Domestic Air Travel Demand Forecasting Model in the Philippines

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Abstract: A study is conducted to develop an air travel demand forecasting model to predict the volume of air passengers travelling in specific routes in the Philippines. The characteristics of domestic air travel demand in the Philippines are investigated through the analysis of statistical data and determination of the correlational relationship between the domestic air passenger traffic, population and gross domestic product (GDP) of the country. Air shares of every route are determined as a function of fare and travel time between the two most competing modes of inter-island travel in the country namely; water and air transport modes. Using the modified gravity model as a function of population, gross domestic product, air mode share and distance, the air travel demand forecasting model is verified. Results show that 62% of the variation of the dependent variable is explained by the independent variables, i.e. population, GDP, distance, air share, in the model.

Keywords: Forecasting Model, Air Travel Demand, Philippines, Gravity Model

1. INTRODUCTION

Transportation is the act of travel from an origin to a specific destination to cater services, goods, commodities and human activities in terms of business, sports, leisure, education and a lot more trip purposes. The adequacy and efficiency of transportation system in a country is highly important to ensure maximum mobility of people, goods and services.

Over the years, the overall demand for transportation, e.g., in water, land and air, has been rapidly increasing. In the Philippines, which is composed of three main group of islands for its 7,100 islands, i.e., Luzon, Visayas and Mindanao, the water mode of transportation should have played a vital role in connecting its people to other islands. However, water mode of transportation and its services are limited and often times unreliable. In the past ten year, it is observed that the demand for air transportation grows at faster rate than in water mode of transportation. The rapid increase in air travel is also caused by many underlying factors which include increasing population, increasing value of time, increasing gross domestic product (GDP), rising educational levels, changing lifestyles, improved technology and many more.

Today's challenge of the growing demand for air travel has caused a number of problems and harsh realities to be attended to: escalation of fuel prices, congestion at air terminals, inadequate facilities, dissatisfaction of passengers, delays of baggage, delays of departures, high transportation cost, high load factors, etc., and even unprofitable flights experienced in other routes (Trinidad, 1987).

The above problems, inherent in air travel, are also experienced in the Philippines in some degrees. The connectivity to the country's more than four thousand islands is another challenge to the government. These problems can be partially solved if there is detailed study and planning. However, good planning and design of airports and air route systems must be preceded by a logical projection of travel demand. In this process then, air travel demand forecasting plays an important role.

2. DOMESTIC AIR TRANSPORTATION IN THE PHILIPPINES

In the Philippine setting, all the domestic commercial airlines, such as, AirAsia Philippines, Cebu Pacific Air, Philippine Airlines, Fil-Asian Airways, Sky Pasada, South East Asian Airlines, Spirit of Manila Airlines, Zest Airways are owned and operated by private companies. With quite a number of airline providers, competition has been close encouraging every company to create business strategies like budget-friendly fare that is very comparable to sea fare for Filipinos and foreign passengers. Thus, the demand for air travel in the Philippines increases significantly through time and is expected to increase more in the near future.

In the whole Philippine archipelago, there are 71 airfields as reported and tallied by the Airport Transportation Authority (ATA) to include commercial airfields, military and private airports. Two (2) of the airline companies, e.g., the Philippines Airlines and the Cebu Pacific Air, have wide operations coverage of commercial airfields in the domestic air markets. Figure 1 shows the domestic air route map of Philippine Airlines and Figure 2 shows the route interactions for the Cebu Pacific Air.

Figure 1. Philippine Airlines Route Map
(Source: www.philippinairlines.com)

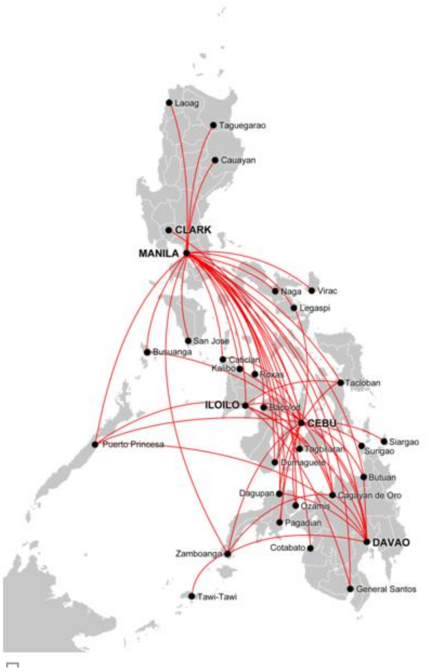

Figure 2. Cebu Pacific Air Destination Interaction Route Map (Source: ww.cebupacific.com)

3. MODEL DEVELOPMENT

The gravity model is one of the most widely used trip distribution techniques in transportation planning. Early studies measured trip generation and attraction components in terms of zonal populations, and the resistance function was assumed to be inversely related to distance. This relationship is similar to Sir Isaac Newton's theory of Gravitation. The early gravity model is expressed in the mathematical form as:

$$I_{ij} = \frac{K \times P_i \times P_j}{D^n} \quad (1)$$

where:

I_{ij}	: interaction between *i* and *j*
P_i	: population at *i*
P_j	: population at *j*
D	: distance between *i* and *j*
K	: some constant
n	: some exponent

Kessler (1965) quoted in his thesis that Stewart and Warntz, and Rice and Gallagher used population modifiers in the generalized expression for total interaction. The model is called modified gravity model. Stewart and Warntz found that some areas and cities have influences greater than the influences of population. He decided to carry the physical analogy further, that the molecular weights should be assigned to the population of different regions, just as specific weighs are attached to molecules of physical masses. The Stewart and Warntz equation became:

$$T_{ij} = k(\mu_1 p_1)^{\alpha_1}(\mu_2 p_2)^{\alpha_2}/d_{ij}{}^{\alpha_3} \quad (2)$$

where:

μ_1, μ_2	: molecular weights of the population at regions *i* and *j*, respectively
α	: a parameter

Trinidad (1987) also developed a model based on the modified gravity model relating the population factor to the modal share in the kingdom of Thailand. The investigators' model was written as:

$$T_{ij} = \frac{k(P_i P_j)^{\alpha_1}}{d_{ij}{}^{\alpha_2}} \times share_{ij} \quad (4)$$

$$share_{ij} = \frac{e^{v_a}}{e^{v_a} + e^{b} + e^{v_r}} \quad (5)$$

where:

T_{ij}	: air travel demand
P_i, P_j	: population in regions i and j respectively
d_{ij}	: the distance between the two regions
$share_{ij}$	: the modal share of air mode with respect to the other modes of transport, water and bus
v_a, v_b, v_r	: the utilities for air, bus and rail modes of transportation's fare and time variables

Matthews (1995) had done measurement and forecasting of peak passenger flow at several airports in the United Kingdom. According to his research, annual passenger traffic demand can be seen as the fundamental starting point, driven by economic factors and forecasting. Forecasts of hourly flows are needed for long-term planning related with infrastructure requirements. Hourly forecasts are almost always based on forecasts of annual flows.

Bafail, Abed, and Jasimuddin (2001) had developed a model for forecasting the long-term demand for domestic air travel in Saudi Arabia. They utilized several explanatory variables such as total expenditures and population to generate model formulation.

Another study for air travel demand forecasting was done by Grosche, Rothlauf, and Heinzl (2007). According to their research, there are some variables that can affect the air travel demand, including population, GDP and buying power index. He considered GDP as a representative variable for the level of economic activity.

From the past studies on transportation modeling and the geographic and demographic characteristics of the country, a modified gravity model of the Philippines is developed as follows:

$$T_{ij} = \frac{k(P_iP_j)^{\alpha_1}(G_iG_j)^{\alpha_2}}{{d_{ij}}^{\alpha_3}} \times share_a \tag{6}$$

where:

T_{ij}	: air travel demand from origin *i* to destination *j*
P_i, P_j	: population in origin *i* and destination *j*
G_i, G_j	: Gross Domestic Product in origin *i* and destination *j*
d_{ij}	: distance between the origin *i* and destination *j*
$share_a$	: modal share of air mode with respect to the water mode of transport between *i* and *j*

Considering that the model is based from the concept of modified gravity model, the air travel demand between origin *i* and destination *j* will thus be assumed to depend upon the following parameters:

(a) The population P_i and P_j of the two regions
As observed in the past studies of different investigators of travel demand it is evident that the factor of population is a highly substantial factor to consider. Thus, we can hypothesize that the greater the population in an area there is a greater generation of trips.

(b) The economic factor using the GDP of origin G_i and destination G_j .
With the improved economic market of the Philippines, it is assumed that this factor will significantly relate to the travel demand in the country. And taking into consideration the ideas from previous researchers, it is assumed that this factor will yield valuable result.

(c) The distance d_{ij} between routes.
Distance is an accomplished factor through time as an agent of travel among passengers throughout the world based on data and examination.

(d) Air modal share
The transport share contributed by the air transport relative to the competing mode of transportation which is the water transport mode is also considered and

analyzed through the statistical records of previous year's data. Using the logit model, the air share can be written as:

$$share_{ij} = \frac{e^{v_1}}{e^{v_1}+e^{v_2}+e^{v_3}} \quad (7)$$

Since we are evaluating with respect to water transport mode, air share can be illustrated as:

$$share_a = \frac{e^{v_a}}{e^{v_a}+e^{v_w}} \quad (8)$$

where:

a,w = represent air and water, respectively
v^a,v^w = utility based for air and water mode's fare and travel time variables

Furthermore, v_a and v_w can be written as:

$$v_a = \alpha\, fare_a + \beta time_a + c_a \quad (9)$$
$$v_w = \alpha\, fare_w + \beta time_w + c_w \quad (10)$$

The method of multiple linear regression is used in order to evaluate the parameters in the model shown in equation 6. Taking the natural logarithm function to both sides of the equation, the model can be transformed as follows:

$$\log_n\left(\frac{T_{ij}}{share_a}\right) = \log_n k + \alpha_1(\log_n P_i + \log_n P_j) + \alpha_2(\log_n G_i + \log_n G_j) - \alpha_3(\log_n d_{ij}) \quad (11)$$

The logarithmic equation now forms a linear equation in four independent variables with four parameters to calibrate, $\beta_0, \beta_1, \beta_2, \beta_3$:

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 \quad (12)$$

where:

$Y = \log_n\left(\frac{T_{ij}}{share_a}\right)$: logarithm of intercity air traffic demand over air mode share
$x_1 = \log_n P_i + \log_n P_j$: sum of logarithm of population
$x_2 = \log_n G_i + \log_n G_j$: sum of logarithm of gross domestic product
$x_3 = \log_n d_{ij}$: logarithm of distance
$\beta_0 = \log_n k$
$\beta_1 = \alpha_1$
$\beta_2 = \alpha_2$
$\beta_3 = -\alpha_3$

The influence of tourists in air travel demand in the country is believed significant, but the non-availability of necessary data to account the tourist factor in the study makes it difficult to pursue.

4. DATA

It is deemed appropriate to know the historical trends of air traffic in every route, to be able to figure out what will happen in the future. The available data for air passenger traffic were obtained from the Civil Aviation Authority of the Philippines (CAAP, 2012) from years 2001-2010, as shown in Table 1. These routes were selected where water mode of transportation is also available to compete with the air travel mode.

The distance between routes was obtained through an online distance calculator, as shown in Table 2. The population and gross domestic product by province were obtained from the National Statistical Coordination Board (NSCB) and the National Economic Development Authority (NEDA), as shown in Table 3 and Table 4, respectively.

For the calculation of air mode share between route, the data on passenger demand, fare, and travel time of the two available modes of transport in competition in the country were needed. Only the five main Luzon-Mindanao and Visayas-Mindanao routes with the complete data set are available at the time of the study, as shown in Table 5. During the conduct of this study, the demand for land mode of transportation cannot yet compete with the air and sea modes due to its very long hours of land trip and limited access for roll-on-roll-off facilities for the inter-island connections. It is assumed that the calculated values of α and β for these routes are also applicable to other routes.

Table 1. Provincial Air passenger traffic at particular airport ($x10^3$)(Source: CAAP Aerodrome Dev.& Mgt.)

Province	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Manila/NCR	5663	5283	6012	7013	7263	8463	9969	10979	12905	14736
Cagayan de Oro /Misamis Oriental	405	468	386	407	464	606	702	902	1110	1301
Cebu	171	1597	1850	1805	1455	609	3021	2727	3453	4206
Cotabato	118	63	46	63	87	125	127	105	199	219
Davao	94	962	724	855	1322	1308	1502	1646	1935	2202
Dipolog	50	54	59	75	76	70	121	144	189	181
Dumaguete	138	136	149	131	164	164	276	306	361	363
General Santos	148	130	187	151	181	208	310	303	405	456
Iloilo	640	677	681	740	708	864	1003	1074	1324	1581
Legazpi	77	90	92	100	100	146	225	282	139	435
Ormoc	0	0	0	0	0	0	13	16	18	32
Ozamis/Misamis Occidental	0	0	0	0	0	0	21	80	161	206
Puerto Princesa/ Palawan	189	148	196	272	268	284	392	482	588	814
Tacloban	299	303	284	290	328	400	511	627	832	1149
Tagbilaran	33	77	106	163	199	241	346	401	563	573
Surigao	4	4	2	9	15	11	27	23	65	90
Zamboanga	270	295	309	353	361	396	485	470	583	624

Table 2. OD of air demand in year 2014 and distance between routes (Source: Distancefrom.com and CAAP)

Origin/Destination	Air Demand	Distance (km)	Origin/Destination	Air Demand	Distance (km)
MNL-CDO	546000	782.42	CBU-CDO	59904	225.71
MNL-CBU	1263600	569.00	CBU-DVO	218400	413.46
MNL-CTO	156000	883.52	CBU-DME	27872	131.33
MNL-DVO	811200	967.37	CBU-GSC	28080	493.03
MNL-DPG	109200	705.25	CBU-ILO	82368	148.22
MNL-DME	202800	629.59	CBU-LZP	22464	308.78
MNL-GSC	139360	1038.33	CBU-OZM	52416	245.64
MNL-ILO	546000	455.99	CBU-PPR	46800	565.96
MNL-LZP	109300	331.67	CBU-SUR	90932	188.54
MNL-ORC	32258	551.37	CBU-ZBA	22460	432.26
MNL-OZM	109100	771.82	DVO-ILO	26208	524.7
MNL-PPR	436800	584.48	DVO-OZM	18720	228.25
MNL-TLN	436600	568.27	DVO-PPR	13936	816.6
MNL-TBN	292656	622.69	DVO-ZBA	29952	391.24
MNL-ZBA	32700	850.76			

Table 3. Population by province ($x10^3$) (Source: National Statistical Coordination Board)

Province	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Manila	9969	10137	10303	10466	10628	10787	10944	11100	11253	11403	11552
Cagayan de Oro/Misamis Oriental	1134	1162	1190	1219	1249	1279	1309	1341	1372	1404	1437
Cebu	3377	3455	3535	3616	3699	3782	3868	39554	4043	4133	4224
Cotabato	965	986	1008	1030	1052	1075	1098	1122	1145	1169	1194
Davao	748	759	771	783	794	807	819	831	843	855	868
Dipolog	762	776	789	803	817	830	845	859	874	888	902
Dumaguete/ Negros Oriental	1136	1156	1176	1196	1218	1239	1260	1282	1304	1327	1350
General Santos	111	1140	1169	1199	1229	1260	1291	1322	1354	1386	1419
Iloilo	1934	1971	2009	2047	2085	2124	2165	2105	2246	2288	2330
Legazpi/ Albay	1111	1140	1169	1199	1229	1260	1224	1245	1268	1291	1314
Ormoc	1600	1632	1664	1697	1730	1764	1798	1833	1868	1903	1939
Ozamiz/ Misamis Occidental	489	497	505	514	523	531	540	549	558	567	577
Puerto Princesa/ Palawan	762	785	810	835	860	886	913	940	968	996	1026
Surigao	484	493	502	512	522	532	542	552	563	574	585
Tacloban/ Leyte	1600	1632	1664	1697	1730	1764	1798	1833	1868	1903	1939
Tagbilaran/ Bohol	1141	1655	1186	1207	1228	1249	1271	1293	1316	1339	1363
Zamboanga	1447	1477	1508	1539	1571	1604	1636	1670	1704	1739	1774

Table 4. Gross domestic product by province (x10^6) (Source: National Economic Development Authority)

Province	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Manila/NCR	1302	1413	1557	1768	2016	2246	2479	2740	2871	3225
Cagayan de Oro/ Misamis Oriental	27.0	35.9	39.4	44.9	49.6	55.5	62.3	72.4	60.4	68.9
Cebu	64.1	69.5	74.1	84.5	94.6	104.2	115.5	126.8	116.1	134.6
Cotabato	18.2	25.7	27.8	32.1	35.00	39.1	44.4	50.2	43.7	49.7
Davao	51.0	43.2	46.8	53.8	60.0	65.9	74.0	84.2	84.1	93.8
Dipolog	20.9	22.6	24.1	26.8	30.2	33.7	37.9	43.3	42.6	46.0
Dumaguete/ Negros Oriental	64.1	70.0	74.1	84.4	94.6	104.2	115.6	126.8	116.1	134.6
General Santos	18.2	25.7	27.8	32.1	35.0	39.1	44.4	50.2	43.7	49.7
Iloilo	39.1	43.3	46.9	52.8	59.2	66.1	73.1	83.5	65.9	58.4
Legazpi/Albay	15.5	17.2	18.3	20.6	22.8	24.7	28.1	31.5	28.5	31.0
Ormoc	14.2	15.6	16.6	19.1	20.8	22.9	23.5	27.5	36.4	37.7
Ozamis/Misamis Occidental	27.0	35.9	39.4	44.9	49.6	55.5	62.3	72.4	60.4	68.9
Puerto Princesa/ Palawan	15.4	16.6	18.4	20.0	22.9	24.7	27.8	32.5	30.9	31.8
Tacloban/Leyte	14.2	15.6	16.6	19.1	20.8	22.9	23.5	27.5	36.4	37.8
Tagbilaran/Bohol	64.1	69.5	74.1	84.5	94.6	104.2	115.6	126.8	116.1	134.6
Surigao	12.4	13.1	13.7	15.0	16.6	19.3	24.1	25.0	21.8	24.6
Zamboanga	20.9	22.6	24.1	26.8	30.2	33.7	37.9	43.3	42.6	46.0

Table 5. Number of Passengers, travel time and fare in five complete data routes for year 2010 (Source: CAAP and published fare matrix of airline and waterline companies)

Sector	Air Mode	Water Mode
Manila – Cagayan de Oro		
Number of Passengers	546000	84773
Travel Time (min)	89	1343
Fare (Pesos)	3030	1610
Manila - Ozamis		
Number of Passengers	109200	37876
Travel Time (min)	88	1511
Fare (Pesos)	2488	1700
Cebu – Cagayan de Oro		
Number of Passengers	59904	263920
Travel Time (min)	46	614
Fare (Pesos)	1350	350
Cebu - Ozamis		
Number of Passengers	52416	180075
Travel Time (min)	48	611
Fare (Pesos)	1170	880
Cebu - Surigao		
Number of Passengers	90932	41261
Travel Time (min)	44	550
Fare (Pesos)	1071	445

5. RESULTS AND DISCUSSION

5.1. Correlation of Variables

In order to check the relationship between dependent variable and independent variables, a correlation test was conducted. Figure 3 shows graphical display between the GDP and the total number of air passenger traffic from 2000-2010 and Table 6 shows the correlational relationship between the two variables.

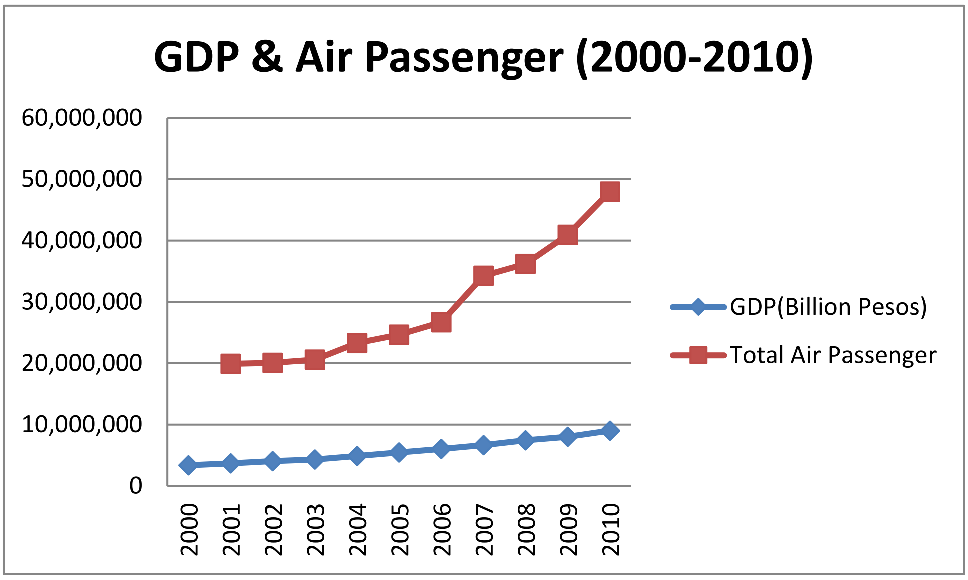

Figure 3. GDP vs. Air Passenger

Table 6. Correlational Relationship of GDP and Air Passenger Traffic

		AIR_Passenger	GDP
AIR_Passenger	Pearson Correlation	1	.758**
	Sig. (2-tailed)		.004
	N	12	12
GDP	Pearson Correlation	.758**	1
	Sig. (2-tailed)	.004	
	N	12	12

The trends in air passengers and the GDP in Figure 3 shows that, as the Gross Domestic Product of the country increases, the air traffic movement also increases. The Pearson correlational value of 0.758 in Table 6 also shows that the two variables have significant relationship. This is an expected movement which shows that as the economic growth increases, there will also be more activities generated from one place to another.

On the other hand, Figure 4 shows the relationship between the population and the air passenger traffic from 2000-2010.

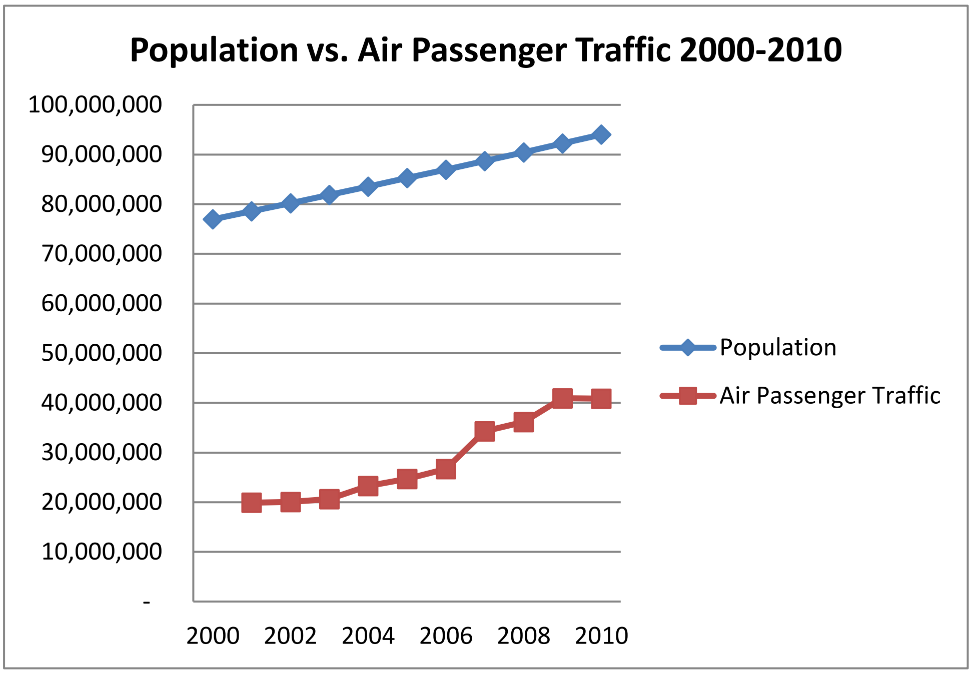

Figure 4. Population vs. Air Passenger Traffic

Figure 4 shows that as the population increases through time, there is also an increase of the air passenger traffic in the country. The Pearson correlational value of 0.823 implies that the two variables have significant relationship.

5.2 Multiple Linear Regression Analysis of the Model

The fare and time difference in five competing modes shown in Table 5 were computed for the statistical analysis to compute for the air mode share. The results are as follows:

Table 7. Computed Values of α, β, c_a and c_b

Parameter	α	β	c_a	C_w
Value	-0.00008149	-0.001	-0.796	0

Thus the air mode share can be expressed as

$$share_a = \frac{e^{v_a}}{e^{v_a} + e^{v_w}}$$

where:

$$v_a = -0.00008149fare_a - 0.001time_a - 0.796$$

$$v_w = -0.00008149fare_w - 0.001time_w$$

Table 7 shows the computed values of the coefficients α, β, and the c_a and c_w are the constants the competing air and water modes of transportation. The expected signs showed up for the variables fare and time and it significantly means that as values of these variables decrease the travel demand increase.

The values of α, β, c_a and c_b were used in the calculation of air mode share for all routes throughout the country.

For the calibration of air travel demand forecasting model using multiple linear regression analysis, equation 12 below is used, where Y is the dependent variable. Tables 8 show the results of the analysis.

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 \quad (12)$$

Table 8. Results of linear regression for all routes

Variables	Coefficient β
x_1, sum of log of population	0.282
x_1, sum of log of GDP	0.459
x_1, sum of log of distance	-0.466
Constant, $\log_n k$	-4.691

R^2 = 0.622

Table 8 shows the results of the multiple linear regression analysis. The negative sign for the distance variable is expected as this means that the decrease of the distance equates to an increase of the travel demand.

From the regression analysis of all routes, the signs for the independent variables are both positive for the population and the gross domestic product and a negative sign for the distance variable. These support the underlying relationships in the modified gravity model from previous researchers that, as the population and gross domestic product increases, air demand also increases and as distance decreases air demand increases. The value of multiple coefficient of determination (R^2) has showed that 62% of the variance in the dependent variable has been explained by the independent variables in the model.

6. CONCLUSION AND RECOMMENDATION

Domestic air travel demand in the Philippines has been studied using the modified gravity model and the data available at the conduct of the study. It is found out that 62% (R^2) of the variation in the dependent variable is explained by the independent variables in the model. The result of this study is not satisfactory for a comprehensive type of study due to the limitations in the data gathered. The R^2 value is believed to improve when a more detailed data are available. The air share mode may also be calibrated to include other routes.

Considering the limitations of this study and based from the above findings, it is recommended to further improve the study by intensifying the gathering of data, use of MAPE to calculate the accuracy of the gravity model and by also identifying other factors that may influence the air travel movements in the country.

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