodity moved between the zones within the study area is represented by a model of transportation demand with Gravity Model Opportunity (GO). In which, T_{id} total movement with the i starting point zone and the d destination zone for all commodity movements purposes are indicated by equation (6)

$$T_{id} = \sum_{k=1}^{K} T_{id}^{k} \tag{6}$$

where the commodity that move from i zone to d zone is shown on equation (7)

$$T_{id}^{k} = b_k . O_i^k . D_d^k . A_i^k . B_d^k . f_{id}^{k} \tag{7}$$

By substituting equation (7) to equation (5), the basic equation for the transportation demand estimation model with traffic flow data is shown on equation (8)

$$V_l = \sum_{k=1}^{K} \sum_{i=1}^{N} \sum_{d=1}^{N} \left(b_k . O_i^k . D_d^k . A_i^k . B_d^k . f_{id}^{k} p_{id}^{l} . \right) \tag{8}$$

2.4 Development of distribution with Breadth-First Search algorithm.

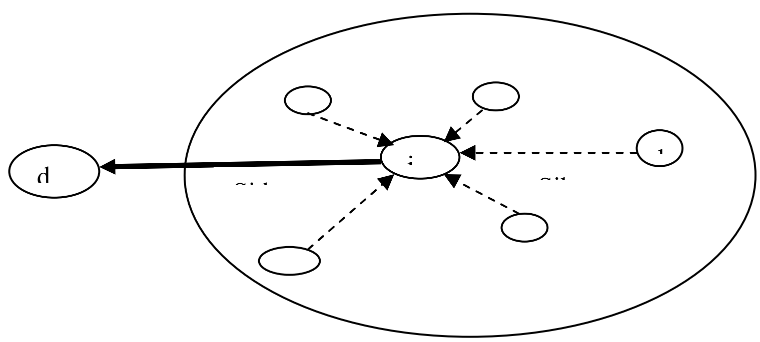

Fig 2. Intervening Opportunities Model

Newton-Raphson method with powel algorithm has efficiency in the iteration process to determine the convergence value. This method is often used to calibrate model parameters for urban areas (Tamin, 2003). Based on the understanding of gravity opportunity model and Newton-Raphson calibration method, it is used to determine the transportation model based on internal-regional needs with the development of Newton-Raphson method with Breadth-First Search algorithm. (BFS). Breadth-First Search (BFS) algorithm, also known as a widening search algorithm, is a search algorithm that broadly visits a node preorder visiting a node and then visiting all the nodes adjacent to that node first. Next, the unoparted node and adjacent to the previously-visited node, and so on. If the tree-shaped graph is rooted, then all the vertices in cascade are visited first before the nodes in the d + 1 direction.

3. Methodology

Development of Road Freight Transportation Distribution Model Based on Vehicle Transportation Inter Zone Requirement is very complex and extensive to simplified by defining the dominant determined variables.

3.1. Variable of Generating Movement

Dependent variables
Y1 = Oi = Generating Movement of coffee Commodity
Independent variables
X1 = population,
X2 = GRDP (Gross Regional Domestic Product),
X3 = Freights based on coffe commodity and their manufactured products IO,
X4 = the length of state highways in the Central Java districts or cities,
X5 = the length of provincial highways in the Central Java districts or cities,
X6 = the length of local highways in the Central Java districts or cities,
X7 = highways in good condition in the Central Java districts or cities,
X8 = highways in moderate condition in the Central Java districts or cities,
X9 = damaged highways in the Central Java districts or cities,
X10 = severely damaged highways in the Central Java districts or cities,
X11 = the number of freights vehicles in the Central Java districts or cities,
X12 = the number of freights vehicles owned by individuals,
X13 = the number of freights vehicles owned by company
b_0 = a constant

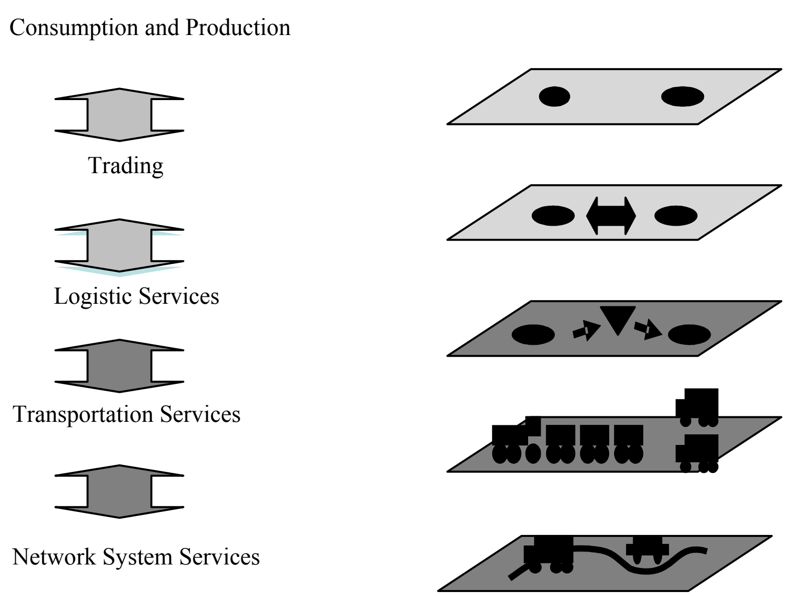

Fig 3. Logical Structure of Freights Transportation

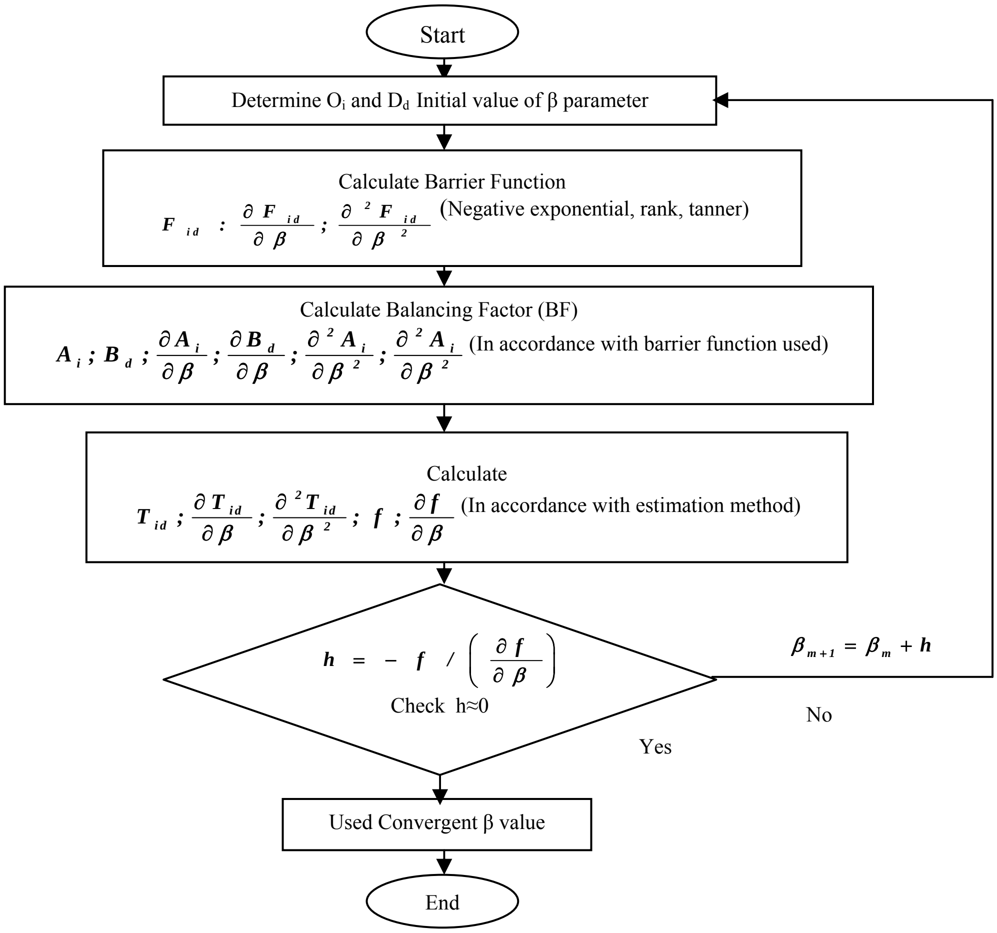

Fig 4. Newton-Rhapson Calibration Method Flow Chart

3.2. Test Model

Correlation Test
The correlation coefficient is a measure of how close the relationship between variables in the model. Correlation Test:

$$r = \frac{N\sum_{i=1}^{N}(X_iY_i) - \sum_{i=1}^{N}(X_i).\sum_{i=1}^{N}(Y_i)}{\sqrt{\left[\sum_{i=1}^{N}(X_i)^2 - \left(\sum_{i=1}^{N}(X_i)\right)^2\right].\left[N\sum_{i=1}^{N}(Y_i)^2 - \left(\sum_{i=1}^{N}(Y_i)\right)^2\right]}} \quad (9)$$

Determination Test

$$R^2 = 1 - \frac{\sum_{i=1}^{N}\sum_{d=1}^{N}(\hat{T}_{id} - T_{id})^2}{\sum_{i=1}^{N}\sum_{d=1}^{N}(\hat{T}_{id} - T_1)^2} \quad (10)$$

$i \neq d$

4. Results And Discussions

4.1. Modeling Trip Generation

Freight movement generation modelling of coffe commodities obtained by indicated equation (11)

$$\text{Ln } Yi = 4.28 + 0.873 \text{ Ln } X1 + 0.0692 \text{ Ln } X2 - 0.00458 \text{ Ln } X3 + 0.0352 \text{ Ln } X4 + 0.0203 \text{ Ln } X5 - 0.004 \text{ Ln } X6 + 0.0226 \text{ Ln } X7 - 0.0264 \text{ Ln } X8 - 0.0202 \text{ Ln } X9 - 0.0178 \text{ Ln } X10 \ldots \quad (11)$$

Based on the result of multiple regression analysis gradually show no multikolinierritas between independent variables. With the results of Determination Test model on the rising movement of coffee commodities superior goods export R2 = 0.85 With the normality test used in this study is One Sample Kolmogorov-Smirnov Test through scatterplot chart. In the One Sample Kolmogorov-Smirnov test, it is known that normal distribution of data if the residual has Asymp. Sig (2-tailed) above 15%. The normality test is shown in the figure. 5

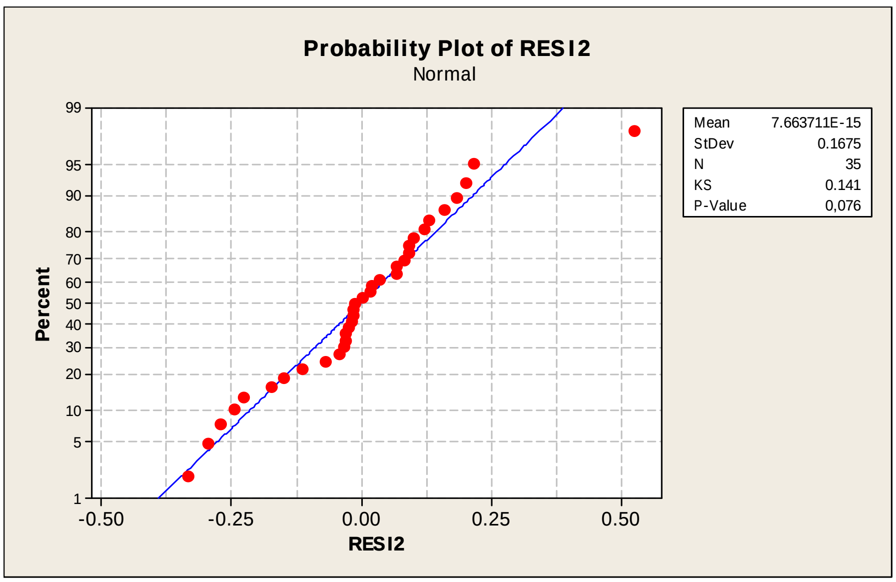

Fig. 5. Normality Test of Multiple Regression of Coffee Commodity

From the equation of the model, the coffee commodity movement is further estimated in accordance with the data of each zone based on the condition oneach zone located in the internal - regional of Central Java Province. Zones with the production of rising coffee commodity movements are shown based on estimation of the generation model. By using computational programming, the estimated model of coffee commodities movement from each zone is indicated by the circle indicated by the zones present in the internal - regional of Central Java Province. The simulation result of the coffee commodity movement model in the internal zone of Central Java Province is shown in the figure. 6

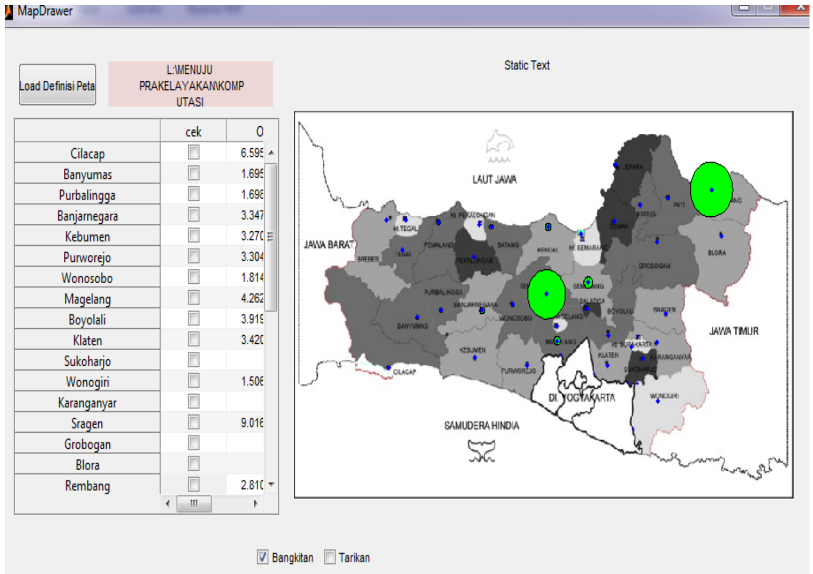

Fig. 6. Simulation Model of Coffee Commodity Generation

Using the same method, the next commodity coffee movement model is simulated with the computational programming shown in Figure 7. It also shows the estimation of the rise and pull ratio on the coffee commodities movement. Characteristics of the rise and pull on coffee commodities are shown from zones that have a surplus of production and zones with high trade in coffee commodities..

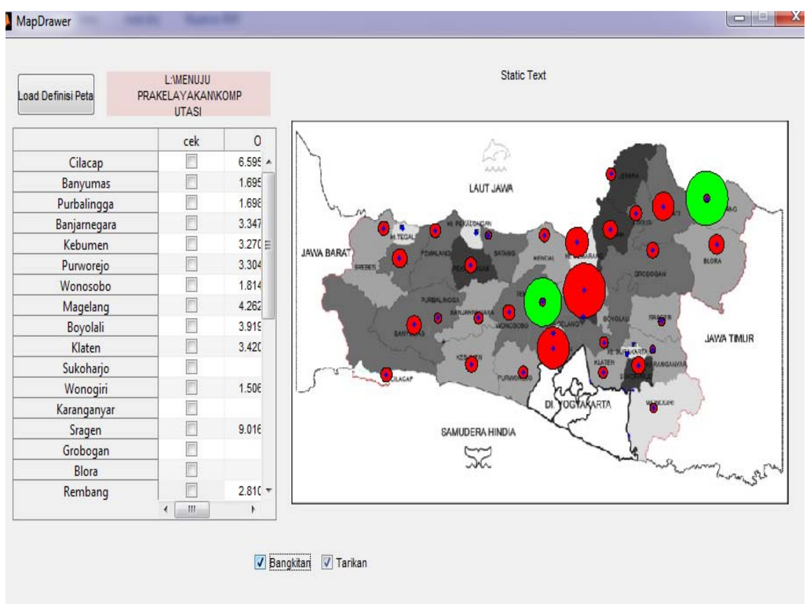

Fig. 7. Simulation Comparison of the Rise and Pull Model on the Coffee Commodities.

4.2. Model of Movement Distribution

The rise and pull model of coffee commodities movement is further used as a basis for modeling the distribution of movements in accordance with the characteristics of the coffee commodity matrix. By using gravity method, distribution of coffee commodity movement with obstacle function shown in figure 7. It shows the function of the power barrier represents the greatest value compared to the value of other obstacle functions.

Table. 1. Unlimited Gravity Modeling Calibration

Function Obstacles	Model Parameter Calibration		
	B	A	β
Rank	-0.435666	25.3428	0.4357
Negative Exponential	-4.846×10^{-12}	18.3218	4.846×10^{-12}
Tanner	-4.846×10^{-12}	18.3218	4.846×10^{-12}

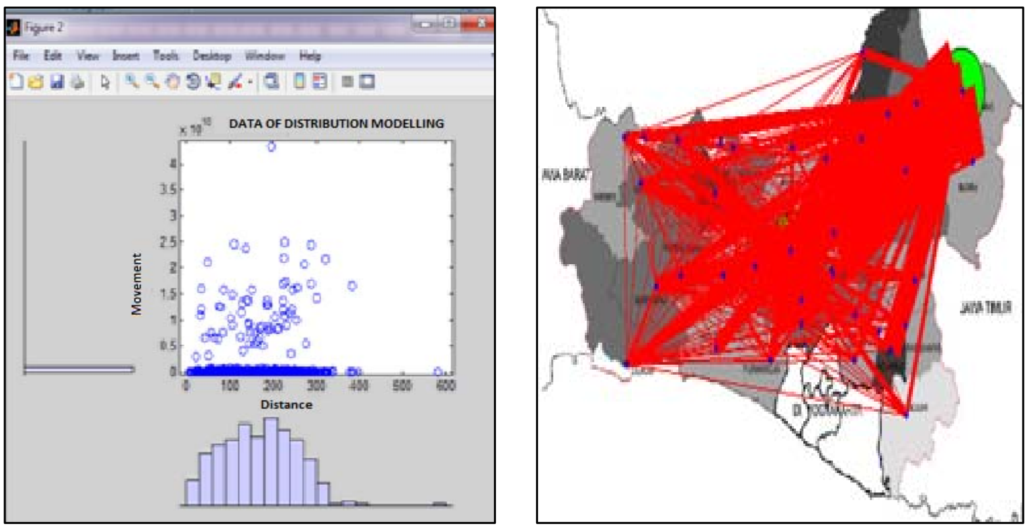

Fig. 8. Distribution Distance and Desireline Model of Coffee Commodity Distribution

The distribution model of coffee commodity movement is then simulated with computational programming on the internal zone matrix of province in Central Java Province as shown in the figure. 8

4.3. Model of Trip Assigment

The loading model of road network system due to the distribution of revival and pulling movement on coffee commodity in Central Java Province based on traffic volume of goods transport vehicle which is in the rise and pull zone of coffee commodity producer. The road network system used for the distribution movement of coffee commodity production has the capacity and type of road that varies according to the class and the function of the road. The variables that determine the capacity of the road are analyzed and determined in accordance with the land use through which the road network system is built. The category and type of road capacity is determined based on the value of the base capacity by influencing the traffic path width factor, side obstacle function, the direction separation adjustment factor and the city size factor. The result of thorough road capacity analysis in road network system in Central Java Province which become the dominant route of coffee commodity distribution is shown in table 2.

Table. 2. Road Capacity in Central Java Network System

Status of the Road	Wide	Co	FCw	FCsp	FCsf	capacity	Model Input
Toll Road		1919					
National and Provincial Roads	17	1900	1.03	1	0.95	7436.6	3718.3
	12	1900	0.91	1	0.95	6570.2	3285.1
	9	1700	1.15	1	0.95	1857.25	928.625
	7	3100	1	1	0.91	2821	1410.5
	6.5	3100	1	1	0.91	2821	1410.5
	6	3100	0.91	1	0.91	2567.11	1283.555

The result of loading model on road network system in Central Java Province based on traffic volume of coffee commodity distribution movement is shown in figure 9.

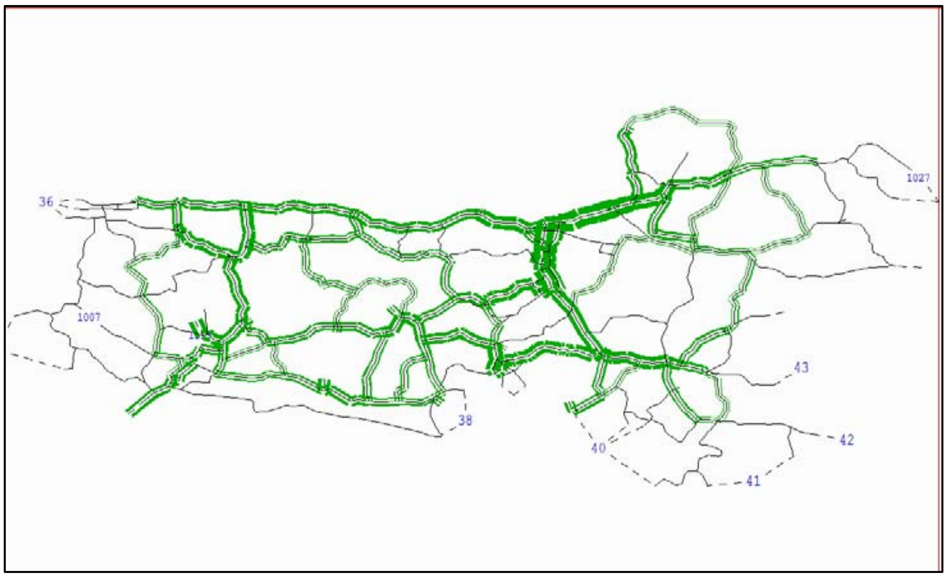

Fig 9. . Model on Trip Assigmnet Network System Distribution of Coffee Commodities

The result of loading model on road network system due to coffee commodity shows the path connecting zones with large production capacity causing the road network system to be jammed compared to the path having smaller commodity production. This is indicated by the amount of desireline on the road network system in figure 9. The distribution model of commodity movements based on the traffic volume on the road network system requires the vehicle traffic efficiency requirements in accordance with the transport capacity that serves the production of commodity movements from the commodity-producing zones in accordance with the needs number of transport vehicles.

4.4. Development of Distribution Model with Breadth-First Search Algorithm

The use of Breadth-First Search algorithm on transportation distribution is the application of intervening event model in inter zone interaction according to the distance of interaction between zones according to supply and demand requirement between distribution volume requirement and distribution capacity according to goods transport vehicle serving in zone production of coffee commodity movement served. Coverage area of coffee commodity movement served by goods transport adjust interaction between zone until reach convergence level by using Newton-Rahpson method iteration. Matrix calibration based on the Breadth-First Search algorithm yields a more rigorous accuracy of decimal values.

Development on transportation distribution model based on Newton-Rahpson method with *Breadth-First Search* algorithm from coffee commodity based on the freight transportation need that is in coverage area of coffee commodity production is shown in Figure 10.

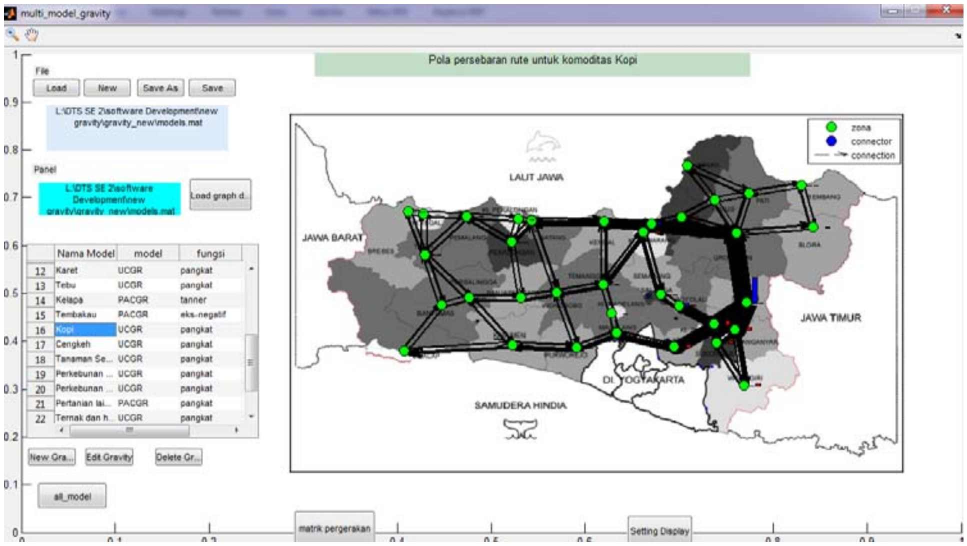

Fig 10. Development of Distribution Model with Breadth-First Search algorithm

The distribution channels of coffee commodity movement based on the need of transportation in the coffee commodity production zone resulted in better distribution efficiency of the movement and the loading of the network system in accordance with the distribution needs of distribution movement volume with closer distribution distances.

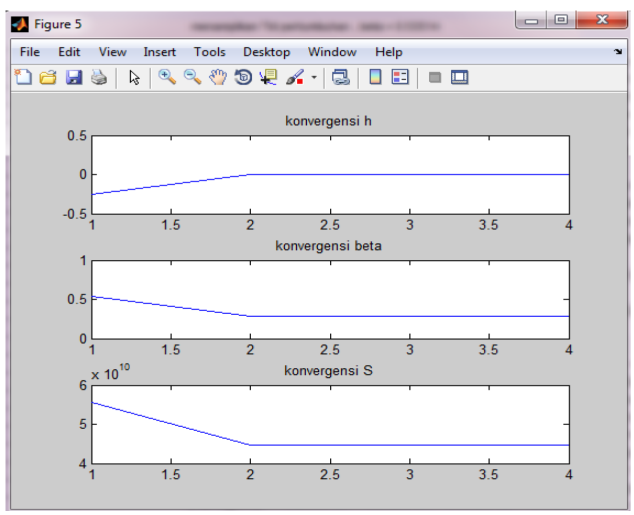

Fig 11. Convergence Process on Newton-Raphson Method with Breadth-First Search Algorithm from Coffee Commodity

The process of distribution model matrix iteration with the Breadth-First Search algorithm has the value of the model accuracy produced better than the distribution model based on the traffic flow on the network system. So that the traffic efficiency that burden the road network system is smaller on the road network

5. Conclusion

Based on the data analysis and development of transportation distribution modeling with Breadth-First Search algorithm, it can be concluded that the production zone of the coffee commodity movement has the movement volume characteristics that adjust the movement direction of coffee commodity trade distribution. Volume of the coffee commodities movement rise requires the availability of transport capacity according to the volume of each zone production coverage. Development of transportation distribution model with Breadth-First Search algorithm by reducing travel production capacity by consolidating the distribution of movement from production zone coverage to target zone with network system path corresponding to road service performance. The total traffic flow generated from the development of transport distribution using the Breadth-First Search algorithm based on the need of more efficient or smaller freight vehicles to overload the existing road network system. So the speed of commodity distribution movement are faster.

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