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Modeling Study on Paddy Commodity Distribution Movements As A Main Stuff and Strategical Limitation of Gravity Model For Trip Generation (PCGR) (A Case Study of Central Java–Indonesia)

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ABSTRACT: Increase of economic activity system in the province resulted in the resurrection and the pull-based production conditions characteristic zones in the region. Main stuff and strategic commodities paddy is a requirement that the primary stuff in the internal region of Central Java province with a regional role to support the strengthening of the region's economic structure needs independently. Paddy commodities sector as the main stuff and starategis categorized based on the type of commodities essential stuff in a region and type of commodities in accordance with the provisions of **the Master Plan for the Acceleration and Expansion of Indonesian Economic Development (MP3EI).** By knowing the model generation and the pull of the movement of stuff can be determined paddy distribution model of the movement that occurs from generation and attraction models based on each zone in the region. With regression analysis method in model generation and pull movements analyzed by socio-economic variables, demographic variables with the dominant factor input and output commodities of various kinds of production of paddy produced in the zones of the Province of Central Java. Based on trip generation and attraction zones with a value-based distribution model of the growth of the movement can be generated. Methods of gravity (GR limit trip generation method (PCGR) to generate the distribution modeling the movement is determined by the characteristics of the study area associated with the development of the region in general and each of the zones. Models have a tendency PCGR exact model on the distribution of the movement due to the use of such methods is the characteristic Central Java with the rapid development of commodity production.

Keywords: Distribution of movement, Commodities Paddy, PCGR

I. INTRODUCTION

The increasing of economic activity impels the development of commodity needs defined in the Input-Output a region. Goods needs paddy is the result of derivative activity sectors of the agricultural production of various types of paddy that caused the purposes of a strategic commodity and staple items that have a very influential economic value of the region.

Central Java Province is a main distribution line crossing the region of Java Island from east to west or vice versa. Have a role that allows it to take over the role of macro or utilize the distribution process. To increase the potential area of Central Java is to create a more equitable distribution of demand needs. Inter-regional trade which is subject to the basis for the consolidation of the regional economy developed in the context of decentralization in governance. The movement of goods is happening in each county and the city shows the interaction needs of each zone of the goods that will be the needs of the district and the city. Description of the movement of goods which is based on the amount of goods moving from the zone of origin and destination city is based on the movements that occur annually. Origin-Destination (OD) movement of goods occurred in Central Java province has a value indicating the amount of supply and demand needs of paddy commodity goods to a zone or city in the province of Central Java.

II. RESEARCH OBJECTIVES

This study has the purpose to model the spread of the movement of essential goods and commodities strategically paddy in Central Java province, with the specific objectives, i.e; 1) Analyzing the movement generation models on commodity goods sector paddy based internal zones in Central Java Regional, 2) Analyzing the distribution model of the movement of the commodity sector and the ordinary public goods by regional internal zones of Central Java Province, and 3) Analyzing the distribution of commodities to the movement distance

Locus Research

Figure 1. Map of Research Locus

Scope of Problem

Research modeling the movement of goods distribution main and strategic commodities paddy in the province of Central Java is limited by the growth method Furness and Methods of Gravity oportunity (GO) Limitation Generation Movement (PACGR). The use of models PACGR caused adequacy and accuracy of the data used long term is not so problematic because the zone changes very quickly.

III. STUDY OF THEORY

Generation and Pull of Movement

Generation and the pull of the movement is the stage of modeling that estimates the number of movements originating from a zone or land use and the amount of movement that attracted to a land use or zone. Generation and the pull of the movement seen in the diagram in Figure 2, (Wells, 1975), (Tamin, 2000).

Flow leaving the zone ***i*** Flow into the zone ***d***

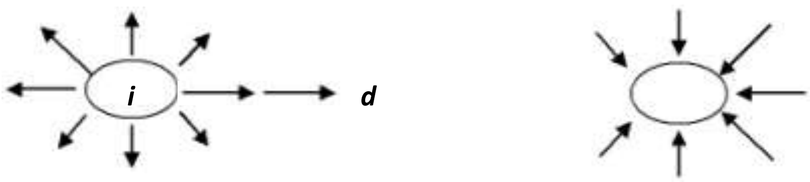


Figure 2. Pull of movement and generation

Generation Model-Pull of Movement

One of the approachs to transportation planning model with four stages is a traffic generation (Trip Generation). Traffic generation is dependent on aspects of land use, transportation and traffic flow can also be used as a quantitative approach. Trip Generation models generally estimate the number of trips for each purpose of the trip is based on the characteristics of land use and socio-economic characteristics in each zone.

The aim of this Trip Generetion planning is to estimate as accurately as possible the traffic generation at the present time, which will be used for future predictions. Modeling traffic generation (Trip Generation) is used to predict the amount of traffic that rise to a condition characteristic of a particular zone. Trip generation is the amount of motion generated by a zone of origin *(Oi)* and the amount of movement that attracted to each destination zone (Dd) contained within the study area. Generation-pull movement greatly influenced by two aspects, as follows:

***Tipe tata guna tanah* Type of Line Use**

Total activity (and intensity) of the land use

Type of land use trip generation characteristics have different, as follows:

• Type of land use is different to produce the different movements
• Type of land use is different to produce the types of different movement
• Type of land use is different to produce the movement at different times.

Factors that affect trip generation modeling for people and goods are as follows:

a. Trip Production for travel of people and goods, i.e; income, vehicle ownership, household structure, household size, land value, density residential areas, and accessibility.

b. Trip Attraction for human movement and goods, i.e; 1) The floor area transform and industrial activities, commercial, offices, shops, services, 2) Trip Production and Trip Attraction for the movement of goods, 3) Number of jobs, the number of marketing, each industry wide, 4) modeling used the trip generation is divided into two parts, i.e; 5) analytical model (regression); Model category.

Spatial Interaction Model Transport of Goods

Black, Jhon (1981) is one of the models of gravity which gives the total volume of the formulation amount of transport of goods by type of commodity being transported from one place to the other, as follows (Equation 2.2)

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

by:

T_{idk} = The amount of commodity *k* produced in region *i* and sent to the area of *J*
S_{ik} = The total number of shipments of commodity *k* from region *i*
Ddk = The total number of requests commodity *k* in region *j*
Fid = Friction factor / obatacle (= 1/*dijλ*)
did = distance from *i* to *j*
λ = parameter

Gravity Models (GR)

Tamin 2000, the synthetic method (spatial interaction) is the most famous and frequently used is the Gravity Model (GR) because it is so simple, so easy to understand and use. This model uses the concept of gravity introduced by Newton in 1686 that developed from the analogy of the law of gravity.

$$F_{id} = G. \frac{m_i . m_d}{d_{id}^2} \qquad \text{G is the gravitational constant...(2)}$$

In geography, the style can be regarded as a movement between two regions, while the mass can be replaced by variables such as population or generation and pull movement, as well as distance, time, or cost as a measure of accessibility (ease). So, for transportation purposes, the model GR is expressed as: (Equation 2.23)

$$T_{id} = k. \frac{O_i . O_d}{d_{id}^2} \qquad \text{k is the constant} \qquad \text{...(3)}$$

Thus, in mathematical form, the model GR can be expressed as:

$$T_{id} = O_i . D_d . A_i . B_d . f(C_{id}) \qquad \text{...(4)}$$

The second equation is satisfied if the delimiter used constants *Ai* and *Bd*, which is associated with the generation and attraction of each zone. The constant is called the balancing factor:

$$A_i = \frac{1}{\sum_d (B_d D_d f_{id})} \quad \text{and} \quad B_d = \frac{1}{\sum_i (A_i O_i f_{id})} \qquad \text{..(5)}$$

Limitation Model Generation Movemen (PCGR)

This model has at least one generation limit (O_i), the total movement produced must equal the total of the expected movement of the trip generation stage. This model is no-limit, in the sense that the model is not required to produce the same total with the total movement from and to each zone is estimated by step, trip generation.

The model can be written as: (Equation 5)

$$\text{Tid} = \text{Oi . Dd . Ai . Bd . f (Cid)} \qquad \text{...(6)}$$

by:

Ai = 1 for all *i* and *Bd* = 1 for all *d*

PCGR's method defines that the pull of the movement required using the basic formula of the Gravity Model used by the limitation provisions of the formula:

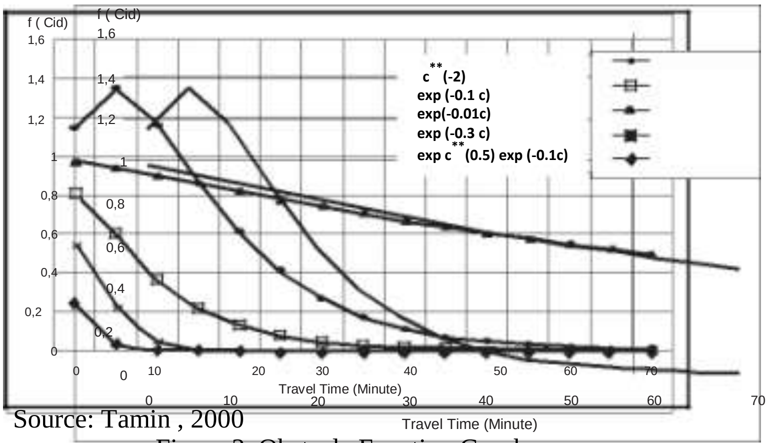
$$A_i = \frac{1}{\sum_{d=1}^{N}(B_d . D_d . f_{id})} \text{ for all } \underline{i} \text{ and } B_d = 1 \text{ for all } \underline{d}$$

Obstacle Function

Rank Obstacle Function = $f(C_{id}) = e^{-\beta C_{id}}$ …(7)

Obstacle Negative Exponential Function = $f(C_{id}) = C_{id}^{-\alpha}$ …(8)

Tanner Obstacle Function = $f(C_{id}) = C_{id}^{-\alpha} . e^{-\beta C_{id}}$ …(9)



Source: Tamin , 2000

Figure 3. Obstacle Function Graphs

Test Model

Correlation Test

The correlation coefficient is a measure of how the relationship between variables in the model. Correlation coefficient of simple linear regression equation is as follows:

Correlaton Test

$$r = \frac{N\sum_{i=1}^{N}(X_i Y_i) - \sum_{i=1}^{N}(X_i).\sum_{i=1}^{N}(Y_i)}{\sqrt{\left[N\sum_{i=1}^{N}(X_i)^2 - \left(\sum_{i=1}^{N}(X_i)\right)^2\right].\left[N\sum_{i=1}^{N}(Y_i)^2 - \left(\sum_{i=1}^{N}(Y_i)\right)^2\right]}} \qquad \text{…(10)}$$

Termination Test

$$R^2 = 1 - \frac{\sum_{i=1}^{N}\sum_{d=1}^{N}(T_{id} - \hat{T}_{id})^2}{\sum_{i=1}^{N}\sum_{d=1}^{N}(\hat{T}_{id} - T_1)^2} \qquad \text{…(11)}$$

$i \neq d$

Illustration Movement Matrix Distribution

Table 1 Illustration Movement Matrix Distribution

Zona	1	2	3	…	N	Oi
1	T11	T12	T13	…	T1N	O1
2	T21	T22	T23	…	T2N	O2
3	T31	T32	T33	…	T3N	O3
⋮	.	.	⋮	…	⋮	⋮
N	TN1	TN2	TN3	…	TNN	ON
Dd	D1	D2	D3	…	DN	T

Source: Tamin, 2000

Gravity Model Calibration

Gravity Model Calibration Method of Linear Regression with negative exponential obstacle function calibration method with linear regression analysis to find the model parameters is done through the stages in the following equation, (Tamin, 2000)

$$\exp\left(-\beta C_{id}\right) = \frac{T_{id}}{A_i . B_d . O_i . D_d}$$

$$\log_e\left(\exp\left(-\beta C_{id}\right)\right) = \log_e\left[\frac{T_{id}}{A_i . B_d . O_i . D_d}\right] \qquad \text{….(12)}$$

$$-\beta C_{id} = \log_e T_{id} - \log e\left(A_i . B_d . O_i . D_d\right)$$

$$\log_e T_{id} = \log_e\left(A_i . B_d . O_i . D_d\right) - \beta C_{id}$$

with the linear transformation: loge Tid = Yi and Cid = Xi

$$-\beta = B = \frac{N\sum_{i=1}^{N}(X_i . Y_i) - \sum_{i=1}^{N}(X_i).\sum_{i=1}^{N}(Y_i)}{N\sum_{i=1}^{N}(X_i^2) - \left(\sum_{i=1}^{N}(X_i)\right)^2} \qquad \text{…(13)}$$

$$A = \overline{Y} - B\,\overline{X}$$

IV. RESEARCH METHODOLOGY

Approach to study the distribution model of the movement of a vast area that many factors influenced land use in each zone requires a lot of data and information that is very complex for its accuracy. Modeling studies of the distribution of movements using secondary data because the data are not sufficient or the results do not matter for the long-term study. So it can be used to simplify the development zones or city in the province of Central Java with the development of agricultural production and the like paddy.

Determination of Variable Model Generation and
Traction Dependent Variables

Y1 = Oi = Generation movement of commodities paddy stuff.

Independent Variables

X1 = GDP counties and cities in Central Java with its growth rate

X2 = Total Population of counties and cities in Central Java with its growth
rate X3 = Commodities paddy stuff

Basic materials sector and strategic commodities are defined on the Input-Output some commodity sectors that fall into the category of goods that are determined based on the provisions of MP3EI. These sectors include basic materials and the result of a strategic industry that is in the province of Central Java is equivalent to the national commodity sector. Sector of the type of staple commodities and strategic commodities are goods produced paddy from paddy farming production activities in each zone with the production of agricultural commodities derivatives of . Productivity of the agricultural activities of IO sector defined an area; the economic results of the commodity economy differentiate into a value in units of currency and weight (tons).

Flowchart of Research

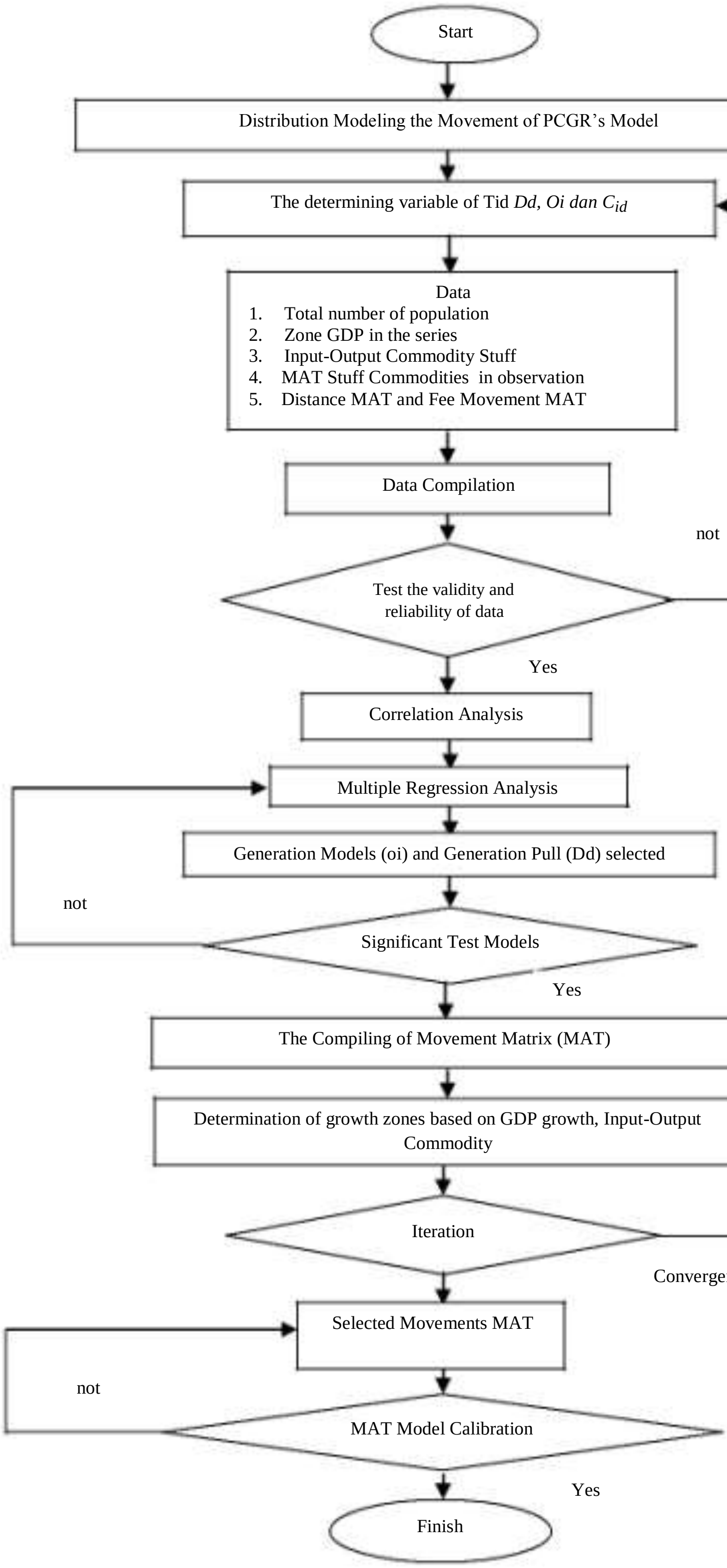


Figure 4. Flowchart of Research

V. RESULTS AND DISCUSSION

Estimation and Modeling Material Movement Generation Commodities Paddy to the Socio Economic Projections Parameters.

There are two methods projections of socio-economic variables used in this study, i.e; Projections based on the tendency which is based on historical trends in the development of socio-economic parameters. Projections based on the pattern you want to target, which is based on the direction of development to be achieved, this prediction is generally associated with spatial management plans and economic development strategies in spatial planning and designs of the MP3EI.

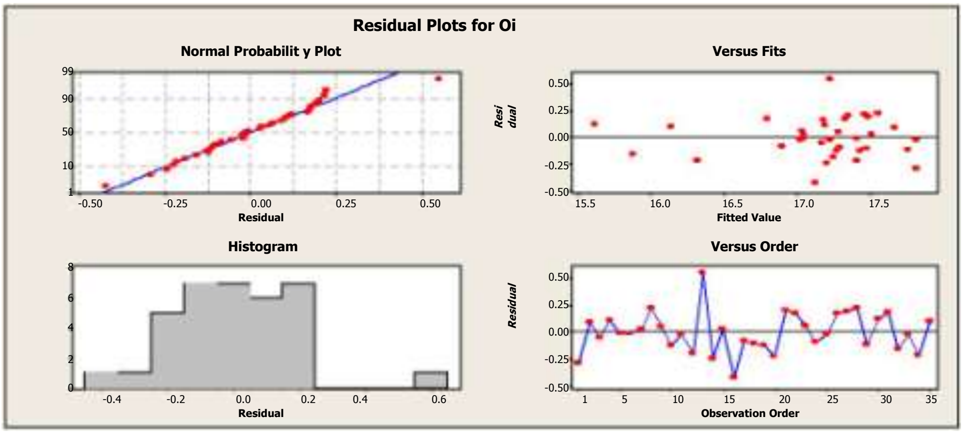
Travel distribution in the future in the form of the MAT was obtained by including estimates of the variables is accepted into the model. Generation/attraction trip in the future can be predicted by using the linear regression method based on several socio-economic variables.

The study area is divided into zones. In accordance with the assumptions in the modeling of transport is that the movement started and ended from/to a point in the zone commonly referred to as the central zone (zone centroid), while the determination of the zone system (including the boundaries) is based on a system of administrative boundaries (counties and cities). The zoning is defined from the number of counties and cities in Central Java.

1. Movement Generation Models:
The regression equation is

$$\text{Ln Oi} = 4.11 + 0.815 \text{ Ln X1} + 0.105 \text{ Ln X2} + 0.0113 \text{ Ln X3} \quad \ldots(14)$$

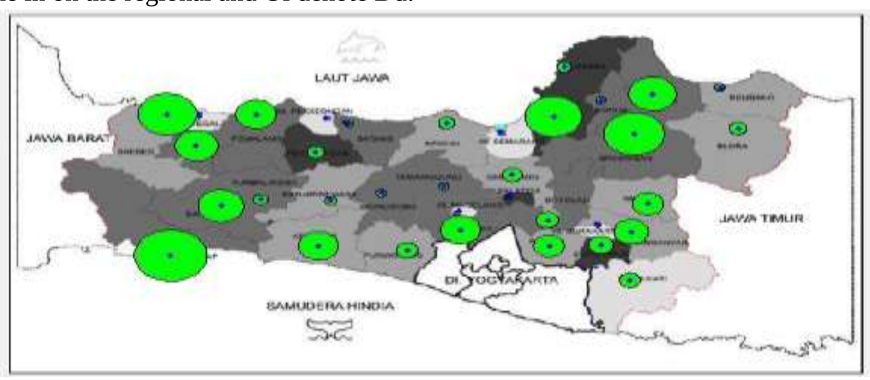
by:
Y = Oi Generation Public Goods and Common
X1 = Output of Public Goods and Common Commodities
X2 = Population
X3 = GDP
S = 0.194962 R-Sq = 87.8% R-Sq(adj) = 86.7%



Sources: Data Analysis Results

Figure 5. Test Validation and Regression Testing Assumption Generation Movement Commodities .

Generation of the model equations and then pull the resulting value can be determined resurrection and pull each internal zone in on the regional and Oi denote Dd:



Source: Results of Computation Analysis

: Movement Generation;

Figure 6. Estimated generation and pull-movement of goods and the usual general

PCGR models (models with restrictions Generation)

PCGR method defines that the pull of the movement is not required. By using the basic formula of the Gravity Model used by the limitation provisions of the formula:

$$A_i = \frac{1}{\sum_{d=1}^{N} (B_d . D_d . f_{id})} \quad \text{for all } \underline{i} \text{ and } B_d = 1 \text{ for all } \underline{d}$$

By using the obstacle function of the phase exponential negative of the PCR is as follows:

$$A_1 = \frac{1}{\left[B_1 . D_1 . \exp(-\beta C_{1.1}) + B_2 . D_2 . \exp(-\beta C_{1.2}) + ... + B_{35} . D_{35} . \exp(-\beta C_{1.35})\right]}$$

$$A_2 = \frac{1}{\left[B_1 . D_1 . \exp(-\beta C_{2.1}) + B_2 . D_2 . \exp(-\beta C_{2.2}) + ... + B_{35} . D_{35} . \exp(-\beta C_{2.35})\right]}$$

$$A_3 = \frac{1}{\left[B_1 . D_1 . \exp(-\beta C_{3.1}) + B_2 . D_2 . \exp(-\beta C_{3.2}) + ... + B_{35} . D_{35} . \exp(-\beta C_{3.35})\right]}$$

...

$$A_{35} = \frac{1}{\left[B_1 . D_1 . \exp(-\beta C_{35.1}) + B_2 . D_2 . \exp(-\beta C_{35.2}) + ... + B_{35} . D_{35} . \exp(-\beta C_{35.35})\right]}$$

The value of A_i then used the value obtained was used to calculate the value of each cell of the matrix using the basic formula of gravity models in the following equation:

$$T_{1.1} = O_1 . A_1 . B_1 . D_1 . \exp(-\beta (C_{1.1}))$$

$$T_{1.2} = O_1 . A_1 . B_2 . D_2 . \exp(-\beta (C_{1.2}))$$

$$T_{1.3} = O_1 . A_1 . B_3 . D_3 . \exp(-\beta (C_{1.3}))$$

...

$$T_{2.1} = O_2 . A_2 . B_1 . D_1 . \exp(-\beta (C_{2.1}))$$

...

$$T_{35.35} = O_{35} . A_{35} . B_{35} . D_{35} . \exp(-\beta (C)_{35.35})$$

By using the gravity model of the basic equations, the iteration matrix calculations performed by computing programming with MATLAB 2012 so get the value of β on the convergence condition of the matrix.

The same steps are performed on the obstacle function of the rank and tanner with the method of calculation procedure PCGR model.

Test Statistics for Distribution Modeling Movement

Calculation of matrix O - D using transportation needs always produce (output) with a level of accuracy depends on several factors, among others, is a model of transport and estimation methods are used. To determine how well the model that has been used, it should be made a comparison between O-D (T_{id}) matrixes of estimation with O-D matrix of observations (T_{id})

a. The accuracy of test models in statistics (Goodness-of-Fit-Statistics)

An investigation of the statistical methods that can be used to compare two matrix Origin-Destination (OD) are different in terms of statistical indicators to see the accuracy of the model (Goodness-Of-Fit-Statistics Indicator) that can be used to compare Origin-Destination matrix (OD) matrix estimation of Origin-Destination (OD) observation that:

b. Root Mean Square Error (RMSE) and standard Deviation (σ)

Methods root-mean-square error is an error measure based on the difference between the two corresponding values are defined as follows:

$$RMSE = \left| \sum\sum_{id} \frac{(T_{id} - T_{id})}{N(N-1)} \right|^{2 \; 1/2} \quad \text{for } i \neq d$$

The standard deviation of the difference between these two values is defined as:

$$\sigma / SD = \left| \sum\sum_{id} \frac{(T_{id} - T_{id})^2}{N(N-1)-1} \right|^{1/2} \quad \text{for } i \neq d$$

Large value of N, the above equation will give the same results can be said, with the RMSE can be called the standard deviation (σ) , or vice versa. RMSE indicator and can not compare a similar model when applied to different areas, because of the value - its value depends on the size of the matrix (number N) and magnitude (T_{id}). The percentage of root mean squared error-average (% RMSE) can overcome the problems of the magnitude (T_{id}) and is defined as: (Tamin, 2000).

$$\% \text{ RMSE} = \text{RMSE} / T_1 * 100$$

The identical form, can define the coefficient of variation/C_v, as:

$$C_v = \frac{\sigma}{T_1.100}$$

by:

$$T_1 = \frac{1}{N.(N-1)} \sum\sum_{id} T_{id} \quad \text{for } i \neq d$$

The greater the value of RMSE, % RMSE, (σ) , and C_V interpret the less precise the results obtained from the model when compared with observations. (Tamin, 2000) e. Mean Absolute Error (MAE)

MAPE (mean absolute error) is the absolute value of the average error is an error form the simplest measure, is defined as:

$$MAE = \sum\sum_{id} \left| \frac{(T_{id} - T_{id})}{N.(N-1)} \right| \quad \text{for } i \neq d$$

The value of the MAE is less sensitive to the absolute value of the errors compared with the RMSE. The greater the value of MAE increasingly imprecise results obtained from the model when compared with observations. (Tamin, 2000)

Coefficient of Determination / R^2 and SR^2

Determinants coefficient are defined as:

$$R^2 = 1 - \frac{\sum_i \sum_d (T_{id} - T_{id})^2}{\sum_i \sum_d (T_{id} - T_1)^2} \quad \text{for } i \neq d$$

by:

$$T_1 = \frac{1}{N.(N-1)} \sum\sum_{id} T_{id} \quad \text{for } i \neq d$$

Coefficient of determination is a measure of the accuracy of the model most widely known, but in this case is a measure of the accuracy of the weakest models. R^2 value was originally used to measure the degree of linear dependence between two random variables. But in the context of modeling the movement of the distribution matrix T_{id} and T_{id} can not be said to be linearly related in the review of the models used. The coefficient of determination (R^2) has a weight that is too large for the value of the absolute error is large, and the high value of R^2 can not be obtained from a matrix with errors are small and the large number of cells, but have a less strong relationship to the value of the cell small. One way to overcome these shortcomings is to calculate the value of R^2 from the root-the value of the cell, i.e:

$$SR^2 = 1 - \frac{\sum_i \sum_d (T_{id}^{1/2} - T_{id}^{1/2})^2}{\sum_i \sum_d (T_{id}^{1/2} - T_2)^2} \quad \text{for } i \neq d$$

by:

$$T_2 = \frac{1}{N.(N-1)} \sum_i \sum_d T_{id}^{1/2} \quad \text{for } i \neq d$$

A large difference between the estimated values of the cell matrix with observation matrix would cause R^2 and SR^2 is worth negative. The greater the value of R^2 and SR^2 more precise results obtained from the model when compared with observations.

d. Normalization error indicators

Some error indicators mentioned above can not be used to compare the model when applied to a different area of study because of its values depend on local conditions such as the size of the matrix, and others.

For this latter purpose, the following indicators can be used:

R^2 SR^2

%RMSE C_v

Normalized mean absolute error/NMAE

$$NMAE = MAE / T_1 * 100$$

by:

$$MAE = \sum_i \sum_d \left| \frac{(T_{id} - \hat{T}_{id})}{N.(N-1)} \right| \quad \text{for } i \neq d$$

$$T_1 = \frac{1}{N.(N-1)} \sum_i \sum_d T_{id} \quad \text{for } i \neq d$$

Gravity modeling of the generation of Limitation Methods (Oi) / PCGR

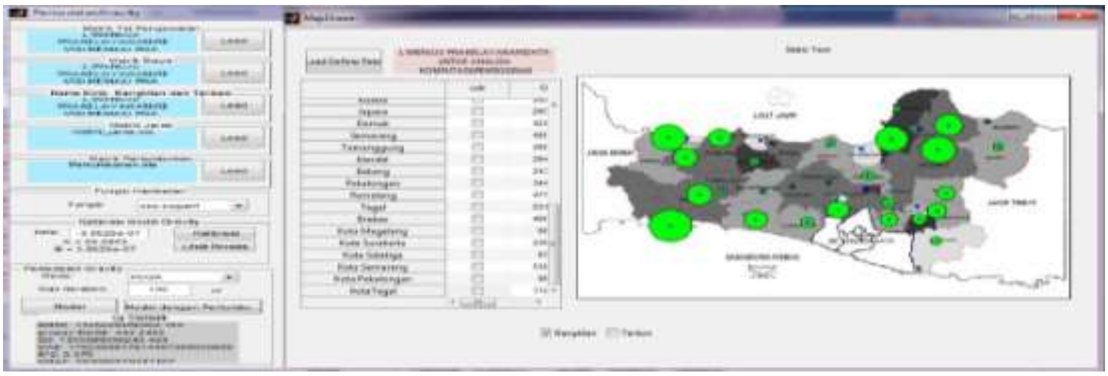
Based on the modeling of the gravity generated by the model parameters as follows:

Table 2. Gravity Modeling Calibration without limitation/Model PCGR

Obstacle Function	Calibration Model Parameters PCGR		
	A	B	β
Negative exponential	24.28	3.9×10^{-7}	-3.95×10^{-7}
Degree	2.4	1.615	-1.615
Tanner	24.3	3.95×10^{-7}	-3.95×10^{-7}

Obstacle Function	Statistical Test					
	RMSE	% RMSE	SD	MAE	R2	NMAE
Negative exponential	1335028066302	444.25	1335589356243.42	1782209937814497.200	0.374	593085579517197
Pangkat	588395976818.7483	1957.797	5886433579429883	802568524097.82	0.659	85505819.03
Tanner	1336000431984	444.57	13336562130740	178489715426293471	0.75	593949840122144

Source: Results of Modeling Analysis



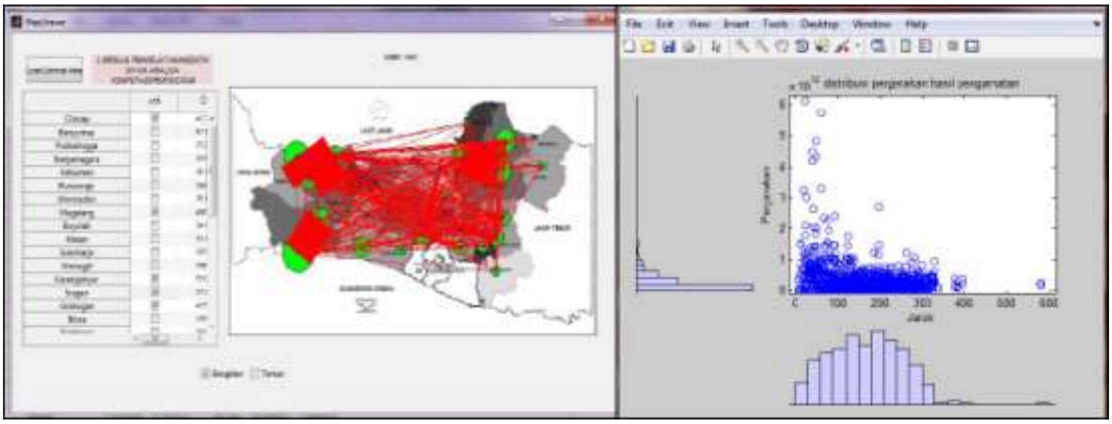
Source: Result of Analysis Modeling

Table 3. Gravity Modeling Test Result Statistics without limitation/PCGR

In gravity modeling with constraints generation method (Oi) shows that the barrier function of the rank indicates significant modeling parameters of the statistical tests in Table 3.

Source: Results of Computational Analysis

Figure 7. Generation between the zones being the smallest and largest



Source: Results of Computing Programming

Figure. 8. Disire Line Distribution Distribution Distribution Movements and Movement

Distribution modeling results indicate that the commodity movement occurs between the zones with the highest movement with a distance of 100 to 300 km. Movement with a distance of 200 km shows that the distance is a movement that shows the optimum level at the cost of movement. The movement of goods with the highest value at a distance of 100 km it shows that the production area of each zone is more efficient distributed at a distance of 100 km from the zone of origin.

VI. CONCLUSION

Based on the results of data analysis, modeling studies the distribution of general goods movement and regular regional internal in Central Java province as follows:

1. Distribution of goods movement greatly influenced paddy agriculture production sector in zones of the commodity producers.
2. Movement generation and strategic staple goods have strong correlation with GDP and population of each zone in the internal regions of the Java provincial regional input-output commodity in the area.
3. Model Generation Movement Ln Oi = 4.11 + 0.815 Ln X1 + 0.105 Ln X2 + 0.0113 Ln X3 with high enough significance to the value of $R^2 = 0.878$.
4. The distribution model of movement is obtained that a model with obstacle function has a significance value rank better model $\hat{T}_{id} = 2.4 + 1.615 T_{id}$ with R2 = 0.659 with a calibrated beta value β = -1.615
5. Distribution of main goods movement and strategic paddy has a tendency movement frequency of the zones dominated by short distances between 200 to 300 kilometers with the highest value of the movement at a distance of 100 kilometers from the zone of origin O_i

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