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FORECASTING AIR FREIGHT TRANSPORTATION DEMAND USING LOG-LINEAR MODEL FOR SOCIO-ECONOMIC FACTORS

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ABSTRACT

Forecasting freight transport demand is of critical importance since investment efficiency is greatly influenced by the estimation performed. In this current study, Log-Linear Models have been developed individually for inbound, outbound and total freight transportation demand in Australia for finding the combined effect of various socio-economic variables in freight movement. Log- linear model is chosen due to its capability of modelling non-linear effects. Data of exogenous variables has been collected from Australian Bureau of Statistics (ABS). Selected independent socio-economic variables are population, GDP, total goods exported, total goods imported, import and export price index and consumer price index. Socio-economic variables are chosen in such a way that the overall model has a good-fit. All the three models have adjusted R-square values greater than 0.95 and standard error within 0.1 indicating goodness of fit and good correlation within the variables. Elasticity analysis is done here. From the elasticity analysis it is found that, Import-Export Price Index (IE-Index) and Consumer Price Index (CPI) have positive elasticity greater than 2 which emphases that the air freight movement is very elastic with respect to IE-Index and CPI. Value of elasticity for GDP is 0.126 for total freight movement, 0.62 and 0.625 for inbound and outbound air freight movement respectively indicating that air freight movement is mostly a necessity for industrial growth in Australia. Negative low value of elasticity(-0.22) for Inbound freight movement is found for the variable of total goods imported which can be described as the fact that capacity of air-freight movement is not unlimited, so with the increase of total imported goods, it doesn't significantly increase the freight movement, rather alternative modes induce negative sign on elasticity value. Such result indicates that a cross-elasticity model may perform even better in the prediction of freight movement demand.

Keywords: *Freight transportation, Log-linear model, Elasticity, Socio-economic factors.*

1. INTRODUCTION

Freight transportation is different from transportation of passengers and their modelling requires different factors. When the transportation of freight is made by air cargo, forecasting becomes more complex. There is very limited study on air freight transportation demand modelling. Totamane et. al. (2014) used Potluck Problem approach to propose a multi-producer/multi-consumer solution for predicting the cargo demand of a specific airline in a given route. Each airline is considered as a producer and the users of air cargo services as consumers, no explicit communication with other producers/airlines was assumed. They mainly used data of different routes of North American Region as training data and proposed a new capacity plan. They modelled the problem using some of the generic predictors, such as time-varying functions, holidays, weekends, and so on. Additional predictors, such as industrial output, industrial growth, GDP, and so on, were considered but not found to make a significant overall difference.

Air freight has become increasingly important for transporting goods on Australia's international routes, largely due to the fact that Australia is a large island nation which lies far from densely populated business centres such as Singapore, Hong Kong, London, Paris, New York and Los Angles and that movement of freight by sea on Australia's international routes is time consuming. Goods that are moved by air are mostly light and high value goods requiring urgent delivery. In 2009-10, a total of 798100 tons of international air freight passed through Australian airports. It included 318600 tons of outbound air freight and 479500 tons of inbound air freight. About seventy per cent of the outbound air freight volume was uplifted at Australia's two major airports, Sydney and Melbourne (Hamal, 2011).

This study focusses on identification and collection of data from Australian Bureau of Statistics (ABS) of exogenous variables which may have direct influence on the demand data for forecasting the demand model of freight transport. The objective of this study is to develop a Log-Linear Demand Model to predict the combined effect of different socio-economic variables, identify the elasticity and determine the most influencing variables for determining the demand. Explanation of elasticity that are found from log linear regression of the variables is also done here.

2. METHODOLOGY

For forecasting transportation demand in Australian freight movement, raw data is taken from Australian Bureau of Statistics (ABS). Data set contained total Australian yearly freight movement statistics for the year 1985 to 2016. These were used to form a log-linear model. Regression analysis result showed elasticity of selected independent variables.

2.1 Selection of Variables

This modelling has two types of variables. One is dependent variables and other one is independent variable. The values of dependent variables depend on the values of independent variables. The dependent variables represent the output or outcome whose variation is being studied by the means of elasticity. Here, the dependent variables are Inbound, Outbound and Total Air Freight Movement for total Australia. Independent variables are population, GDP, total goods exported, total goods imported, import and export price index and consumer price index. Here, the independent variables are socio-economic factors. The variable consumer price index is a measure of changes in the purchasing-power of a currency and the rate of inflation. This variable is only considered for the model of forecasting total freight movement. Here, such socio-economic variables are selected which showed good fit in the model. Table 1 shows input data for regression analysis taken from Australian Bureau of Statistics.

Table 1: Input Data for Regression Analysis

Year	Inbound Air Freight (Tonnes)	Outbound Air Freight (Tonnes)	Total Air Freight (Tonnes)	Total goods exported ($ million)	Total goods imported ($ million)	GDP ($)	Population	Import and Export Price Index
1985	118,478	112,523	231,002	32807	34149	11452.66	15,901,000	66.0
1986	106,914	141,825	248,739	33768	36515	11379.52	16,139,000	77.3
1987	120,716	167,215	287,931	38942	38193	11643.95	16,395,000	84.5
1988	145,316	163,567	308,884	42562	43338	14283.38	16,687,000	86.8
1989	179,556	168,284	347,839	47021	51216	17838.36	16,937,000	79.0
1990	174,933	182,106	357,039	50712	50216	18249.29	17,170,000	83.1
1991	171,628	188,074	359,703	54316	49772	18865.34	17,379,000	88.9
1992	186,343	219,704	406,048	58265	56064	18616.32	17,557,000	85.3
1993	197,719	257,017	454,736	62648	62760	17681.15	17,719,000	93.9
1994	240,976	279,622	520,598	64675	69053	18102.32	17,893,000	99.0
1995	247,681	301,244	548,925	71800	77619	20384.67	18,120,000	94.1
1996	265,490	317,333	582,823	76944	77902	21944.16	18,330,000	97.3
1997	302,764	344,082	646,846	87099	85038	23551.22	18,510,000	91.0
1998	302,643	329,265	631,908	88976	97277	21365.98	18,706,000	96.7
1999	335,268	346,247	681,515	86705	101774	20561.48	18,919,000	102.0
2000	332,095	347,915	680,010	110283	118916	21690.92	19,141,000	99.2
2001	289,661	350,461	640,121	123412	119927	19517.84	19,386,000	114.8
2002	305,095	340,831	645,926	119633	129835	20081.82	19,605,000	113.1
2003	313,619	297,592	611,210	108695	132223	23465.39	19,827,000	108.0
2004	383,423	293,070	676,493	118178	143769	30472.38	20,046,000	94.4
2005	414,431	294,238	708,668	140462	158730	34016.71	20,312,000	94.8
2006	440,678	306,050	746,728	165320	181365	36118.28	20,628,000	97.0
2007	452,850	308,998	761,848	169925	194674	40991.98	21,016,000	97.0
2008	451,321	304,152	755,474	222795	232312	49664.69	21,476,000	94.8
2009	405,210	309,146	714,356	198343	204735	42743.00	21,866,000	114.8
2010	492,036	314,365	806,402	231699	219953	51874.08	22,172,000	97.0
2011	521,483	316,989	838,472	262895	241145	62245.10	22,527,000	96.1
2012	541,205	328,900	870,105	249386	257534	67635.32	22,942,000	100.6
2013	524,642	354,153	878,795	262957	255940	67708.69	23,322,000	99.7
2014	515,061	383,722	898,783	267287	264381	62099.61	23,673,000	104.9
2015	506,112	472,736	978,848	250881	275885	56408.34	24,013,000	105.2
2016	502,586	514,058	1,016,643	258078	267035	49755.32	24,127,159	107.7

2.2 Regression Analysis

Considering different variables stated in section 2.1, log linear regression analysis is done. Log-linear regression model is chosen because it capable of modeling nonlinear effects. Again, coefficients themselves directly represent the demand elasticities with respect to the different explanatory variables. The form of log linear regression analysis is shown in equation (1) to (3).

$$Ln\ (Inbound\ Air\ Freight\ Movement) = \beta_0 + \beta_1 ln\ (Population) + \beta_2 ln\ (Total\ Goods\ Imported) + \beta_3 ln\ (Total\ Goods\ Exported) + \beta_4 ln\ (GDP) + \beta_5 ln\ (Import\text{-}Export\ Index) + \epsilon \quad (1)$$

$$Ln\ (Outbound\ Air\ Freight\ Movement) = \beta_0 + \beta_1 ln\ (Population) + \beta_2 ln\ (Total\ Goods\ Imported) + \beta_3 ln\ (Total\ Goods\ Exported) + \beta_4 ln\ (GDP) + \beta_5 ln\ (Import\text{-}Export\ Index) + \epsilon \quad (2)$$

$$Ln\ (Total\ Air\ Freight\ Movement) = \beta_0 + \beta_1 ln\ (Population) + \beta_2 ln\ (Total\ Goods\ Imported) + \beta_3 ln\ (Total\ Goods\ Exported) + \beta_4 ln\ (GDP) + \beta_5 ln\ (Import\text{-}Export\ Index) + \beta_6 ln\ (Consumer\ Price\ Index) + \epsilon \quad (3)$$

Here, variables are shown in parantheses. β's are regression analysis co-efficient, ϵ's are error terms.

Total goods exported and total goods imported are specified in million dollars, GDP is specified as dollars per capita. Remaining parameters are specified as values.

2.3 Elasticity Analysis

The variation in demand in response to a variation in price is called the price elasticity of demand. It may also be defined as the ratio of the percentage change in demand to the percentage change in price of particular commodity. When the price elasticity of demand for a good is perfectly inelastic, changes in the price do not affect the quantity demanded for the good. When the price elasticity of demand for a good is relatively inelastic ($-1 < Ed < 0$), the percentage change in quantity demanded is smaller than that in price. When the price elasticity of demand for a good is unit (or unitary) elastic ($Ed = -1$), the percentage change in quantity demanded is equal to that in price. When the price elasticity of demand for a good is relatively elastic ($-\infty < Ed < -1$), the percentage change in quantity demanded is greater than that in price. Regression analysis done in section 2.2 yields to the values of β (regression co-efficient) for corresponding variables assigned. These β values are analyzed if those are in elastic or inelastic in nature as stated above.

3. DATA ANALYSIS

From the regression analysis, forecasting model is formed and adjusted R-square values are checked.

3.1 Forecasting Model

Result from regression analysis is shown in table 2.

Table 2: Result from regression analysis

Variables	INBOUND	OUTBOUND	TOTAL
Intercept (β_0)	30.31	-37.8215	27.46
Population (β_1)	0.37	-0.417	1.44
Total Goods Imported ($) ($\beta_2$)	-0.22	0.153	0.426
Total Goods Exported ($) ($\beta_3$)	0.71	1.34	0.06
GDP($) ($\beta_4$)	0.62	-0.625	-0.126
Import Export Index (β_5)	2.11	2.53	2.3
Customer Price Index (β_6)	------	------	3.04
R Square	0.995	0.989	0.951
Multiple R	0.9974	0.995	0.97
Adjusted R Square	0.994	0.987	0.950
Standard Error	0.038	0.038	0.105
Observations	32	32	32

Adjusted R Square value indicates good-fit for all the three models. The standard errors found are all within 0.1, which also indicates the good correlation among the data.

Using the regression co-efficients shown in table 2, equations (1) to (3) can be written as shown in equations (4) to (6)

Ln (Inbound Air Freight Movement) = 30.31+ 0.37ln (Population) – 0.22ln (Total Goods Imported) + 0.71ln (Total Goods Exported) + 0.62ln (GDP) + 2.11ln (Import-Export Index) (4)

Ln (Outbound Air Freight Movement) = -37.82 - 0.417ln (Population) + 0.153ln (Total Goods Imported) + 1.34ln (Total Goods Exported) - 0.625ln (GDP) + 2.53ln (Import-Export Index) (5)

Ln (Total Air Freight Movement) = 27.46 + 1.44ln (Population) + 0.426ln (Total Goods Imported) + 0.06ln (Total Goods Exported) - 0.126ln (GDP) + 2.3ln (Import-Export Index) + 3.04ln (Consumer Price Index) (6)

3.2 Elasticity

Regression co-efficient values from table 2 is used to explain elasticity of a socio-factor with its corresponding model.

3.2.1 Import-Export Price Index

Import and export price indexes measure changes in the price of goods and services in international trade. From table 2, it is found that IE- Index has positive elasticity greater than 2 for all the three models, these emphases that the air freight movement is very elastic with respect to IE-Index. It indicates that if IE-index varies the number of freight trips will vary significantly. Import Export Price Index has overall positive effect on air freight movement.

3.2.2 GDP

GDP is a key performance indicator of a nations economy. From table 2, it is found that regression coefficients for inbound, outbound and total freight movement is 0.62, -0.625 and -0.126. Value of elasticity for GDP is very low and almost same in all cases. This indicates that air freight movement is mostly a necessity for industrial growth. Gross Domestic Product (GDP) per capita has inelastic effect on demand.

3.2.3 Population

From table 2, for independent variable popuation, it is found that regression coefficients for inbound, outbound and total freight movement is 0.37, -0.417 and 1.44. Elasticity value greater than one indicates increase in population has larger increase in freight movement. More people require more goods i.e. more freight movement. The effect of population is positive in case of Inbound and Total Air Freight movement but negative in case of outbound movement. If we consider inbound and outbound freight movement individually, both are inelastic range.

3.2.4 Total Goods Imported

From table 2, it is found that regression coefficients for inbound, outbound and total freight movement for total goods imported is 0.22, 0.153 and 0.426. Value of elasticity for total goods imported is very low and almost same in all cases. This indicates that air freight movement is mostly a necessity for industrial growth. Negative low value of elasticity for Inbound freight movement for total goods imported can be described as the fact that capacity of air-freight movement is not unlimited, so with the increase of total imported goods, It doesn't significantly increase the freight movement , rather alternative modes induce negative sign on elasticity value.

3.2.5 Total Goods Exported

From table 2, it is found that regression coefficients for inbound, outbound and total freight movement for total goods exported is 0.71, 1.34 and 0.06. Total goods exported have positive elasticity of 1.34 as

it directly emphases the outbound Air freight demand. It has inelastic behavior or no change of behavior on inbound Freight Movement. Total goods exported has overall positive effect on air freight movement.

3.2.6 Consumer Price Index

A measure of changes in the purchasing-power of a currency and the rate of inflation is termed as consumer price index. From table 2, it is found that regression coefficients for total freight movement for this variable is 3.04. Here it can be seen that CPI has very high elasticity with Air Freight Movement. It has a value greater that 3 indicating high dependency of air freight on the CPI.

4. CONCLUSIONS

From this study, it is found that for maximum variables (population, GDP, Total Goods Imported and Total Goods Exported), freight movement is inelastic nature. These result shows similarity with the study of Totamane et. al. (2014) where they found that industrial output, industrial growth, GDP don't make a significant overall difference. International Trade Expense (Import and Export Price Index) is the most effective variable for freight movement according to this analysis and very elastic in nature for inbound, outbound and total freight movement. Introducing cross-elasticity analysis for these socio-economic factors can help to replicate the actual scenario in a better way.

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