Journal of Positive School Psychology http://journalppw.com
2022, Vol. 6, No. 6, 5529 – 5536

Analysis Comparison Gravity Model And O-D Survey

[1]Chairul Insani Ilham, [2]Irwan, [3]Doharman Lumban Tungkup, [4]Arman Harahap

[1]Lecturer of the Inland Water Transportation Management Study Program at Inland ate and Ferries Transportation Polytechnic Palembang, Indonesia, chairul@poltektranssdp-palembang.ac.id
[23]Lecturer of the Inland Water Transportation Management Study Program at Inland ate and Ferries Transportation Polytechnic Palembang, Indonesia
[4]Universitas Labuhanbatu, Sumatera Utara, Indonesia

Abstract

Gravity theory is rarely used to predict the spread of travel from one zone to another zone. This is due to several weaknesses from the results of the analysis, as for several factors that affect the accuracy of the analysis of the spread of this trip, such as economic growth, technological progress, and political fluctuations. However, in the province of Aceh Darussalam, this theory was used and also tried by comparing the results of the origin- destination survey in the same year, and the results showed that the distribution was around -10% < X < 10% which statistically for the transportation sector is still recognized. Therefore, the results of this study are still used for policies on developing sea transport routes and Ferries Transport in Aceh Darussalam Province. In order to optimize the role of regional feeder ports to increase economic growth in Aceh Province in accordance with activities at regional feeder ports and applicable regulations.

Keywords: Gravity, Spread, Zone, Origin, Destination, Travel and Route.

1. Introduction

The node is a place of movement to different levels of the ship, this enabling the delivery of goods from one transportation to another. It also functions as a connecting node between sea and land which also functions as a center of activity in the zone (region) which is better known as the port. Conceptually, ports have three strategic functions. First is as a sustainable chain or link. That means that the port is one of the links in the transportation process from the origin place of goods/people to the destination. Second is as an interface (meeting point), means that the port as a meeting place for two modes of transportation, for example sea transportation and land transportation. Third is as a gateway, means that the port as the gateway from a region/country. In relation to its function as a gateway, it is not too surprising that every ship which visiting a region/country must comply with the regulations and procedures applicable in the region/country where the port is located. (Lasse, 2015)

Today much of the world's wealth is produced or facilitated by sea ports in all its activities. The port is a location where trade, logistics and production become one unit (Harry Geerlings, BartKuipers, Rob Zuidwijk, 2017). The function of the regional feeder port which is the gateway for national economic connectivity in Aceh Province is in accordance with the Decree of the Minister of Transportation of the Republic of Indonesia Number KP 432 of 2017 concerning the National Port Master Plan, namely the Susoh Port located in Southwest Aceh Regency, Tapak Tuan Port in South Aceh Regency, and Sinabang Port in Simeulue Regency. The three ports serve shipping between districts/cities within Aceh Province. So, in this study an assessment of the policy prospects of developing transportation

services from-to- destination to these three ports is carried out, both existing conditions and policies that have been in the future using the Gravity Model and also comparing the results obtained from this model with origin-destination surveys conducted by other parties with a view to validating the analyzed data to make it more convincing to use. The aim is to provide an overview of the potential for regional feeder ports so that the existing economic potential can be optimized to generate economic development in the province of Aceh which will stimulate the welfare level of the regional and national community by itself, based on the theoretical concept of travel distribution by utilizing the recognized gravity model theory scientifically (Warpani, ITB 1990).

2. Method

This Gravity model (GR) is more used by researchers in estimating the flow of travel between zones in the future in a synthetic method at the travel distribution stage, because in addition to the model being which is simple to understand and apply, this model is also analogous to the concept of the law of gravity (force of gravity attraction between 2 objects) by Isaac Newton a physicist in 1686 whose law is: "The attractive force (F) between 2 objects (object 1 and 2), is directly proportional to the masses of the two objects and inversely proportional to the square of the distance between the two masses object, which if we analogy to transportation (trips between 2 zones) is: "The number of trips (T) between the 2 origin and destination zones (Ti-j) is directly proportional to the number of trips originating from origin zone I and heading to destination zone J (Oi and Dj) and inversely proportional to the square of the distance between the origin zone I and destination J in the form of physical distance, time to reach destination zone j (time) and cost of journey (cost) which is symbolized by di-j for physical distance, hi-j for time of reaching the destination zone j and ci-j for travel costs". These two laws are mathematically in general form.

Newton's Law of Gravity:

$$F = G.\frac{m_1.m_2}{d^2{}_{i-j}} \quad (1).$$

Where:

F	=	attractive force between 2 objects
$m_1 . m_2$	=	mass of each object
$d^2{}_{1-2}$	=	the square of the distance between the 2 objects
G	=	gravitational constant

While in transportation, the gravity model formula becomes:

$$T_{i-j} = k.\frac{O_i.D_j}{d^2{}_{i-j}} \quad (2)$$

Where:

T_{i-j}	=	Number of trips from o destination zone j
O_i and D_i	=	The number of tri (originating) from the or attracted (toward) to t zone j
$d^2{}_{i-j}$	=	The square of the di measure of the level of the form of the distanc travel time i-j and fare i obstacle/ constraint i-j
K	=	gravitational constant

If we make an analogy between the original formulations, it would be such:

F	Analogous to T_{i-j}
m_1 and m_2	Analogous to O_i and D_j
$d^2{}_{i-j}$	Analogous to $d^2{}_{i-j}$
G	Analogous to k

In use, there are actually 4 types of Gravity (GR) models in the above formulation, namely:

1.The Unlimited Model (LinConstrained Gravity/UCGR)

2.Model with Single Constraint Gravity (SCGR), with constraint di origin zone i (Production Constraint Gravity/ PCGR)

3.Model with one constraint (Single Constrain Gravity/SCGR), with constraint di destination zone j (Atraction Constrain Gravity/ ACGR)

4.Model with Two Constraints (Double Constrain Gravity/ DCGR) which is in the form of boundaries in both the origin and destination zones (Production-Atraction Constrain Gravity/PACGR) or also mentioned with the model with Full Constraint Gravity (FCGR)

We can explain each type of gravity model above in the following sections, namely:

Ad.1 UCGR (Unlimited):

This model is not required to produce a total trip equal to the total movement from and to each trip generated zone or it is unnecessary Oi = Oi (G), Dj = Dj (G) and Ti-j = Ti-j (G).

Mathematically, it looks like this:

Ti-j = Oi . Dj . Ai . Bj. f (Ci-j)

Where:

Ai = 1, for all (i) Bj = 1, for all (j)

Ad.2 PCGR (With Limitation in Origin Zone):

This model states that we know the amount of flow of people leaving a zone, and do not know exactly how many people are attracted (to/coming) to a zone, here : Bj = 1, for all j.

$$Ai = \frac{1}{\sum_{j=1}^{N}(Bj\ .Dj.f\ (ci-j)}$$

$$Ai = \frac{1}{\sum_{j=1}^{N}(Bj\ .Dj.f\ (ci-j)}$$

For the whole I, and f (ci-j) is the exponent (-β ci-j). Then Ti-j is:

For the whole I, and f (ci-j) is the exponent (-β ci-j). Then Ti-j is:

$$T_{i-j} = Oi \qquad \frac{\frac{aj}{(c_{i-j}^2)}}{\sum_{j=1}^{N}\frac{aj}{(c_{i-j}^2)}}$$

Where:

Ti-j = Number of trips produced by origin zone I with a destination in the destination zone j

Oi = Total number of trips produced by origin zone i

Aj = The attractiveness of the destination zone j such as land area, factory, lots of trade, parking and other attractions (m^2)

C_{i-j} = Distance, time and cost (mile, hour, Rp)

n = Number of zones

3. Results And Discussion

Aceh's Population Potential

Aceh is a province in Indonesia whose capital is Banda Aceh. Aceh is one of the provinces in Indonesia which is given the status of a special region and is also given special autonomy. Aceh is located at the northern tip of the Sumatera Island and is the westernmost province in Indonesia. According to the results of the 2019 Central Statistics Agency census, the population of this province is around 5,281,891 people.

The potential for travel in Aceh Darussalam province is described by the population and production of agricultural products, whether it's from agriculture, mining, plantations, fisheries and manufactured products industry, which is the production point of trip generation that must be served by the transportation sector, especially sea transportation, this potential is illustrated by the attractiveness of the district's area, population, and production of goods from the study area district, as stated in table 1 as below.

Table 1. Production Data per Regency/City

No	Harbor (District / Province)	Area (KM^2)	People (Total Population)	Production goods (tons)
1	Sir's site	3,841.50	230.254	125,033.52
2	Susoh	1,490.60	148,687	141,826,70
3	Sinabung	2,051.48	89,327	180,033.52
4	Calang	3,812.99	86,058	127.081.38
5	Aceh Singkil	2,185.00	129,963	42,520,50
6	East Aceh	6,286.01	42,261	274,089
7	Malahayati	61.36	238,814	150.280.0
8	Langsa	262.41	182.424	16,332.96
9	Pidie Jaya	3,086.95	148,687	156.040.15
10	Sabang	153	4004	48.005.50
11	Lhoksumawe	181.06	190,624	95,927.7
12	Meulaboh	2,927.95	189,119	158.836.00

Source: Aceh in 2018 figures.

There are 12 districts/cities in Aceh Darussalam Province. From these twelve districts there are only seven districts where a comparison/or study of the distribution of trips is carried out based on the results of a field survey and the results of calculations based on the theory of gravity model, while the other five districts were not studied with consideration of technical conditions and economic factors that do not support the application of the model, this is based on the opinion of several experts who conducted scientific studies that the error percentage difference is below 10 percent due to several considerations, such as:

1. Problems with different service systems from one region to another region or with other cities, (Dewantoro, 2001).

2. The different of region development prospects, resulting in the volume of goods flow also different (Marbun, 1979).

3. The situation of the region will greatly affect the attraction of the trip, especially regarding sustainable land use policy (Riyadi, 2003).

4. Inequality of economic growth and mobility of economic activity (Bennett, William, Jeffreyy and Bright, 2005).

5. Patterns of community activities that do not support the movement of the flow of goods and rates population growth (Dewantoro, 2009).

From these five points, it is used as a basis for sorting the area, it can be estimated that the application of the theory of gravity model is impossible to use as a basis. To examine the results of the trip distribution of four districts/cities within the province of Aceh Darussalam, As shown in table 1 above.

Study Area Coverage

Hinterland or the coverage of the study area, in this study covers the regencies / cities of Aceh province which have a travel contribution which is part of each district that has a travel contribution to the interface or gates which are gathering point for goods and passengers. In this study activity the object of comparison is only seven districts, this is due to internal factor from all zones that support theoretical concept of the area as already described in the previous discussion. So that gravity theory users can provide results that support < 10% deviation and can be used for service development from existing passenger and goods movement nodes. The details can be seen in Figure 1 below;

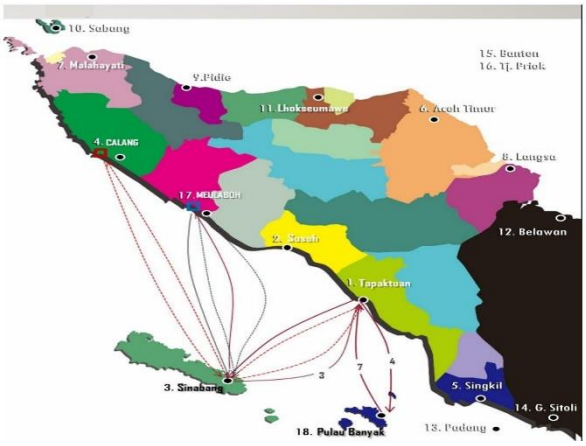

Figure 1. Study Area

For the analysis of the survey results and the calculation of the distribution of trips calculated based on the theory of gravity model can be seen in Table 2. And the results in the seven study area locations show that the average survey results are different, which has a value below 10 percent; the example of zone 2 (Susoh district) the difference between the two is -9.1 percent, this value is the largest difference in value from the calculation of the gravity model with O-D surveys from all zones (1-7); and another example that can be seen is from zone 2 (Susoh district) to zone 4 (Calang district), the largest difference in value is -9.3 percent and this value is still below to 10 percent (deviation range). By looking at the results of this analysis that the theory of gravity can be said to be significant enough to be used as a basis for calculating the volume of the origin and destination of the trip, this conclusion is considered on the basis of the results of other researchers' studies or in other words based on the references of articles or books that have been published.

Table.2. Survey Results and Travel Distribution Analysis

No	Origin / Destination	1	2	3	4	5	6	7
1	A	-	55	123	253	45	452	222
	B	-	60	127	246	42	414	215
	Δ	-	-5	-4	+7	+3	+38	+7
	%	-	-9,1	-3,2	2,7	6,7	8,4	3,1
2	A	55	-	126	75	147	407	195
	B	50	-	133	82	150	401	210
	Δ	+5	-	-7	-7	-3	+6	-5
	%	9,1	-	-5,5	-9,3	-2,1	1,5	-2,7
3	A	123	135	257	300	185	448	230
	B	119	142	260	321	190	452	212
	Δ	+4	-7	-3	-21	-5	-4	+18
	%	3,2	-5,1	-1,1	-7	-2,7	-0,1	7,8
4	A	415	183	305	-	522	927	647
	B	411	173	333	-	527	901	617
	Δ	+4	+10	-28	-	-5	+26	+30
	%	0,1	5,4	-9,1	-	0,1	2,8	4,6
5	A	340	375	405	1933	-	233	160

	B	318	371	421	1975	-	241	175
	Δ	+22	+5	-16	-42	-	-8	-15
	%	6,5	1,3	-4	-2,2	-	-3,4	-9,3
6	A	865	462	667	1002	128	-	169
	B	860	457	656	993	134	-	171
	Δ	+5	+5	+11	+9	-6	-	-2
	%	0,6	1,08	1,7	1	2,3	-	0,8
7	A	221	195	223	185	281	220	-
	B	241	188	219	167	280	215	-
	Δ	-20	-7	-4	18	1	20	-
	%	-9,4	-3,5	-1,7	9,7	0,11	9,1	-

Description :				
1. Tapak Tuan	***2. Susoh***	***3. Sinabang***	***4. Calang***	***5. Aceh Singkil***
6. Meulaboh	***7. Malahayati***	***A : Gravity Theory Calclation on Result***		
B. Field Survey Results	***Δ : Difference (A-B)***			

Error Percent or percentage of error is expressed as the percentage difference between estimated or measured values or exact or known values. It is used in science to report the difference between a measured or experimental value from a true or exact value. The main points (error percent were seen from several aspects), such as:

- The purpose of calculating the percentage of error is to measure how close the measured value is to the actual value (in this case the results of a field survey).

- The error percent is the difference between the experimental value and the theoretical gravity model multiplied by 100 which gives the percent.

- In some fields, error percent is always expressed in numbers and in others has a positive or negative value is true.

- Error percent is one type of error calculation, absolute and relative error are two other common calculations and error percent is part of a comprehensive error analysis. (Bennett, Jeffrey, Bright and William, 2005)

The concept of opinion is stated in the following analysis which is based on the results of the compilation of survey data for MTPD cadets in the province of Aceh Darusalam and the results of the calculation of the Gravity Theory model in table 3 above and by comparing the data in the table as stated, that from the different percentage in calculation between riil survey and Theoretically calculated the percentage difference which is considered the error percent value with a rounded distribution is $-10 < x < 10$, where this value shows convincing results that the similarity of result can be recognized as true (Jennifer Spirko, 2021). This is caused by tolerable errors such as instrument deviation, premises or observations that can arise from several causes in the measurement and validation of supporting data, such as: balanced population growth, economic growth, balanced per capita income between selected zones, the same type of economic activity, business patterns will greatly determine the final result of the distribution of data, so that it can reveal how accurate the calculation of the data collection is and the formula can be abstracted as follows; (Y1-Y2)/Y1 x 100% is a value to be trusted. The difference in values in percentage terms <10% can still be said to be valid (Mendenhall/Reinmuth, 1981), and the same thing is also reinforced by N. Sumartojo (1991).

In addition, Anto Dayan (1984) stated that the difference of less than 10% can be considered justification and also supported by Nugroho and Djazuli etc, 1985, that the difference smaller than 10 percent can be ignored.

Development Prospects

Hinterland or in Indonesian as a Coverage Area is an area that becomes a Trip Production for both goods and passengers from the activity center where loading and unloading activities are carried out, as well as a market for the coverage area.

In connection with the study conducted in the province of Aceh Darussalam, there are 3 centers of loading and unloading activities that have the potential for development in the future, namely:

1. Tapak Tuan Harbor;

2. Susoh Harbor;

3. Sinabang Harbor

These three travel distribution centers generate and attract trips between 8000 - 10,000 trips per year and these results indicate the need to develop service facilities for passengers. While for the transport of goods in and out of the three centers zone has the volume of transportation from 125 thousand tons to 200 thousand tons (table 1), therefore it is necessary to develop a route for the distribution of travel, both goods and passengers, as shown in table 5. Recommended to route improvement.

4. Conclusion

The application of the gravity theory is actually more practical and when compared with the real results of the survey, the deviation is around -10% < X < 10%, which theoretically in the field of transportation is still considered quite reliable.

1. Track Network Development

Seeing the prospect of growth in goods transport, both loading and unloading at the ports of Tapak Tuan, Susoh, and Sinabang; the three of which are interfaces (meeting points) of sea transportation, it is recommended to develop a sea transportation route network as set out in Table 5 below;

Table 5. Development of Marine Transport Route Network

Gate Way	Distribution Area / Track
Tapak Tuan	-Sinabang, Susoh, P.Banyak, Singkil, Calang, Malahayati, Sabang -Gong Susoh, Padang, Tj Peureulak, Banten
Sinabang	-P.Banyak, Tapak Tuan, Singkil, Calang, Meulaboh, Susoh, Malahayati -Padang, Gong Susoh, Belawan, Tj Peureulak, Banten
Susoh	-Tapak Tuan, P.Banyak, Sinabang, Meulaboh, Singkil, Calang, Malahayati -Padang, Gong Susoh, Belawan, Tj Peureulak, Banten

References

[1] Law No. 11 of 2006 concerning the government of Aceh.
[2] Law No. 17 of 2008 concerning shipping.
[3] Decree of the Minister of Transportation Number KP,432 of 2017 concerning Plans National Harbor Master.
[4] Decree of the Minister of Transportation Number 52 of 2004 concerning Needs of Port Facilities.
[5] Abubakar, Kenasin, Wiratno and Barzach. 2013. Crossing Transportation A Introduction. Jakarta: PT Raja Grafindo Persada
[6] Abubakar, Kenasin and Barzach. 2011. An introduction to Mainland Water Shipping. Jakarta: Transindo Media
[7] Chairul I. Ilham, ATD, MM, 2016 River Transportation Planning, Publisher Alfabeta Bandung.
[8] Chaidirrozi.2018.Dredging Techniques.Palembang: Land Transportation Education and Training Center
[9] Harry Geerlings, Bart, Rob. Z(2017), Port and Net works, Rouledge Taylor & Francis Group. London and Newyork

[10] Lasse, DA. 2012, Management of Supply Chain Activities in the Port Area. Edition 1 Jakarta, Rajawali Pers.
[11] Triatmojo, Bambang.2010.Port Planning.Yogyakarta: Beta Offset
[12] Warpani.Ir, ME 1990, Transportation Planning Publisher ITB Bandung.
[13] Van Exel, N, J, A. and Rietveld, P. 2010. Perception of Public Transport Travel Time and Their Effect on Choice sets Among Car Drivers. Journal of Transport and Land Use.