Chapter 6

FORECASTING OF FUTURE AIR FREIGHT

Introduction

The purpose of forecasting future air freight is to examine the future prospects for the development of air cargo transportation at Bangkok International Airport , and to examine some factors that may influence the growth of air cargo transportation .

Three parts of studying are provided as ;

1. Reviews historical trends of air cargo transportation at Don Muang and predict these trends in the future
2. Considers certain factors that may influence the development of air freight in the future
3. Determines available forecasts of freight traffic at this airport

Trend Projection

Theory

The first step taken in order to forecast the air traffic , the historical data in form of time series have to be studied and then the analysis of the trend of development can be performed . Using an isolating trend , regular or smooth movement of time series , a forecast is made . This procedure is called the extrapolating from the trend and it is assumed that whatever factors determine the magnitude of traffic , they will continue in the same way in the future as they did in the past except that there may be a level of saturation beyond which traffic will not grow .

To isolate the trend in a time series , the first procedure is to plot the time series on a piece of standard graph paper . The traffic variable or anything to be forecasted (the dependent variable) is plotted on the horizontal axis . When each point in the time series is plotted , a smooth curve which seems to come to all the points can then be drawn by freehand style . This curve gives the first preliminary indication of the pattern of development . A trend will appear if the growth rate tends to be stable in absolute or in percentage terms , if the percentage rate of growth has decreased gradually over the years or if there is even more marked indication of saturation . Based on this evidence , the type of trend curve which is most representative may be selected and on that basis a projection of the trend carried out .

If the trend seems to show that the dependent variable changes by a constant amount overtime , a straight line would be the appropriate curve to fit to the data . The straight line , in the form $y = a + bx$, where y is the variable to be forecasted , x is time and a and b are constants , is the simplest trend curve to work with , but it is not often representative for air traffic development trends .

If the trend seems to show that the dependent variable changes by a constant percentage with each change in the independent variable (time) , am exponential curve is the appropriate trend curve to use. The equation of the exponential curve is given by $y = ab^x$ where x , y a and b have the same meaning as indicated before . One of the interesting features of the exponential relationship is that , if the variables are converted into logarithms , the relationship becomes linear;

$$\log y = \log a + x \log b$$

It is frequently easier to plot the variables on ratio or linear logarithmic graph paper if an exponential trend is expected since this curve will appear as a straight line on such paper and is therefore easier to identify .

It has been observed that sometimes a series which achieves a rapid growth rate during a given period of time eventually tends to reach a plateau or upper limit at some point . This concept of a saturation level can be introduced directly into the equation for an exponential trend curve by adding a constant (k) to the equation . The equation then becomes :

$$y = k + ab^x$$

Depending on the values of a and b , this curve may take different shapes . If a is negative , k becomes an upper limit which y will approach with time but never exceed .

Two other growth curves which asymtotically approach an upper limit are the logistic curve (also called the Pearl-Reed curve) and the Gompertz curve . The logistic curve takes the form :

$$\frac{1}{y} = k + bc^x$$

i.e., $\frac{1}{y}$ is related to time (x) in the same way as y is related to time by the modified exponential curve . In spite of basic difference, however , the growth patterns may be similar in the two cases when the signs and magnitudes of the constants are different .

The Gompertz curve gives results similar to those of the logistic curves and appears in the form :

$$y = ka^{b^x}$$

In this curve the first differences of the logarithms of the y values changes by a constant rate and the constant k becomes the limit or asymtote . In other words , the first differences of the logarithms of the y values are linearly related to time . This equation can be written in logarithms as ;

$$\log y = \log k + (\log a)(b^x)$$

Let $\log y = \hat{y}$, $\log k = \hat{k}$, $\log a = \hat{a}$, then the equation becomes :

$$\hat{y} = \hat{k} + \hat{a}b^x$$

and it takes the same form as the modified exponential curve .

The linear , exponential , logistic and Gompertz curves are shown graphically in Figure 6.1 .

It may be necessary to combine two or more types of trend curves especially for extremely long series . A number of the curves presented before tend ultimately to reach a plateau or upper limit which seems to be most reasonable . However , after such a plateau in trend , the series may again enter a stage of rapid growth , or again , it may decline indefinitely or even vanish . A radical change in the trend of development may occur , for example , in periods of upheavals or under influence of great technological changes . These considerations suggest that two or more types of trends may be spliced , especially if the series is a long one . Not withstanding anything defined before , most trend curves in air transport forecasts are linear or exponential . The latter is used more frequently and is usually presented as a linear relationship in the logarithm of the variables . The other relationship presented above may be useful in special circumstances , possibly when describing traffic over a well-developed route or forecasting the long-run trend in business travel .

Fitting trend curves to observed data

The initial graphic examination of what type of trend curve best fits a time series of traffic data may suitably be carried out by using different types of graph paper and different ways of plotting the data. Plotting the data on ordinary graph paper with even spacing (arithmatic grid paper) will show a linear growth pattern as a straight line .

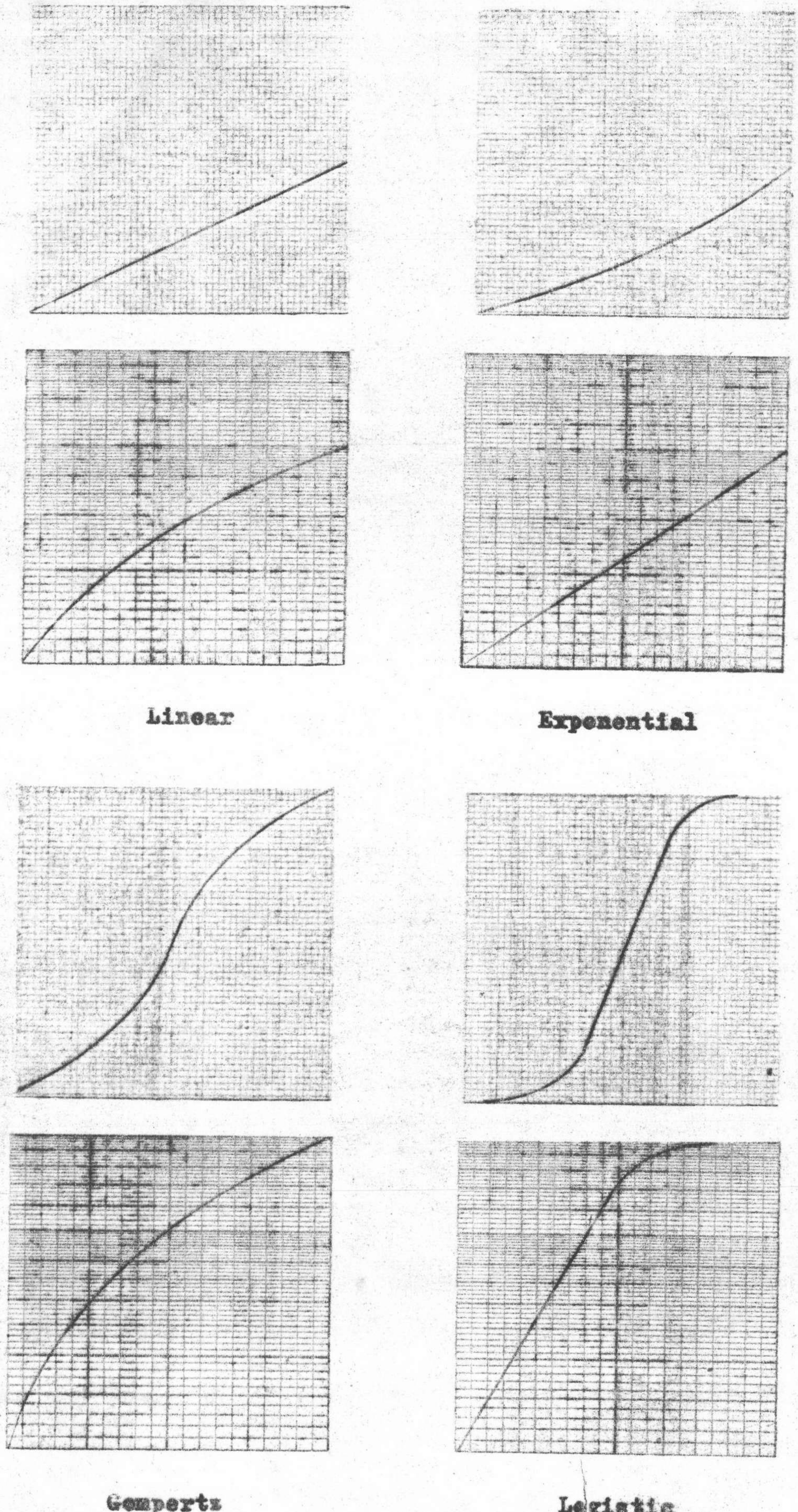


Figure 6.1 Linear , Expenential , Legistic and Gompertz curve

An exponential growth pattern will appear as a straight line on linear-logarithmic paper (linear time scale , logarithmic traffic scale) . The linear-logarithmic plotting will also indicate if there is a trend for the percentage rate of growth to gradually decline with time .

Certain plots on linear-logarithmic paper based on annual differences can also be made to indicate whether a modified exponential curve , a logistics curve or a Gompertz curve would represent the historical trend of traffic development .

After the data have been plotted on graph paper and a trend curve which appears to fit the data is established , the forecaster could then simply extend the visually fitted trend curve to the future period for which the forecast is desired . The forecast data could then be read from the graph and presented in a table . Often , however , this procedure is too crude for the purpose for which a forecast is required .

On obvious difficulty with the above procedure is the absence of any objective criteria for establishing which trend curve " best fits " the data . If visual inspection by the forecaster is to be the criterion , it is likely that different forecasters would come up with different curves as best fits for the data .

The objective establishment of a " best fit " is a fairly simple task when it can be assumed that a straight line best represents the trend of the time series under study . It does not matter whether the linear relationship is in the variables themselves or in their logarithms since the procedure is the same in both cases . For example , if the relationship is linear in the logarithms of the variables (e.g., an exponential curve) , the terms log x , log y can be substituted wherever x and y appear .

The technique which is currently used most frequently for determining this " best fit " line is known as the method of least squares . The least squares criterion requires that the line which is fitted to the sample data be such that the sum of squares of the vertical deviations (distances) from the points to the line be a minimum . The reason the sum of the deviations are minimized and not just the sum is because some of the deviations are positive (above the line) and some are negative (below the line) so , even though the deviations are large , their sum would be zero unless they are squared .

The problem can now be restated in summary . Given the sample data , and seeking the straight line , in the form $y = a + bx$ which best represents the trend in the data , the values for " a " and " b " must be found such that the sum of squared deviations from the sample points to the line are minimum . In Appendix D-1 the method of calculating " a " and " b " from observed values of x and y is desired .

However , the calculation of the values of " a " and " b " which satisfy the least squares criterion leaves unanswered the question of how well the corresponding straight line represents the data .

This " goodness of fit " is usually measured and expressed by an index called the coefficient of correlation , " r " , or by the square of quantity , " r^2 " , called the coefficient of determination . If the fit of data is poor , the coefficient of correlation , " r " , will be close to zero . If the fit is good , the coefficient of correlation will be close to +1 or -1 . Section II of Appendix D-1 discusses this coefficient of correlation and the coefficient of determination in more detail and shows how these coefficients can be calculated .

It is a good practice to subject both the coefficient , " b " and the coefficient of determination , " r^2 " , to a " test of significance " . It could be that the data in the sample analysed were related only by chance and that if the sample were sufficiently expanded it would be discovered that in fact " x " and " y " are not related . The test of significance gives the probability of obtaining this accidental relationship in a sample . An alternative way of dealing with the sample problem is to calculate the " confidence interval " for the coefficients " a " and " b " . A full discussion of significance tests and confidence intervals can be found in standard statistics text books.

The least squares method is readily applicable when seeking the straight line or the exponential curve that best fits a time series of traffic data . With respect to the other types of trend curves , it should be mentioned that a simple method can be used to determine a modified exponential or Gompertz curve which represents a good fit to a series of observed data . This method is described in Appendix D-2 .

Forecasting of future air freight by fitting trend curves with observed data are divided into four outlines as follow :

a. Total air freight

b. Total international air freight

c. Total domestic air freight

d. Total transit air freight

All data used in fitting such trend curves have their sources in manifest books of Bangkok International Airport . Available data are during the years of 1968 to 1976 and the forecasts are from 1977 to 1986 which are ten years . Forecasts by fitting trend curves are reliable within certain period of forecasting such as 2-5 years which development in aeronautical technology especially in the field of commercial flights and facilities for air freight will generally justify .

a. Total air freight

From recorded data , values of total air freight are plotted in ordinary graph paper as shown in Figure 6.2 , this trend curve seems to be as exponential curve which may be substituted by the equation ;

$$\log y = a + bx$$

$$\text{or} \quad \hat{y} = a + bx$$

Also , such recoreded data are plotted on linear-logarithmic graph paper as shown in Figure 6.3 where time scale is linear and volume scale is logarithmic and the occurance from plotting shows a straight line of linear growth . To determine the values of " a " and " b " and the coefficient " r " and " r^2 " , from Table 6.1 we find

$$\Sigma x = 36 , \quad (\Sigma x)^2 = 1,296$$

$$\Sigma y = 42.43 , \quad (\Sigma y)^2 = 1,800.30$$

$$\Sigma xy = 174.36 , \quad \Sigma x^2 = 204$$

$$n = 9 , \quad \Sigma y^2 = 200.40$$

Then ,

$$a = \frac{(204)(42.43) - (36)(174.36)}{(9)(204) - (1,296)}$$

$$= 4.40$$

and
$$b = \frac{(9)(174.36) - (36)(42.43)}{(9)(204) - (1,296)}$$

$$= 0.08$$

and
$$r = \frac{(9)(174.36) - (36)(42.43)}{\sqrt{[(9)(204) - (1,296)][(9)(200.40) - (1,800.30)]}}$$

$$= 0.99$$

$$r^2 = (0.99)^2$$

$$= 0.98$$

From values of " a " and " b " equal to 4.40 and 0.08 respectively , the equation for trend projection of future total air freight may be written as :

Year	Air freight , ton.
1968	25,400
1969	28,700
1970	37,600
1971	44,500
1972	50,100
1973	59,000
1974	81,200
1975	99,800
1976	91,600

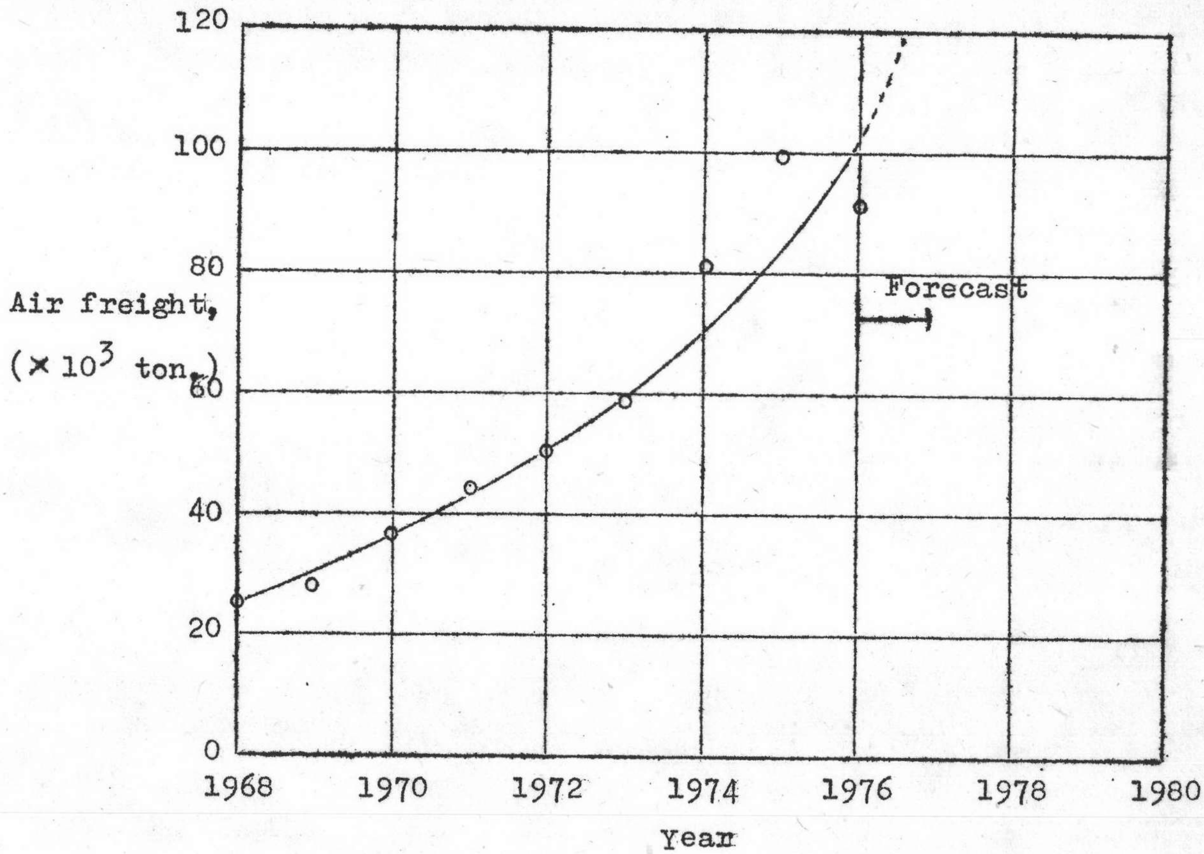


Figure 6.2 Trend curve of total air freight

Remark ; Total air freight including loaded , unloaded and transit air freight

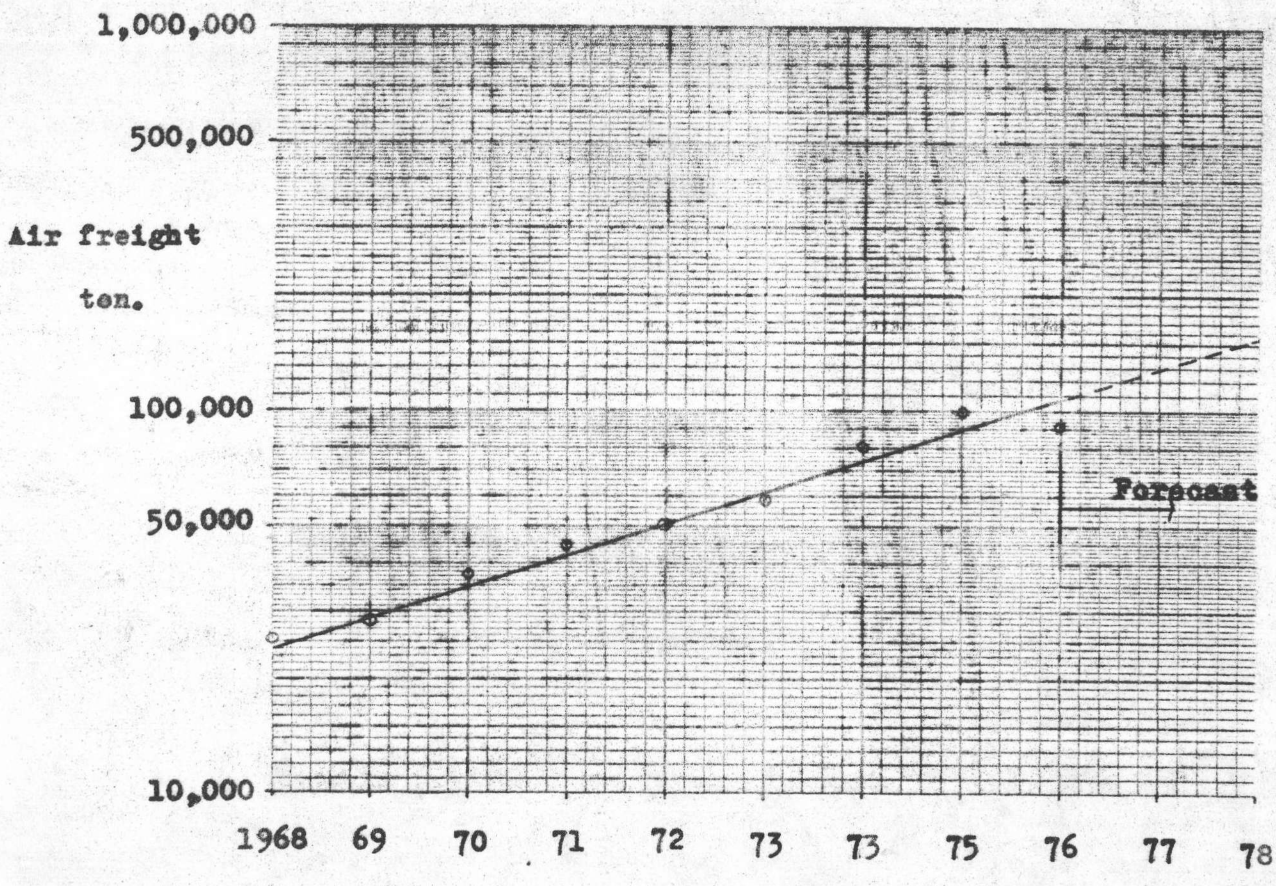


Figure 6.3 Logarithmic trend curve of total air freight

Table 6.1 Determination of trend projection of total air freight

Year	Year x	Air freight , ton. y	log y or $\hat{y}$	$x\hat{y}$	x^2	$\hat{y}^2$
1968	0	25,400	4.40	0	0	19.36
1969	1	28,700	4.46	4.46	1	19.89
1970	2	37,600	4.58	9.16	4	20.98
1971	3	44,500	4.65	13.95	9	21.62
1972	4	50,100	4.70	18.80	16	22.09
1973	5	59,000	4.77	23.85	25	22.75
1974	6	81,200	4.91	29.46	36	24.11
1975	7	99,800	5.00	35.00	49	25.00
1976	8	91,600	4.96	39.68	64	24.60
Total	36	517,900	42.43	174.36	204	200.40

$$\log y = 4.40 + 0.08x$$

and the determination for values of " y " or air freight volumes in the future are as indicated in Table 6.2 . Trend curve of future total air freight at Bangkok International Airport from such determination is shown in Figure 6.4 which it indicated that in 1986 , the volume of total air freight here will climb up to be 691,000 tonnes or about seven times of that in the present , this is quite a problem .

b. Total international air freight

From recorded data , values of total international air freight are plotted as shown in Figure 6.5 for ordinary linear scale and in Figure 6.6 for linear-logarithmic scale . This trend curve obviously shows the shape of exponential curve like that of total air freight and the same equation to determine future total international air freight , $y = a + bx$, is also used . From Table 6.3 , we find

$$\Sigma x = 36 , \quad (\Sigma x)^2 = 1,296$$

$$\Sigma \hat{y} = 40.08 , \quad (\Sigma y)^2 = 1,606.41$$

$$\Sigma x\hat{y} = 165.47 , \quad \Sigma x^2 = 204$$

$$n = 9 , \quad \Sigma y^2 = 178.93$$

Then ,

$$a = \frac{(204)(40.08) - (36)(165.47)}{(9)(204) - (1,296)}$$

$$= 4.11$$

Table 6.2 Determination of trend projection of future total air freight

Year	x	0.08x	log y = 4.40 + 0.08x	y
1977	9	0.72	5.12	132,000
1978	10	0.80	5.20	158,000
1979	11	0.88	5.28	190,000
1980	12	0.96	5.36	229,000
1981	13	1.04	5.44	275,000
1982	14	1.12	5.52	331,000
1983	15	1.20	5.60	398,000
1984	16	1.28	5.68	478,000
1985	17	1.36	5.76	575,000
1986	18	1.44	5.84	691,000

Year	Air freight , ton.
1977	132,000
1978	158,000
1979	190,000
1980	229,000
1981	275,000
1982	331,000
1983	398,000
1984	478,000
1985	575,000
1986	691,000

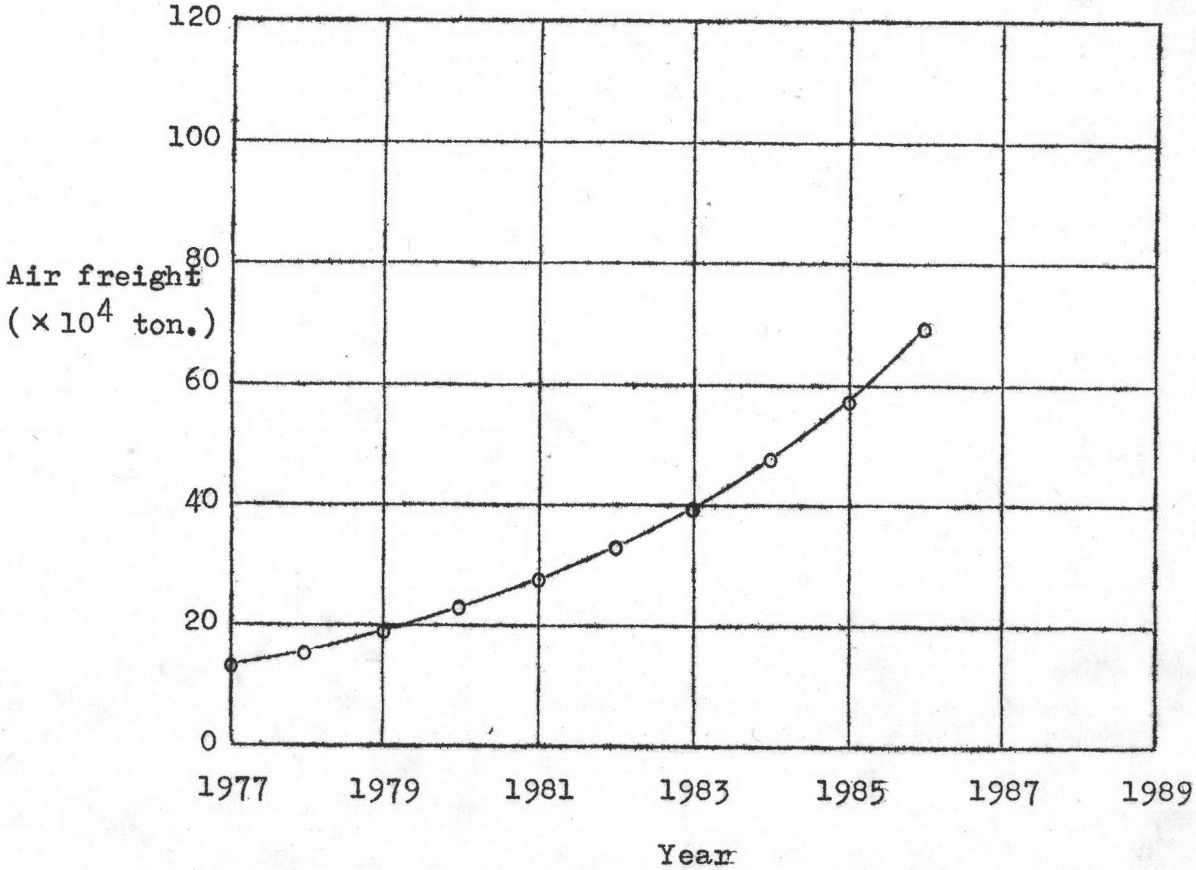


Figure 6.4 Trend curve of future total air freight

$$\text{and} \quad b = \frac{(9)(165.40) - (36)(40.08)}{(9)(204) - (1,296)}$$

$$= 0.09$$

$$\text{and also} \quad r = \frac{(9)(165.47) - (36)(40.08)}{\sqrt{[(9)(204) - (1,296)][(9)(178.93) - (1,606.41)]}}$$

$$= 0.99$$

$$r^2 = (0.99)^2$$

$$= 0.98$$

Then , the equation of $\hat{y} = a + bx$ or $\log y = a + bx$ of total international air freight can be substituted to be as

$$\log y = 4.11 + 0.09x$$

and the determination of future total international air freight from this equation is as shown in Table 6.4 . Future trend of total international air freight seems alike that of total air freight but it is quite a bit more , trend curve as shown in Figure 6.7 indicated that in 1987 the volume of total international air freight will be about eight times of that in the present day . It is quite a question again whether how the existing facilities and buildings here can serve for such volume of air freight .

Year	Air freight , ton.
1968	13,400
1969	14,700
1970	20,200
1971	24,100
1972	25,500
1973	33,700
1974	45,000
1975	51,700

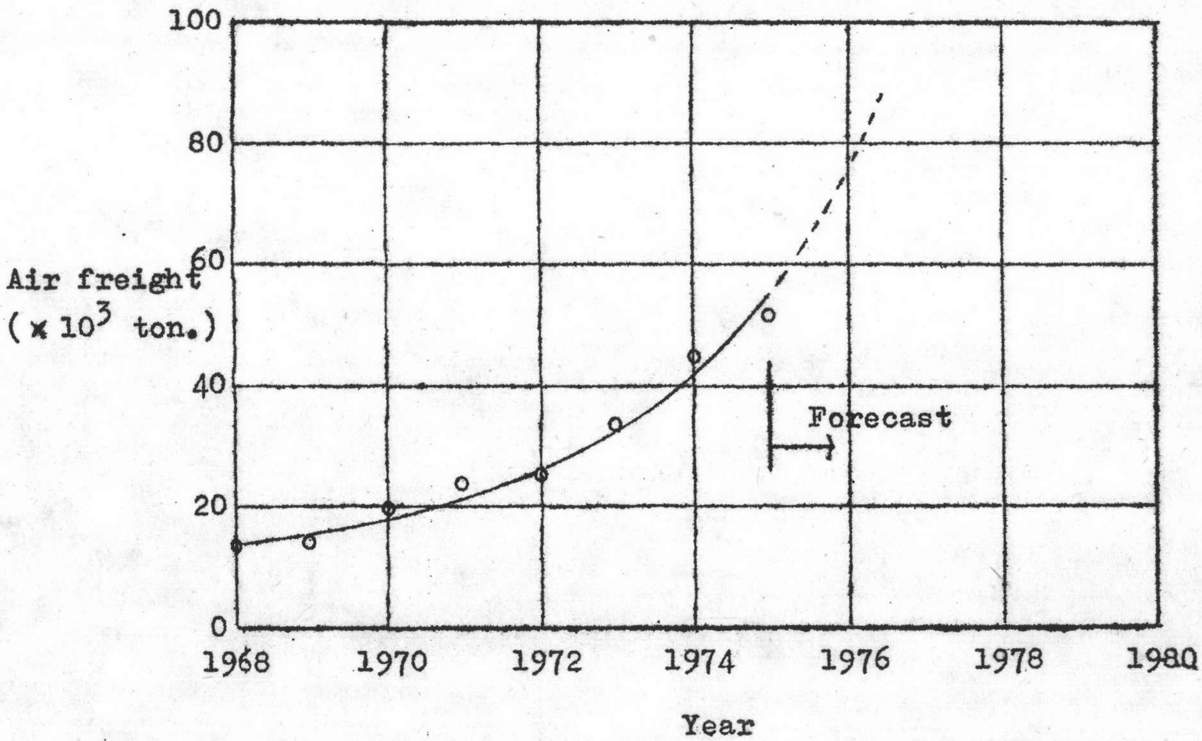


Figure 6.5 Trend curve of total international air freight

Remark ; Total international air freight including loaded and unloaded air freight

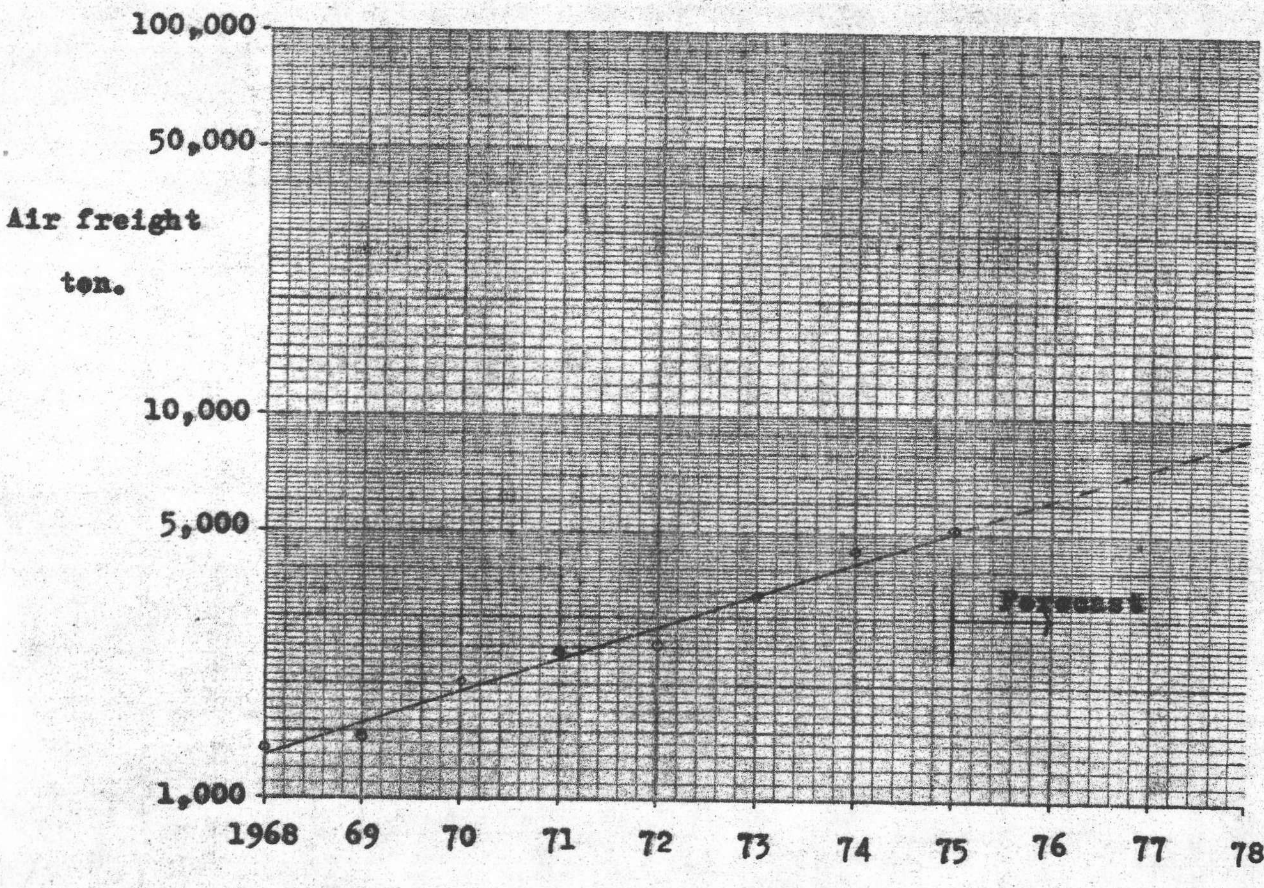


Figure 6.6 Logarithmic trend curve of total international air freight

Table 6.3 Determination of trend projection of total international air freight

Year	Year x	Air freight, ton. y	log y or $\hat{y}$	$x\hat{y}$	x^2	$\hat{y}^2$
1968	0	13,400	4.13	0	0	17.06
1969	1	14,700	4.17	4.17	1	17.39
1970	2	20,200	4.30	8.60	4	18.49
1971	3	24,100	4.38	13.14	9	19.18
1972	4	25,500	4.41	17.64	16	19.45
1973	5	33,700	4.53	22.65	25	20.52
1974	6	45,000	4.65	27.90	36	21.62
1975	7	51,700	4.71	32.97	49	22.18
1976	8	63,500	4.80	38.40	64	23.04
Total	36	291,800	40.08	165.47	204	178.93

Table 6.4 Determination of trend projection of future total international air freight

Year	x	0.09x	log y = 4.41 + 0.09x	y
1977	9	0.81	4.92	83,000
1978	10	0.90	5.01	102,000
1979	11	0.99	5.10	126,000
1980	12	1.08	5.19	155,000
1981	13	1.17	5.28	190,000
1982	14	1.26	5.37	234,000
1983	15	1.35	5.46	288,000
1984	16	1.44	5.55	355,000
1985	17	1.53	5.64	436,000
1986	18	1.62	5.73	536,000

Year	Air freight , ton.
1977	83,000
1978	102,000
1979	126,000
1980	155,000
1981	190,000
1982	234,000
1983	288,000
1984	355,000
1985	436,000
1986	536,000

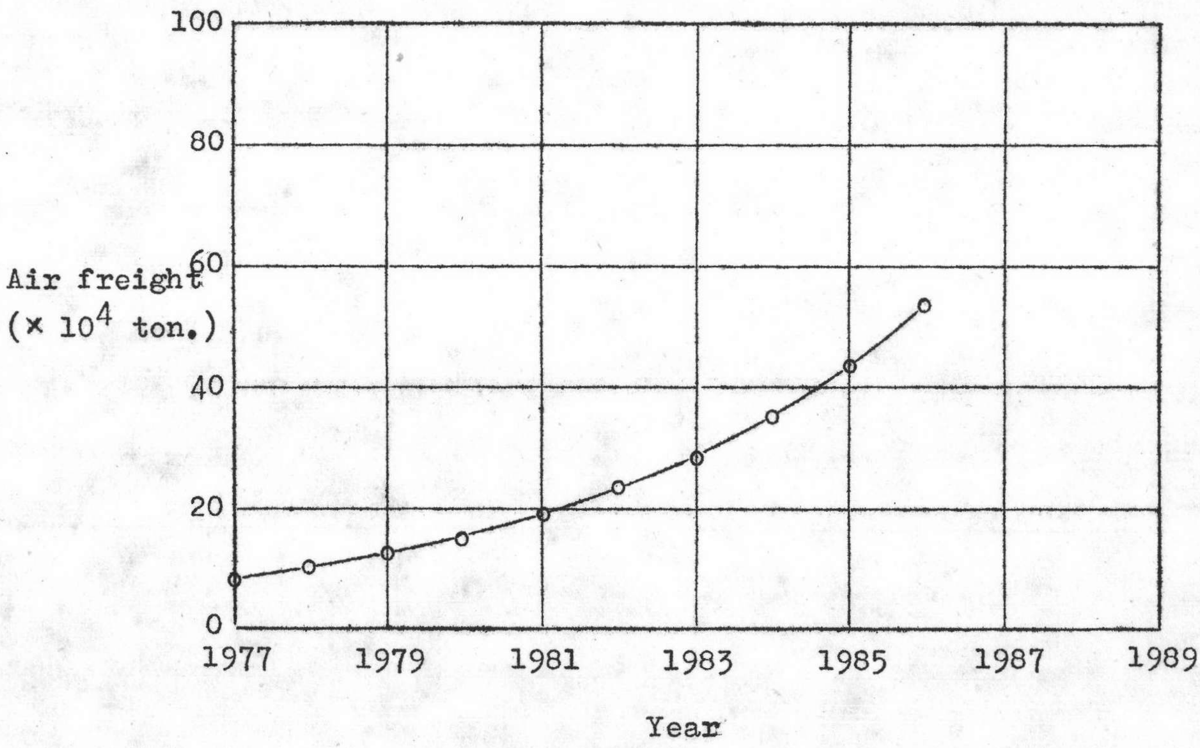


Figure 6.7 Trend curve of future total international air freight

c. Total domestic air freight

From trend curve of total domestic air freight as shown in Figure 6.8 , it shows more fluctuation in term of volume of air freight. The curve actually dips down during the period of 1968 to 1973 . this is according to the result of road improvement all over Thailand since that time . Cargo , even express cargo , could reach the destination through out most of Thailand within 10 hours from Bangkok . But there are some cargo that still require more careful and shorter period in transportation , these cargo then have to go by air . Such commodities are such as newspapers , spare parts of machine tools , medical apparatus or medicines and some special fruits such as strawberry from Chieng Mai . Again , from trend curve it shows that some growth of total domestic air freight occured in the period of 1973 to 1976 . This was according to the increase in number of flight and some new accessible domestic airports in Thailand . Further more , there were many new factories in each part of Thailand , trend projection of future total domestic air freight of Thailand may grow as that indicated in Figure 6.8 . The extending of trend curve during the period of 1973 to 1976 is used for this forecast and this seems to be rather crude , but it is quite a reasonable one for such slope of growth .

d. Total transit air freight

This type of air freight is only according to international air freight since this airport is only the origin or destination of domestic air freight . From Figure 6.9 , trend curve of total transit air

Year	Air freight , ton.
1968	1,280
1969	1,020
1970	1,200
1971	1,120
1972	1,020
1973	850
1974	880
1975	1,000
1976	990

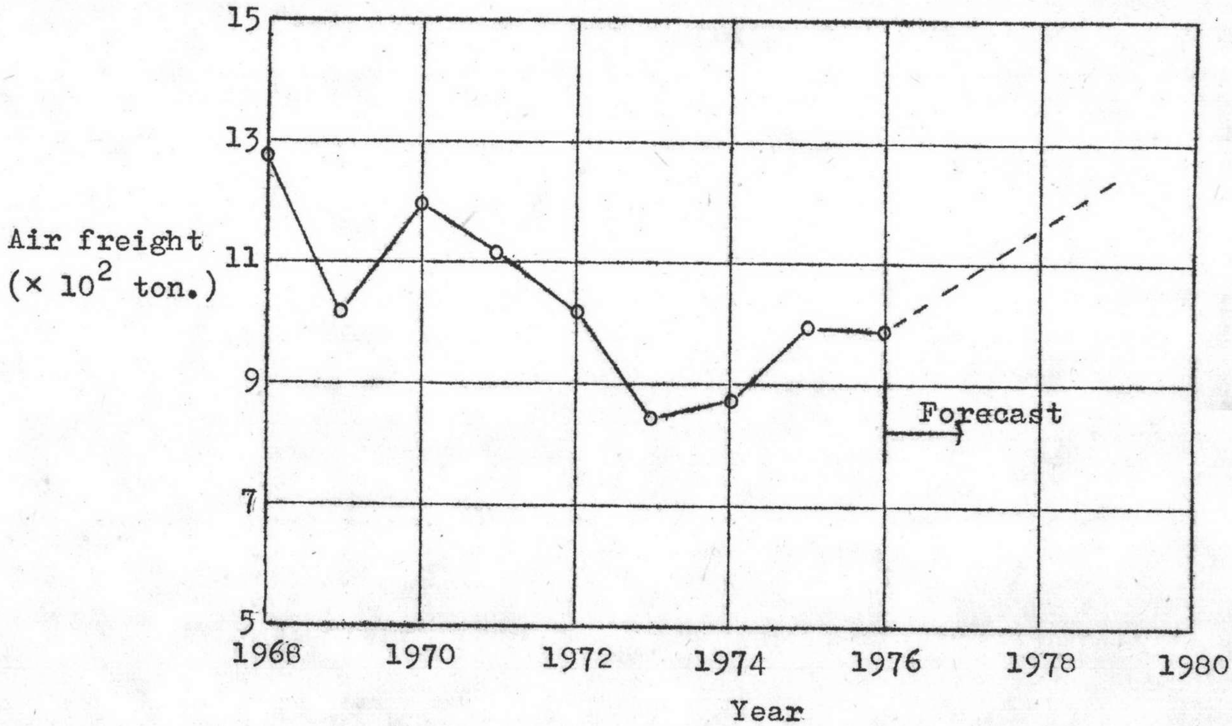


Figure 6.8 Trend curve of total domestic air freight

Remark ; Total domestic air freight including loaded and unloaded air freight

freight is plotted on simple linear scale showing quite shape of exponential curve . Also , Figure 6.10 is the plot of volumes of this type of air freight on a linear-logarithmic graph paper which trend curve occurs nearly as a straight line . From Table 6.5 we find

$$\sum x = 36 , \quad (\sum x)^2 = 1,296$$

$$\sum y = 39.12 , \quad (\sum y)^2 = 1,530.37$$

$$\sum xy = 161.15 , \quad \sum x^2 = 204$$

$$m = 9 , \quad \sum y^2 = 170.43$$

Then ,

$$a = \frac{(204)(39.12) - (36)(161.15)}{(9)(204) - (1,296)}$$

$$= 4.04$$

$$b = \frac{(9)(161.15) - (36)(39.12)}{(9)(204) - (1,296)}$$

$$= 0.08$$

and

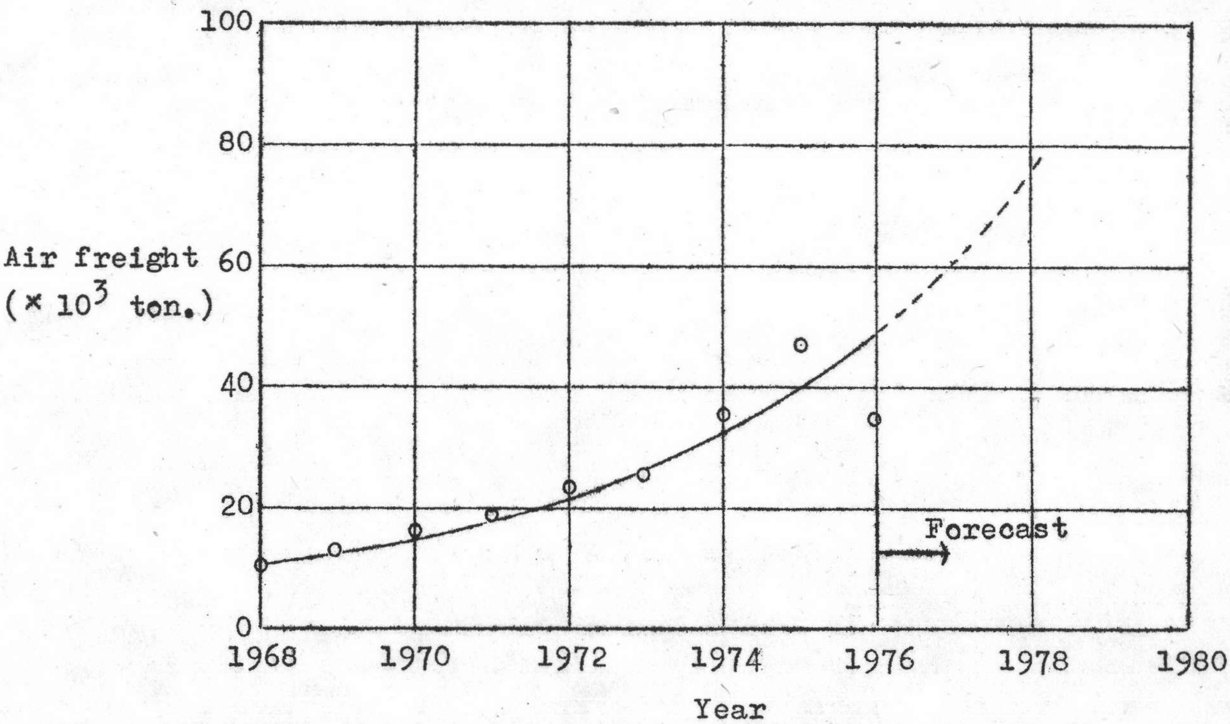
$$r = \frac{(9)(161.15) - (36)(39.12)}{\sqrt{[(9)(204) - (1,296)][(9)(170.43) - (1,530.37)]}}$$

$$= 0.97$$

$$r^2 = (0.97)^2$$

$$= 0.94$$

Year	Air freight , ton.
1968	10,200
1969	12,700
1970	16,000
1971	18,800
1972	23,400
1973	25,700
1974	35,300
1975	47,000
1976	34,600



<u>Figure 6.9</u> Trend curve of total transit air freight

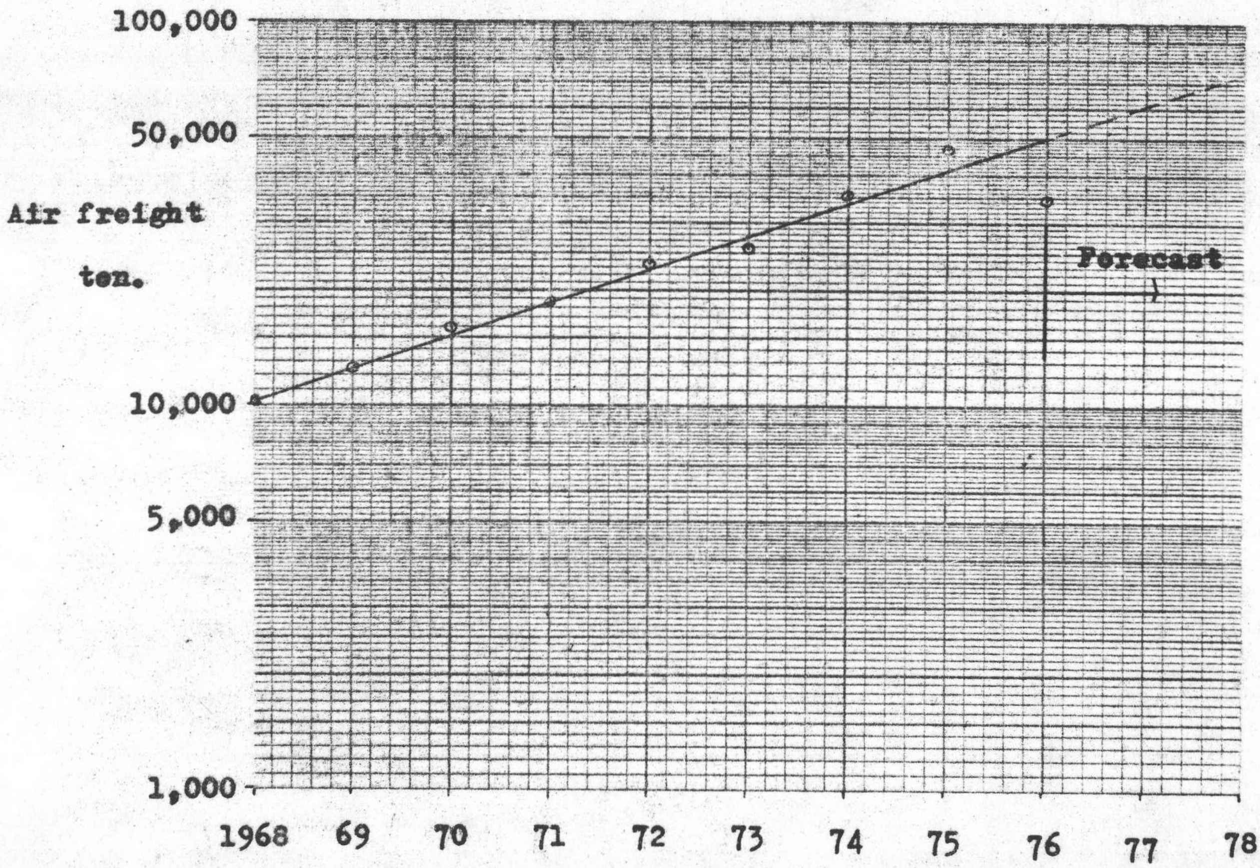


Figure 6.10 Logarithmic trend curve of total transit air freight

<u>Table 6.5</u> Determination of trend projection of total transit air freight

Year	Year x	Air freight , ton. y	log y or $\hat{y}$	xy	x^2	y^2
1968	0	10,200	4.01	0	0	16.08
1969	1	12,700	4.10	4.10	1	16.81
1970	2	16,000	4.20	8.40	4	17.64
1971	3	18,800	4.27	12.81	9	18.32
1972	4	23,400	4.37	17.48	16	19.10
1973	5	25,700	4.41	22.05	25	19.45
1974	6	35,300	4.55	27.30	36	20.70
1975	7	47,000	4.67	32.69	49	21.81
1976	8	34,600	4.54	36.32	64	20.61
Total	36	223,700	39.12	161.15	204	170.42

Table 6.6 Determination of trend projection of future total transit air freight

Year	x	0.08x	log y = 4.40 + 0.08x	y
1977	9	0.72	4.76	57,500
1978	10	0.80	4.84	69,100
1979	11	0.88	4.92	83,000
1980	12	0.96	5.00	100,000
1981	13	1.04	5.08	120,000
1982	14	1.12	5.16	144,000
1983	15	1.20	5.24	174,000
1984	16	1.28	5.32	209,000
1985	17	1.36	5.40	251,000
1986	18	1.44	5.48	302,000

Year	Air freight , ton.
1977	57,500
1978	69,100
1979	83,000
1980	100,000
1981	120,000
1982	144,000
1983	174,000
1984	209,000
1985	251,000
1986	302,000

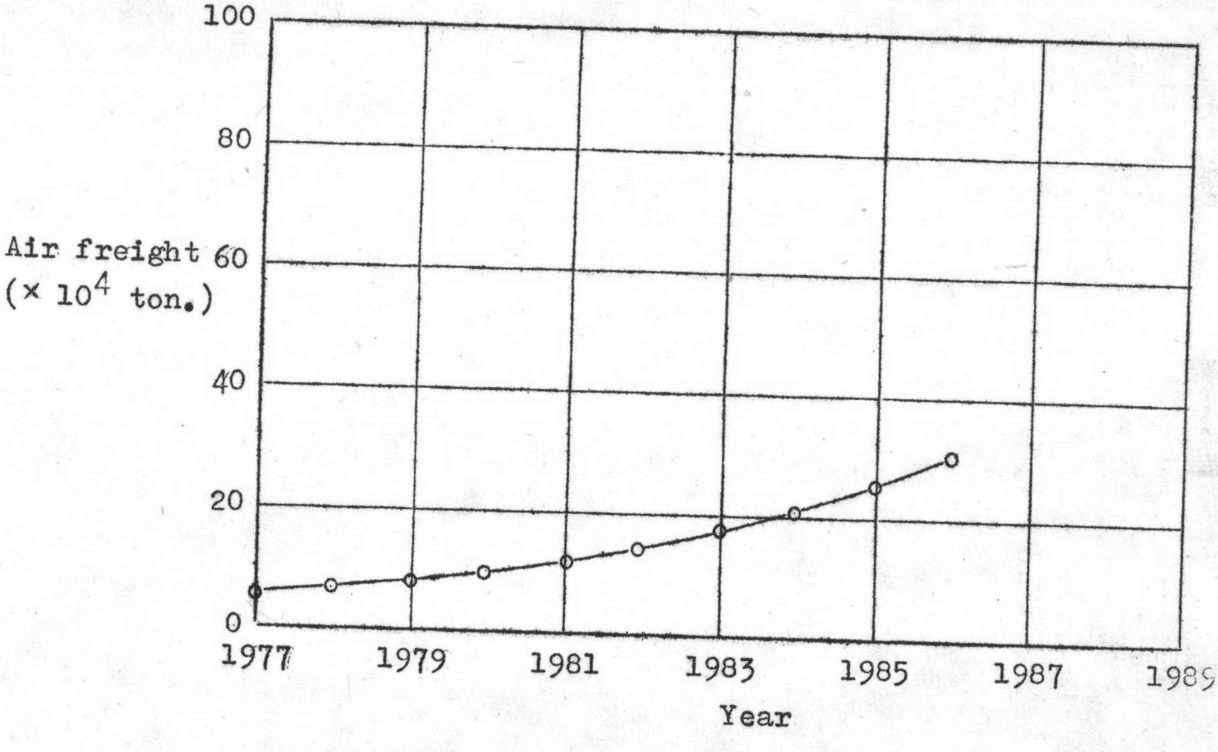


Figure 6.11 Trend projection of future total transit air freight

Then , the equation of $\hat{y}$ = a + bx of total transit air freight is substituted as

$$\hat{y} = 4.04 + 0.08x$$

$$\text{or } \log y = 4.04 + 0.08x$$

and the determination of future total transit air freight from the previous equation is as shown in Table 6.6 . Future volumes of transit airfreight at this international airport from the forecast seem to be quite a serious number , it will grow up to be about nine times that of the present day . But certainly , this number may not occur when much improvement about ground facilities , especially for cargo storages have been done and it would be suddenly begun just at this moment .

Econometric Forecasting

General principles

Air freight traffic forecast arrived by projection of past trends does not explicity take into account the way in which various economic , social and operational conditions affect the traffic development . Where past trends have been smooth and persistent , and there are reasons to expect that the influence of underlying factors on the continued development will not change greatly over the forecast period , trend projection is undoubtedly a reliable method of traffic forecasting . However , if the statistical basis for trend projection is inadequate , if the past traffic development is erratic or if there is a risk that a continuation of the past trend of traffic development is inconsistent with realistic economic , social or technological development , it becomes necessary for the forecaster to study the significance factors underlying the development of the traffic and derive forecasts of traffic from such studies . A technique of doing this , often referred to as econometric forecasting , is to develop mathematical relationship (models) expressing the dependence of traffic development upon the factors concerned , and verify the varidity of these relationships by statistical methods .

So far , econometric forecasting has mostly come into use in developed countries . To some extent this is due to the fact that such countries are usually better equipped to carry out econometric forecasting . However , it also seems that existing econometric forecasting techniques basically tend to be more relevant to the air transport situation in highly developed countries . In a developed country the air transport market is made of a wide spectrum of users of which a large proportion belongs to the country under study . The economic and social conditions in that country are accordingly very pertinent to the development of its traffic . In many developing countries or regions a great proportion of market is represented by foreign nationals (tourists , expatrietes) or foreign shippers while the internal market may consist of relatively few large consumers of air transport services . In such circumstances most existing methods of econometric forecasting would not be readily applicable and trend projection or other approaches may be more fruitful . For Bangkok International Airport or may be said as for Thailand , this country is classified as a developing country with the national economics are on the growth . To use the economic and social conditions of this country to forecast future air freight may not be one reliable method of prediction , but it is a useful guide in forecasting of future air freight .

Whether applied to freight transport , the conduct of an econometric forecast comprises in principle the following four phases :

(A) identification and selection of the factors (independent variables)(1) to be taken into account in forecast the air traffic activity (dependent variable) ;

(B) determination of the type of functional relationship existing between the dependent variable and the independent variables ;

(C) empirical testing of the mathematical expression for the relationship between the dependent and independent variables , including evaluation of coefficients or exponents ;

(D) forecast of future development of the independent variables and subsequent derivation of air freight forecast .

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(1) The term independent variable is used for variables representing factors which affect air freight traffic but unaffected by traffic variable

Variables considered in econometric forecast

In selecting the variables to be taken into account in a particular traffic forecast , the primary criterion is ofcourse that they should be of significant importance in the particular circumstances . Another important criterion is that they should be measurable and capable of being forecast , and that their magnitude should be on record so that their influence on the traffic can be quantified through statistical analysis .

The variables included in econometric model of air freight traffic development may reflect different types of influence on the traffic. Table 6.7 indicates independent variables for types of influence on freight traffic .

For this econometric forecast , two variables considered are :

(a) Exports of Goods & Services

and (b) Gross National Product , GNP

which both types of data are available for the period of 1970 to 1976 . These independent variables are classified by type of influence on traffic as " Size and Spending Ability of Market " .

Table 6.7 Example of independent variables in econometric air freight traffic forecast

Type of influence on traffic	Variable
Size and spending ability of market	(1) Industrial production index (volume or value) (2) Gross national product or gross domestic product (3) Foreign trade for all or selected commodities (by volume or value)
Cost of using air transport services	(1) Published air transport tariffs (2) Average normal fare or rate per ton.-km. (3) Freight rate plus ancillary costs of shipping
Transportation time	(1) Total transport time including airport transportation and waiting time
Service reliability	(1) Percentage of planned flight cancelled

According to Appendix D-3 , the use of variables in the equation are as follow :

x_1	=	Independent Variable
	=	Export of Goods & Services
x_2	=	Independent Variable
	=	Gross National Product , GNP
y	=	Dependent Variable
	=	Volume of total air freight

Forecasting the independent variables and air freight

As the independent variables considered for this econometric forecast are (a) Exports of Goods & Services , x_1 and (b) Gross National Product , x_2 , trend projection of both values are as shown in Figure 6.12 . To forecast these independent variables , as trend projection of both values are quite straight lines of linear growth , the extending of both trend projection is used and the result is as shown in Table 6.8 .

From Appendix D-3 , the following equations are given :

$$b_1\Sigma X_1^2 + b_2\Sigma X_1X_2 = \Sigma X_1Y \qquad \text{...........(7)}$$

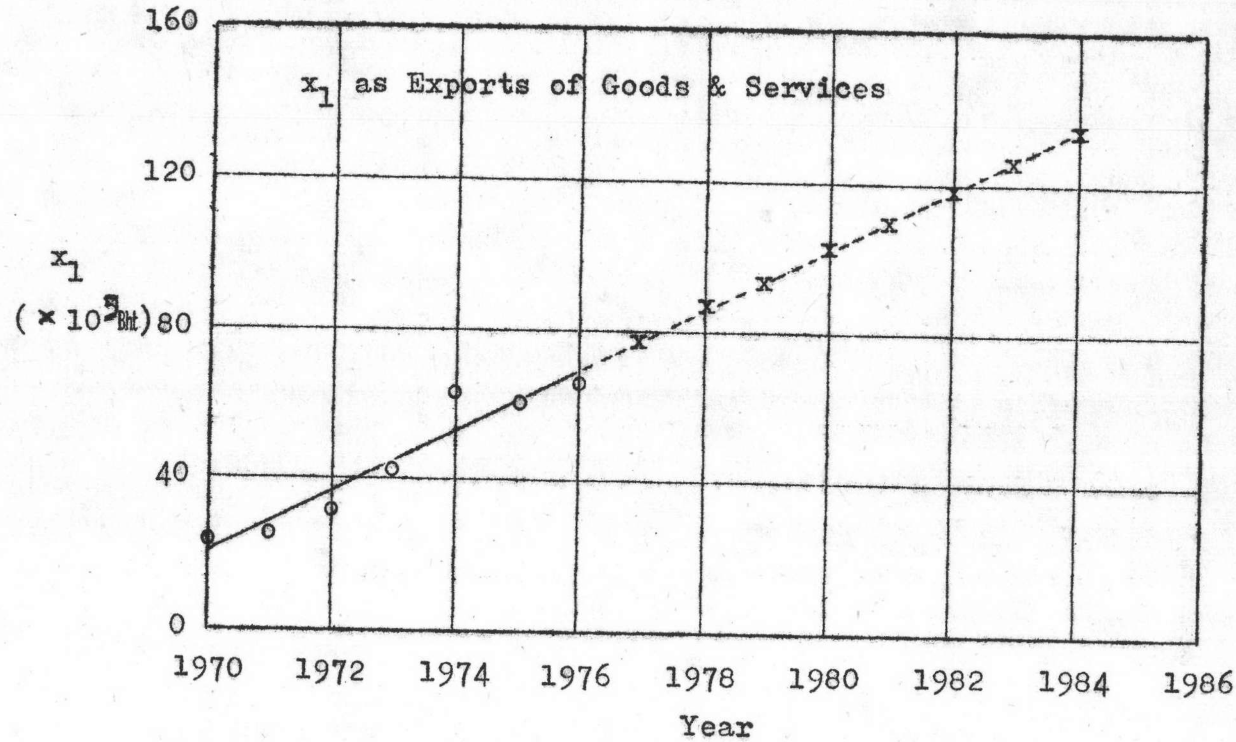
and

$$b_1\Sigma X_1X_2 + b_2\Sigma X_2^2 = \Sigma X_2Y \qquad \text{...........(8)}$$

where $X_1 = x_1 - \bar{x}_1$, $X_2 = x_2 - \bar{x}_2$ and $Y = y - \bar{y}$

Table 6.8 Forecast of independent variables

Year	x_1 , 10^3 million Bht	x_2 , 10^3 , million Bht
1977	76.0	336.0
1978	84.6	404.0
1979	92.8	440.0
1980	101.0	478.0
1981	109.4	516.0
1982	117.8	552.0
1983	126.0	590.0
1984	134.0	630.0



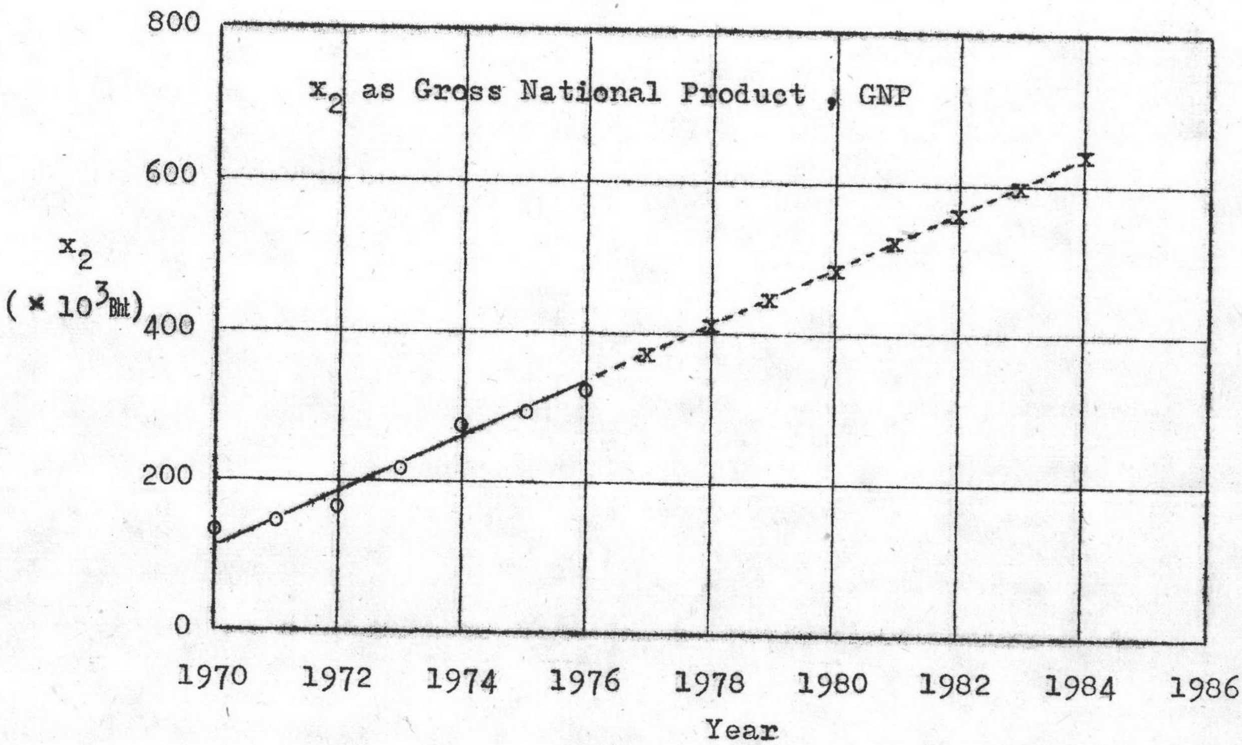


Figure 6.12 Forecast of independent variables

Also , the computational formulas to calculate X_1^2 or X_2^2 and X_1X_2 are as follow :

$$\Sigma X_1^2 = \Sigma (x_1 - \bar{x}_1)^2 = \Sigma x_1^2 - n(\bar{x}_1)^2$$

and $$\Sigma X_1X_2 = \Sigma (x_1 - \bar{x}_1)(x_2 - \bar{x}_2) = \Sigma x_1x_2 - n(\bar{x}_1)(\bar{x}_2)$$

From Table 6.9 , we find

$$\Sigma x_1^2 = 15{,}894.95 \quad , \quad \Sigma x_2^2 = 376{,}289.43$$

$$\bar{x}_1 = 44.5 \quad , \quad \bar{x}_2 = 221.0$$

$$\Sigma x_1x_2 = 77{,}075.96 \quad , \quad \Sigma X_1Y = 2{,}613.05$$

$$\Sigma X_2Y = 10{,}759.00$$

Then , from substituting of these values we get

$$\Sigma X_1^2 = 15{,}894.95 - 7(44.5)^2$$

$$= 2{,}033.20$$

$$\Sigma X_2^2 = 376{,}289.43 - 7(221.0)^2$$

$$= 34{,}402.43$$

and $$\Sigma X_1X_2 = 77{,}075.96 - 7(44.5)(221.0)$$

$$= 8{,}234.46$$

From determined values of ΣX_1^2 , ΣX_2^2 , ΣX_1X_2 , ΣX_1Y and ΣX_2Y , the values of b_1 and b_2 can be found by substituting such values in (7) and (8) as follow :

$$2{,}033.20b_1 + 8{,}234.46b_2 = 2{,}613.05$$

$$8{,}234.46b_1 + 34{,}402.43b_2 = 10{,}759.00$$

Table 6.9 Evaluation of Econometric Forecast of Future Total Air Freight

Year	x_1	x_1^2	x_2	x_2^2	x_1x_2	y	y^2	x_1y	x_2y	Y	Y^2	X_1Y_2	X_2Y_2
1970	22.7	515.29	136.4	18,604.96	3,096.28	37.6	1,413.76	853.52	5,128.64	-28.7	823.69	625.66	2,428.02
1971	25.2	635.04	144.6	20,909.16	3,643.92	44.5	1,980.25	1,121.14	6,434.70	-21.8	475.24	420.74	1,665.52
1972	31.9	1,017.61	164.3	26,994.49	5,241.17	50.1	2,510.01	1,598.19	8,231.43	-16.2	262.44	204.12	918.54
1973	42.5	1,806.25	216.1	46,699.21	9,184.25	59.0	3,481.00	2,507.50	12,749.90	-7.3	53.29	14.60	35.77
1974	62.6	3,918.76	270.0	72,900.00	16,902.00	81.2	6,593.44	5,083.12	21,924.00	14.9	222.01	269.69	730.10
1975	60.6	3,672.36	291.9	85,205.61	17,689.14	99.8	9,960.04	6,047.88	29,131.62	35.5	1,260.25	539.35	2,375.15
1976	65.8	4,329.64	324.0	104,976.00	21,319.20	91.6	8,390.56	6,027.28	29,678.40	25.3	640.09	538.89	2,605.90
Total	311.3	15,894.95	1,547.3	376,289.43	77,075.96	463.8	34,329.06	23,238.89	113,278.69	0	3,737.01	2,613.05	10,759.00
Mean	44.5		221.0			66.2							

Remark ; (1) x_1 and x_2 in 10^3 million baht

(2) y in 10^3 ton.

For simultaneous solution , the top equation is divided by 8,234.46 and the bottom equation by 34,402.43 to eliminate b_2 . The value of b_1 is thus +0.58 . Substituting this value of b_1 back into either equation gives b_2 of +0.17 .

To solve for a the values of b_1 and b_2 are substituted into the first normal equation (eq.4 in Appendix D-3)

$$na + b_1\Sigma x_1 + b_2\Sigma x_2 = \Sigma y$$
$$7a + 0.58(311.3) + 0.17(1,547.3) = 463.8$$

which gives a value for a of +2.89 .

Thus the regression line is :

$$y' = 2.89 + 0.58x_1 + 0.17x_2$$

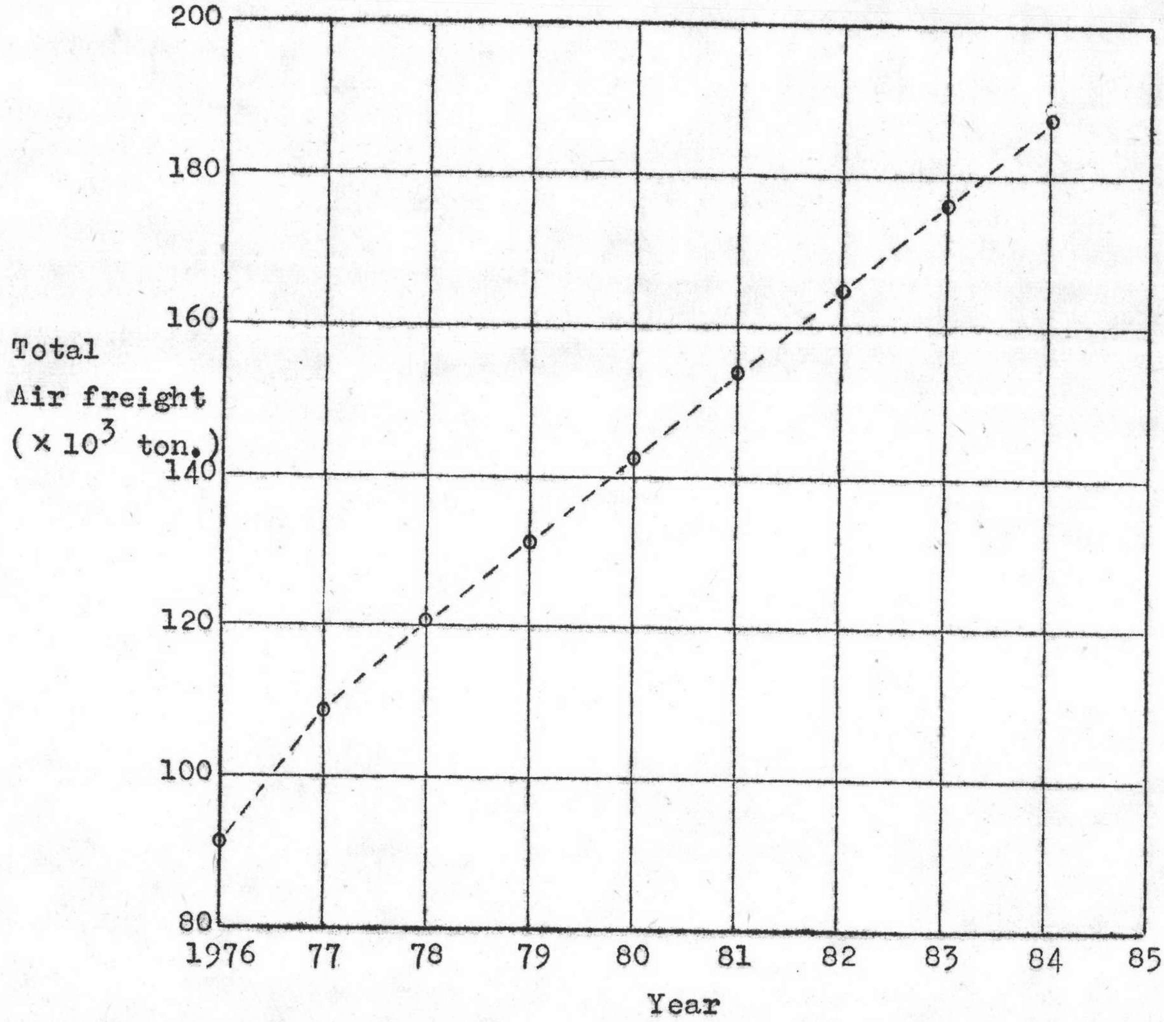
From the equation of regression line and values of forecasted independent variables x_1 and x_2 , values of predicted air freight volume are as determined in Table 6.10 and trend curve is as shown in Figure 6.13 .

To evaluate the coefficient of multiple determination , R^2 of the regression equation to know the closeness of fit of the regression plane to the actual data , the short cut method explained in Section II of Appendix D-3 is used as follow :

$$R^2 = \frac{b_1\Sigma X_1Y + b_2\Sigma X_2Y}{\Sigma Y^2}$$
$$= \frac{0.58(2,613.05) + 0.17(10,759.00)}{3,737.10}$$
$$= 0.8950$$

<u>Table 6.10</u> Forecast of total air freight by econometric method

Year	x_1	$0.58x_1$	x_2	$0.17x_2$	$y' = 2.89 + 0.58x_1 + 0.17x_2$
1977	76.0	44.08	336.0	62.22	109.19
1978	84.6	49.07	404.0	68.68	120.64
1979	92.8	53.82	440.0	74.80	131.51
1980	101.0	58.58	478.0	81.26	142.73
1981	109.4	63.45	516.0	87.72	154.06
1982	117.8	68.32	552.0	93.84	165.05
1983	126.0	73.08	590.0	100.30	176.27
1984	134.0	77.72	630.0	107.10	187.71



<u>Figure 6.13</u> Trend curve of future total air freight by econometric forecasting

Therefore we can say that about 85.5 % of the total deviation in the data has been explained by the regression line

$$y' = 2.89 + 0.58x_1 + 0.17x_2$$

For the partial correlation coefficient , r_{ij} as explained in Section III of Appendix D-3 , the evaluation is

$$r_{12} = \frac{\Sigma x_1 x_2}{\sqrt{\Sigma x_1^2 \Sigma x_2^2}}$$

$$= \frac{23,238.89}{\sqrt{(34,329.06)(15,894.95)}}$$

$$= 0.9948$$

$$r_{13} = \frac{\Sigma x_1 x_3}{\sqrt{\Sigma x_1^2 \Sigma x_3^2}}$$

$$= \frac{113,278.69}{\sqrt{(34,329.06)(376,289.43)}}$$

$$= 0.9967$$

$$r_{23} = \frac{\Sigma x_2 x_3}{\sqrt{\Sigma x_2^2 \Sigma x_3^2}}$$

$$= \frac{77,075.96}{\sqrt{(15,894.95)(376,289.43)}}$$

$$= 0.9966$$

$$r_{12.3} = \frac{r_{12} - r_{13} \cdot r_{23}}{\sqrt{(1 - r_{13}^2)(1 - r_{23}^2)}}$$

$$= \frac{0.9948 - (0.9967)(0.9966)}{\sqrt{[1 - (0.9967)][1 - (0.9966)^2]}}$$

$$= 0.2226$$

From the above results it can be seen that the dependent variable is closely related to each of the independent variables (r_{12} and r_{13}) . The relationship between the dependent variable and first independent variable , holding the second independent constant ($r_{12.3}$) is positive but rather weak .