A MULTI-REGRESSION ANALYSIS OF AIRLINE INDIRECT OPERATING COSTS

N.K. Taneja
R.W. Simpson

This work was performed under Contract C-136-66 for the Office of High Speed Ground Transport Department of Transportation, Washington, D.C.
A multiple regression analysis of domestic and local airline indirect costs was carried out to formulate cost estimating equations for airline indirect costs. Data from CAB and FAA sources covering the years 1962-66 was used, and the costs were broken down into the classification of the uniform system of accounts Form 41, used by the airlines in reporting to the CAB. Thus regression equations were found for 1) annual system expenses in the categories such as Passenger Servicing, Traffic Servicing, Promotion and Sales, General and Administrative, etc. as well as an overall indirect operating cost; and 2) annual station expenses where the Aircraft and Traffic Servicing expenses for individual stations are examined.

A stepwise regression technique is used to select the best combinations of independent variables for the equations. The independent variables were data such as revenue passenger miles, passengers enplaned, revenue aircraft miles, total revenue aircraft departures, etc. The results generally showed that a high degree of correlation could be found between the costs and some combination of these variables.
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I. INTRODUCTION

The total operation costs of an airline can be separated into two major components; the direct operating costs (D.O.C.) and the indirect operating costs (I.O.C.). The direct operating costs are those incurred as a necessary result of, and directly related to, flying the aircraft. The indirect operating costs are those which are not directly related to the operation of the aircraft. In broad terms, the indirect operating costs are incurred to provide operating services on the ground, and the usual overheads associated with administration or management of a business.

The purpose of this study is to try to develop formulae to predict the behavior of and provide a yardstick for the measurement of the indirect operating costs of domestic trunk carriers and local scheduled airlines. The investigation will have a practical application, in that the formulae so developed could be used in conjunction with those of the Air Transport Associations' methods of calculating the direct operating costs. An air transportation management or planner can utilize these formulae for any project requiring estimates of the operating costs given certain traffic and service pattern characteristics of the airline transportation system.

The methodology used was a multiple regression analysis which related various categories of indirect cost to appropriate related measures of activity. The statistical data required was available through airline cost reporting to the Civil Aeronautics Board. The specific data used in
this report covered the years 1962-1966 inclusive, and was available for domestic trunkline, and local service carriers. The analysis results are a series of cost estimating equations which are capable of reasonably accurately estimating the present indirect operating costs of U.S. airline systems.

Two approaches to estimating indirect costs were taken. The first was to treat indirect costs on an annual system basis wherein all categories of annual indirect costs were related to appropriate annual statistics which measured activities of the system. The second approach was to study the largest component of indirect cost, station operating expenses, again on an annual basis but obtaining data for individual stations as opposed to the total airline system.
II. RESULTS

Annual System Expenses

The cost equations for annual system expense by category, and for total indirect operating cost are presented in Table II-1 for domestic airlines and Table II-2 for local airlines. Chapter V may be consulted to find their "goodness of fit" and standard error of estimate. In general, their accuracy is very good, and there are some indications of stability as data years are added which would lend some confidence to predicting at least a few years ahead of current regression equations.

The regressions can be updated as new annual data is received. A trend variable should be added to the independent variables to see if it would aid predictive capabilities. This was not studied in this report. (An incremental model for station costs was tried, but it exhibited no stability from year to year.)

The constant term which has been allowed as a degree of freedom in the regression allows us to make some observations on "economics of scale" for airline indirect costs. A positive constant would mean that as airline activities grew larger, the unit costs become smaller, or economics of scale exist. This is apparently not true for airline costs, since the signs are predominantly negative. For domestic only G & A costs, and Advertising
### TABLE II-1. DOMESTIC CARRIERS INDIRECT COST EQUATIONS ANNUAL SYSTEM EXPENSES

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Account</th>
<th>Constant x 10^{-6}</th>
<th>RPM</th>
<th>RM</th>
<th>RPO</th>
<th>D</th>
<th>E</th>
<th>E/D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger Service</td>
<td>5500</td>
<td>-0.784</td>
<td>0.00549</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aircraft Servicing</td>
<td>6100</td>
<td>-3.55</td>
<td>0.00421</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Traffic Servicing</td>
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<td>37.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Servicing Admin.</td>
<td>6300</td>
<td></td>
<td></td>
<td></td>
<td>2.46</td>
<td>466,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Station Costs</td>
<td>6400</td>
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<td>0.607</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Res. and Sales Costs</td>
<td>6500</td>
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<td>0.0585</td>
<td>0.360</td>
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<tr>
<td>Adv. and Pub. Costs</td>
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<td>0.00172</td>
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</tr>
<tr>
<td>Promotion &amp; Sales</td>
<td>6700</td>
<td>+0.0413</td>
<td>0.00640</td>
<td>0.574</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G and A Costs</td>
<td>6800</td>
<td>+0.073</td>
<td>0.00156</td>
<td>0.0483</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL I.O.C.</td>
<td></td>
<td></td>
<td></td>
<td>-7.20</td>
<td>0.0146</td>
<td>0.645</td>
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</table>

RPM = revenue passenger miles/year, RM = revenue aircraft miles/year, RPO = revenue passenger originations/year, D = aircraft departures/year, E = passenger enplanements/year

### TABLE II-2. LOCAL SERVICE CARRIERS INDIRECT COST EQUATIONS ANNUAL SYSTEM EXPENSES

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Account</th>
<th>Constant x 10^{-6}</th>
<th>RPM</th>
<th>RM</th>
<th>RPO</th>
<th>E</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger Service</td>
<td>5500</td>
<td>-0.128</td>
<td>0.00151</td>
<td>0.0780</td>
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<td>Station Costs</td>
<td>6400</td>
<td>-0.128</td>
<td>0.2610</td>
<td>2.14</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Promotion &amp; Sales</td>
<td>6700</td>
<td>-0.0413</td>
<td>0.00640</td>
<td>0.574</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G and A Costs</td>
<td>6800</td>
<td>+0.073</td>
<td>0.00156</td>
<td>0.0483</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL I.O.C.</td>
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<td></td>
<td>+2.0</td>
<td>0.43</td>
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</table>

RPM = revenue passenger miles/year, RPO = revenue passenger originations/year, RM = revenue aircraft miles/year, E = rev. enplanements/year, R = total transport revenue ($/year)
(or Promotion and Sales) have a positive constant, and it is easy to understand economics of scale in these areas. For the remainder, Passenger Service, Traffic Servicing, Station Costs, and Reservations and Sales, unit costs would seem to be higher either due to increasing complexities of larger scale operations or a desire of larger domestic carriers to offer a higher level of service to the passenger. A similar situation occurs for local carriers except that Promotion and Sales also has a negative sign implying no economics of scale.

Table II-3 shows an application of these cost equations for American Airlines, 1967. The comparison of actual and calculated costs is reasonably good for these rather simple equations.

Annual Station Expenses

The cost equations suggested for estimating local station expenses are given below for domestics and local airlines. The cost/enplanement is indicated by the E coefficient and shows that domestics spend about twice as much per enplanement as the locals do. This seems to be a matter of managerial policy since station costs seem to vary widely within a given airline.

**Station Costs - Domestic**

Cost ($/year) = -371,200 + 4.94 E + 13593 (E/D)

**Station Costs - Local**

Cost ($/year) = 30,400 + 2.84 E
<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Cost Calculation</th>
<th>Calc. Cost (Millions)</th>
<th>Actual Cost (Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger Service</td>
<td>$-0.785 \times 10^6 + 0.00549 \times (13209) \times 10^6 = 73.3$</td>
<td></td>
<td>76.4</td>
</tr>
<tr>
<td>Aircraft &amp; Traffic Servicing</td>
<td>$-5.74 \times 10^6 + 0.607 \times (226.6) \times 10^6 = 132.3$</td>
<td></td>
<td>144.1</td>
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<tr>
<td>(Station Costs)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Promotion and Sales</td>
<td>$0.0413 \times 10^6 + 0.0064 \times (13209) \times 10^6 + 0.574 \times (16.0) \times 10^6 = 93.7$</td>
<td></td>
<td>87.8</td>
</tr>
<tr>
<td>General and Admin.</td>
<td>$0.073 \times 10^6 + 0.00156 \times (13209) \times 10^6 + 0.0483 \times (226.6) \times 10^6 = 31.6$</td>
<td></td>
<td>29.8</td>
</tr>
<tr>
<td>TOTAL I.O.C. (less depreciation)</td>
<td>$-7.20 \times 10^6 + 0.0146 \times (13209) \times 10^6 + 0.645 \times (226.6) \times 10^6 = 332.3$</td>
<td></td>
<td>338.2</td>
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DISCUSSION

The purpose of this investigation was to produce methods of estimating indirect costs for air transportation systems, and to identify good measures of activity associated with each category of cost. The cost estimating equations produced for domestics and locals show that good equations can be produced with relatively simple equations using rather straightforward measures of activity. The differences between locals and domestics emphasizes that these costs are subject to managerial policies and decisions, and that there can be no direct application of these cost estimates to other forms of air transportation. Scattered data from helicopter and air taxi carriers, as well as intercity bus operations confirm this point. However, the same measures, or the same form of cost equation for the various categories may well be used with a regression performed on the available data to produce the best coefficients.

The equations are based on data covering a five year period 1962-66, and can be used to predict costs during the next few years. Additional data can be added as time goes on to keep them up to date and a trend variable added. However, the future introduction of new methods of automation in the form of automatic ticketing, monthly billings, etc. would probably invalidate such cost categories as Traffic Handling or Reservations and Sales, and a new set of data and an analysis on it would be necessary. Even the introduction of large size aircraft might cause new methods
in this area and thereby invalidate the use of these equations in those categories.

This study has grouped airlines into domestic and locals. An individual airline could produce similar analyses for its operations, and perhaps break the costs and activities into different groupings which require different data than that reported to the CAB. It would be interesting to see a set of cost equations for the individual airline stations in terms of their activities. From the data available, it does not seem possible to discover if the station costs for a short haul, commuter or shuttle type of air system are different although one suspects this to be true. The answer is hidden behind levels of service offered by the airlines in individual markets where airline competition exists. Properly phrased, the question probably should be; for a given level of service at individual stations in terms of waiting times for ticket, information, or baggage service, what is the cost of this station operation and how does it vary with the scale of station operations?

Despite the wealth of statistical data, and the existence of sophisticated computer methods of analyzing the data, cost estimation remains an art, not a science. Yet the prediction of future costs of operation for transportation systems of all modes is a vital, necessary part of planning for future transport systems.
III. THE AVAILABLE DATA

The source of data for this study are the Form 41 Reports of the Uniform System of Accounts for Air Carriers as submitted by the airlines to the Civil Aeronautics Board. These reports contain detailed financial information and traffic and operating statistics. The data was collected to cover a recent five year period from 1962 to 1966 inclusive. Twenty-four U.S. airlines are considered: eleven domestic trunks, and thirteen local airlines.

The carriers included in the two groups are:

<table>
<thead>
<tr>
<th>Domestic Trunk Carriers</th>
<th>Local Service Carriers</th>
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<td>Tran-Texas Airways, Inc.</td>
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<td>West Coast Airlines, Inc.</td>
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The total indirect operating costs are divided into eight categories for the domestic trunk carriers and five
categories for the local carriers.

**Domestic Trunk Carriers**

Account 5500 - Passenger Service  
Account 6100 - Aircraft Servicing  
Account 6200 - Traffic Servicing  
Account 6300 - Servicing Administration  
Account 6500 - Reservation and Sales  
Account 6600 - Advertising and Publicity  
Account 6800 - General and Administrative  
Account 7000 - Depreciation and Amortization of Ground Property and Equipment

**Local Carriers**

Account 5500 - Passenger Service  
Account 6400 - Aircraft and Traffic Servicing  
Account 6700 - Promotion and Sales  
Account 6800 - General Administrative  
Account 7000 - Depreciation and Amortization of Ground Property and Equipment

It is important to understand the way the categories are formed for the two groups of carriers. For local carriers Account 6400 is equivalent to the sum of Accounts 6100, 6200 and 6300 for the domestic trunks and Account 6700 is equivalent to the sum of Accounts 6500 and 6600. Accounts 5500, 6800 and 7000 have the same meaning in both groups of carriers.
Below is a brief description of the functional classification as used by the Civil Aeronautics Board in their Uniform System of Accounts and Reports.

**Account 5500 - Passenger Service**

This function includes all expenses chargeable directly to activities contributing to the comfort, safety and convenience of passengers while in flight and when flights are interrupted. It does not include expenses incurred in enplaning and deplaning passengers, or in securing and selling passenger transportation and caring for passengers prior to entering a flight status.

**Account 6100 - Aircraft Servicing**

This function includes the compensation of ground personnel and other expenses incurred on the ground incident to the protection and control of the in-flight movement of the aircraft; scheduling or preparing aircraft operational crews for flight assignment; landing and parking aircraft; visual inspection; routine checking, servicing and fueling of aircraft; and other expenses incurred on the ground incident to readying for arrival and take-off of aircraft.

**Account 6200 - Traffic Servicing**

This function includes the compensation of ground personnel and other expenses incurred on the ground incident to handling traffic of all types and classes on the
ground subsequent to the issuance of documents establishing the air carriers responsibility to provide air transportation. Expenses attributable to the operation of airport traffic offices are also included in this category; expenses attributable to reservation centres are not included. It includes expenses incurred in both enplaning and deplaning traffic as well as expenses incurred in preparation for enplanement and all expenses subsequent to deplanement. This function also includes costs incurred in handling and protecting all non-passenger traffic while in flight.

Account 6300 - Servicing Administration

This function includes expenses of a general nature incurred in performing supervisory or administrative activities relating solely and in common to functions 6100 Aircraft Servicing and 6200 Traffic Servicing. This function does not include expenses of a general administrative character and of significant amount regularly contributing to operating functions generally. Such expenses are included in function 6800 General and Administrative.

Account 6500 - Reservation and Sales

This function includes expenses incident to direct sales solicitation, documenting sales, controlling and arranging or confirming aircraft space sold, and in developing tariffs and schedules for publication. It also includes expenses attributable to the operation of city traffic offices.
Account 6600 - Advertising and Publicity

This function includes expenses incurred in creating public preference for air carrier and its services; stimulating development of the air transport market; and promoting the air carrier or developing air transportation generally.

Account 6800 - General and Administrative

This function includes expenses of a general corporate nature and expenses incurred in performing activities which contribute to more than a single operating function such as general financial accounting activities, purchasing activities, representation of law, and other general operational administration, which are not directly applicable to a particular function. Also, expenses of a general administrative character and of significant amount regularly contributing to operating functions, are included in this function.

Account 7000 - Depreciation and Amortization

This function includes all charges to expense to record losses suffered through current exhaustion of the service-ability of property and equipment due to wear and tear from use and the action of time and the elements, which are not replaced by current repairs, as well as losses in service-ability occasioned by obsolescence, supersession, discoveries
change in popular demand or action by public authority. It also includes charges for the amortization of capitalized development and pre-operating costs, and other intangible assets applicable to the performance of air transportation.

This account is not investigated in this report for two reasons. First, the activities which the airlines associate with this cost account are not sharply defined. Secondly, the total expense in this category is very small as compared to the other categories. See Figures 1 and 2.

The following two functions are only applicable to the local carriers. For local carriers, functional account 6400 replaces 6100, 6200, and 6300 as defined for domestic trunks and functional account 6700 replaces 6500 and 6600.

Account 6400 - Aircraft and Traffic Servicing

This function includes the compensation of ground personnel and other expenses incurred on the ground incident to the protection and control of the in-flight movement of aircraft, scheduling and preparing aircraft operational crews for flight assignment, handling and servicing aircraft while in line operation, servicing and handling traffic on the ground, subsequent to the issuance of documents establishing the air carriers' responsibility to provide air transportation, and in-flight expenses of handling and protecting all non-passenger traffic including passenger baggage.
FIGURE 1. DOMESTIC AIRLINES 1962-1965
The function includes only those aircraft servicing and cleaning expenses which are incurred as in incidental routine during the normal productive use of aircraft in line operations.

Further, for the purpose of this system of accounts, expenses attributable to the operation of airport traffic offices, excluding reservation centres, are included in this function.

Account 6700 – Promotion and Sales

This function includes expenses incurred in creating public preference for the air carrier and its services; stimulating the development of the air transport market; and promoting the air carrier or developing air transportation generally. It includes compensation of personnel and other expenses incident to documenting sales; expenses incident to controlling and arranging or confirming aircraft space for traffic sold; expenses incurred in direct sales solicitation and selling of aircraft space; and expenses incurred in developing tariffs and schedules for publication.

Expenses attributable to the operation of reservation or aircraft space control centres are included in this function, regardless of the location at which incurred.

Figures 1 and 2 indicate the relative amount of money spent by domestic and local airlines in these categories for recent years. The percentage breakdown of these costs
FIGURE 2  LOCAL AIRLINES 1962-1965
INDIRECT OPERATING EXPENSE
by component within each category are given in the section dealing with that category of cost. In this report we are especially interested in station operating costs, or station costs which are taken to be Account 6400 for local airlines, and the sum of Accounts 6100, 6200 and 6300 for domestic airlines. Station costs are roughly equal to the remaining indirect costs and can be related to measures of the ground operations of the system in terms of passengers handled, or aircraft departures.

For the studies of local station expense, references were made to CAB Schedule P - 9.2 of the Form 41 reports entitled "Distribution of Ground Servicing Expenses by Geographic Location". This gave local station employees and a breakdown of expenses into Aircraft Servicing, Traffic Servicing, and Servicing Administration. Measures of activity of the various airlines at a given station were taken from an FAA publication - "Airport Activity Statistics of Certified Route Air Carriers" which is based on CAB data. The number of departures, enplanements, and tons of cargo loaded were obtained from this source for a given airline, airport and year.

The following list identifies the airline stations selected for study.
### Medium Stations

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IV. THE TECHNIQUES OF ANALYSIS

The purpose of this study is to investigate certain economic hypotheses about cost-output relationships through empirical testing. These hypotheses are cost estimating equations which explain the variation of the indirect operating costs of an airline as the level of output changes. In general the airlines produce many different outputs. They provide, for example, first class passenger service, coach passenger service, scheduled cargo service, non-scheduled service and various charter services. It would not be meaningful to analyze the total indirect operating costs directly with respect to all of these measures. Keeping this in mind, the total indirect operating costs were divided into various categories (described in detail later) so as to relate them to a relatively small number of output variables.

The economic analysis on the theory of cost usually involves two kinds of cost-output variation. The first is the so called "short term" in which the airline's actions are subject to the constraint that certain factors of production cannot be quickly changed. No such constraint applies to the second type, the so called "long term" in which elements such as investment, organization, equipment and so on, can be varied freely to achieve new levels of output.

We shall consider the cost-output relations on the basis of "long-term" activity, although it is debatable as to whether a five year period can be considered "long-term" in the airline industry. Since no major changes took place
in the period considered, for our purposes we will consider this period as "long-term". It is true that costs will fluctuate for example in a period between schedule changes in an airline. These fluctuations however are small and tend to occur frequently. As long as significant changes, such as those which would occur when supersonic aircraft come into operation or the introduction of a new computer system do not occur, we are justified in considering our observation period as "long-term", and typical of the present airline industry.

It can be seen in the sketch that in the region when the level of output, $x$, lies between "b" and "a", the cost increase is the same for a given output increase. On the "long-term" basis it is justifiable to say that most of the airlines considered would operate at a level of output lying in the region $a$-$b$. Marginal cost, defined as the change in
- cost per unit change in output, is relatively constant in the region a-b.

In general we will consider the curve between "a" and "b" to be linear. The approximated straight line will intersect the "cost" axis at $C_2$, referred to as the fixed costs. In the empirical study $C_2$ provides a good approximation to $C_1$, known as the threshold costs, i.e. costs for producing the minimum output for the constant slope region of the cost curve.

A linear approximation may be valuable even when we know that a linear relationship cannot be true. For example in the sketch the relationship is obviously not linear for the range $0 \leq X \leq b$. However if we are interested primarily in the range $a \leq X \leq b$, a straight line relationship evaluated from observations in this range might provide a perfectly adequate representation of the function in this range. The relationship thus fitted would not apply to values of $X$ outside this restricted range, and could not be used with confidence for predictive purposes outside this range.

Similar arguments apply when more than one output or independent variables are involved. If for example we wish to examine the way in which a response $Y$ depends on variables $X_1$, $X_2$, ... $X_k$, we determine regression equations from data which "cover" certain areas of the "X-Space". If we were to pick a point $X_o = (X_{10}', X_{20}', ... X_{k0}')$ which lies outside the regions covered by the original
data, then while we can mathematically obtain a predicted, value $\bar{Y}(X_o)$ for the response at the point $X_o$, it must be realized that the reliance on such a prediction is extremely dangerous and becomes even more dangerous the further $X_o$ lies from the original data set.

In this section we briefly discuss the two procedures employed to investigate the variation of the cost categories defined previously. Each functional cost is examined in detail to see if it relates to any of the airline activities. Two approaches were taken, the graphical and linear regression techniques.

The Preliminary Graphical Analysis

In the detailed graphical examination each cost category is plotted against various output variables taken one at a time. The main object of the graphical investigation is to identify the variables which are most directly related to the costs. Some variables are seen to have definite relationship with the cost category, others merely show a trend and some offer no explanation at all. Only those variables which are seen to bear a relationship with the cost category or show a definite trend, are finally used in the regression analysis. No single line fits the points precisely, yet the points display a visual tendency to lie along a straight line indicating some underlying law of association, disturbed by idiosyncrasies in individual cases.

Because it is important to know which variables do not adequately explain a given cost category, all variables
tested are listed at the beginning of each appendix.

The Multiple Regression Analysis

Multiple regression is used in data analysis to obtain the best fit of a set of observations of independent and dependent variables in an equation of the form

\[ y = b_0 + b_1X_1 + b_2X_2 + \ldots + b_nX_n \]

where \( y \) is the dependent variable and \( X_1, X_2, \ldots, X_n \) are the independent variables. Coefficients \( b_0, b_1, \ldots, b_n \) are to be determined.

The observed value of \( y \), say \( y_i \), for the \( i \)th observation, differs from the theoretical by some error term \( e_i \). The method involves estimating the values of the coefficients \( b_0, b_1, \ldots, b_n \), given the observed values of \( y_i \) and \( X_{i1}, X_{i2}, \ldots, X_{in} \).

Hence we can assume

\[ y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots + \beta_n X_{in} + e_i \]

where the \( \beta \)'s are the estimates of \( b \)'s and \( e_i \) is the difference between the observed and the estimated value of \( y \) for the \( i \)th observation. The aim here is to find the coefficients which minimize the sum of the squares of \( e_i \). Use is made of the computer to perform the calculations and determine the coefficients.
The multiple regression technique manipulates the statistical data and produces the appropriate relationship between the cost and its relevant variables. The program, described below, carries this out in a well defined step-by-step process which introduces or deletes variables in accordance with the prescribed criteria, in order to find the expression that fits best with the data. Deviations from the regression line will be expected since we are only using a limited number of variables to describe the cost.

In the stepwise procedure, intermediate results give valuable statistical information at each step in the calculation. Basically we obtain a number of intermediate regression equations as well as the complete multiple regression equation. These equations are obtained by adding one variable at a time and thus give the following intermediate equations,

\[
\begin{align*}
    y &= b_0 + b_1 x_1 \\
    y &= b_0' + b_1' x_1 + b_2' x_2 \\
    y &= b_0'' + b_1'' x_1 + b_2'' x_2 + b_3'' x_3
\end{align*}
\]

The variable added is the one which makes the greatest improvement in "goodness of fit." The coefficients represent the best values when the equation is fitted to the specified variables.

The beauty of the stepwise procedure is 1) a variable may be indicated to be significant in any early stage and
thus enter the equation, and 2) after several other variables are added to the regression equation, the initial variable may be indicated to be insignificant, in which case it will be removed from the regression equation before adding an additional variable. Thus the final, best fit equation includes only the significant variables.

The BMDO2R Stepwise Regression Program

This program (Bio Medical Computer Program BMDO2R) developed by the University of California and modified to a suitable form to be used on the MIT 7094, computes a sequence of multiple linear regression equations in a stepwise manner. At each step one variable is added to the regression equation. The variable added is the one which makes the greatest reduction in the error sum of squares. A line or a plane is found such that the sum of the squared vertical distances between the data values and the regression line or plane are minimized. Equivalently it is the variable which has the highest partial correlation with the cost or dependent variable partialed on the output or independent variables which have already been added, and equivalently it is the variable which, if it were added would have the highest F value.

There are two F values. "F-to-enter" indicates the improvement that the addition of a relevant variable to the regression equation, would make to reduce the residual error. The "F-to-remove" is an indication that the variable
under consideration is not contributing very much to increasing the goodness of the fit. In this analysis the values of "F-to-enter and F-to-remove" were chosen to be 0.500 and 0.300 respectively, meaning that if a variable which does not appear in the equation, has an F-to-enter value of 0.500 or greater, then it will be eligible to enter the equation. The variable with the highest F-to-enter value will be chosen first. Conversely if a variable already in the equation, gets an F-to-remove value of 0.300 or lower at some step, then it will be removed from the regression equation in the next step.

One other feature of the program is that variables, if desired, can be forced into the regression equation. They will automatically be removed when their F values become too low. "Forcing" in the regression equation, a particular value, can be achieved by using a special card, and punching a priority number on it ranging from 3 to 9. The variable associated with the highest number on this special card will be "forced" in the regression equation first and will remain in the equation until the F-to-remove value falls below 0.300.

Also in the output, we receive two other statistics. These provide us with information which is useful in judging the "goodness" of fit. One gives us the standard deviation which measures the amount of residual error between the observed points and the computed regression line. The other called Multiple R, is the multiple correlation coefficient and has value ranging from zero to unity.
The MIT (TSP) Program

TSP is a program for statistical analysis of time series data by ordinary least squares and two stage least squares analysis, using an IBM 1620 II computer in the Sloan School of Management. The program is organized to handle a large volume of data (one can load an annual GNP series from 1233 B.C. to the present!). The program is not stepwise regression, but it does have a flexible method of generating new variables from functional representations of basic input variables. Thus, besides a linear equation relating cost to output variables, one can use a logarithmic linear form, or can create squares, sums, combinations of the output variables, etc., to be used in a new form of cost estimating relationship. This became attractive in studying local station costs, and this program was used in various ways as described in Appendix B.

Problems in Regression Analysis

1. The problem of missing a variable is an important one. If an important variable is left out then there will be a wide error range in the estimated value of the dependent variable, which in our case is the cost. This is due to the variation in the standard error. The estimate of the regression coefficients will, however, be unbiased if the missing independent variable is uncorrelated. On the other hand if the variable "missed" does have a correlation, then there will exist a bias in the regression coefficients.
The included variables will pick up the effect of the excluded variable. The DW statistic is a good indicator to see if an important variable has been left out.

2. The problem of multicollinearity exists when two independent variables under test are themselves interrelated. Simply leaving out one of the variables does not solve the problem as it then leads to problem number one. If we include the variable, the effects are 1) the standard error of the regression coefficients changes with no bias on the regression coefficient itself and 2) we notice a wide distribution in the estimated value of the regression coefficients. As to whether we leave out a variable or include it depends how highly the two variables are correlated. Should the correlation be slight, then multicollinearity may not present a great problem.

3. Spurious correlation is involved when we include a variable which is not directly related to the case under consideration. This problem is not very significant in this analysis, since we do know that the independent variables, so chosen, are the ones which explain airline activity.

4. The problem caused by the error in the observation of the independent variable is also a serious one. However in this study, the problem under consideration was not under our control as the data was taken directly from the CAB accounts.
5. The problem of heteroscedasticity comes into existence if the error terms are not independent of the size of the explanatory variables. Various tests were carried out in the section on Station Costs to check for this problem. Deflating the cost function by a parameter representing the size of airline, produced results to about the same accuracy as those prior to deflation, thus indicating the non-existence of heteroscedasticity in analysis under consideration.

Statistical Analysis of Regression Equations

Certain statistics are available at the end of each regression run to help us judge the significance of the regression equation. These statistics are described briefly below. The reader is reminded that these statistics should be judged as a group and not independently. For example a high value of $R$ by itself is not a good indicator to make a critical judgement of the regression equation.

F-Test Value

This essentially tests whether the regression equation as a whole is significant, that is to say whether the independent variables are significantly explaining the dependent variable. The higher the F-Test value, the more significant is the regression equation as a whole. For three variables, i.e., degrees of freedom and fifty data points, the critical
F-test value is found to be 2.79 at significance level of 0.05. It is 4.20 at significance level of 0.01. In broad terms, significance level of 0.05 means that the odds are that the true value will lie 95% of the time within two standard deviations of the estimated value.

**Durbin Watson (D-W) Statistic**

This is a test to see whether the error term in one time period is related to the error term in the next time period. A value of 2 for the D-W indicates that the error terms in different time periods are unrelated, that is, they move systematically over time. A value of D-W falling in the range 1.75 to 2.25 is considered to be good.

The D-W statistic is used to determine whether a significant independent variable has been left out. If for example the value of D-W turns out to be 0.5, the reader should suspect at once, that an important independent variable has been left out. It does not however tell us which variable it is that we have left out.

**Multiple R**

This is determined from $R^2$, which gives us the percentage of variance in the dependent variable, explained by the independent variables. The closer is this value to unity, the better is the regression equation statistically.
V. SUMMARY OF RESULTS - ANNUAL SYSTEMS EXPENSES

This section shall present the cost estimating relationships chosen for the various categories of annual systems expenses. More detailed descriptions of the analyses performed, along with variants of the cost estimating relationships presented here are given in Appendix A. The data source for equations presented in this section are CAB Form 41 Reports for the years 1962-1966 inclusive. The cost estimating relations for both domestic and local service carriers will be presented, sometimes in a combined relationship which covers both classes of carriers.

V.1 Passenger Service Annual Expenses - Account 5500

The percentage breakdown of Passenger Service Account 5500 into sub-accounts is shown by figures 3 and 4 for domestic and local airlines respectively. This account represents about 20% of indirect operating costs for domestic carriers, and only 11% for local airlines. The difference is mainly due to the higher food expenses of domestic airlines.

The cost estimating relationships selected are:

**Domestic Trunk Carriers - Account 5500**

\[
\text{Passenger Service Costs} (\$/\text{year}) = -785,620 + 0.00549 \times (RPM)
\]

where RPM = revenue passenger miles/year

\[
R = 0.994, \, F = 4654, \, \text{Std. Error} = 1.84 \times 10^6 (\$/\text{year})
\]
**Figure 3** Domestic Airlines 1962-1965
Breakdown of Account 5500 (Passenger Service)

**Figure 4** Local Airlines 1962-1965
Breakdown of Account 5500 (Passenger Service)
Local Service Carriers - Account 5500

Passenger Service Costs ($/year) = -127890
+ .0780 (RM)
+ .00151 (RPM)

where RM = revenue aircraft miles/year
R = .968, F = 458, Std. Error = 105,700 ($/year)

V.2 Aircraft Servicing - Annual Expenses

Account 6100 (Domestics only)

This account represents about 21% of indirect operating costs for domestic carriers. Figure 5 indicates the breakdown of this account into sub-accounts and shows that personnel salary expenses are predominant. The cost estimating relationship selected for Aircraft Servicing is;

Aircraft Servicing Costs ($/year) = -3,550,350
+ 37.64 (D)
+ .00421 (RPM)

where D = aircraft departures/year
RPM = revenue passenger miles/year
R = .993, F = 1456, Std. Error = 2.09 X 10^6 ($/year)

V.3 Traffic Servicing Annual Expenses - Account 6200

(Domestics only)

The percentage breakdown of this account is shown in Figure 6. Again it is predominantly wages of baggage and passenger handling personnel which represents almost
Figures 5 and 6 show the breakdown of account 6100 and 6200 for domestic airlines from 1962 to 1965, respectively.
70% of this account. The account itself represents about 16% of total indirect costs.

As seen in Figure A-9.1 in Appendix A a good regression can be constructed using the number of employees in this category as a strong variable. Since it was felt that this variable would not be available, it was locked out of the regression. The following result was then obtained:

\[
\text{Traffic Servicing Costs (}$/\text{year}) = -12,960,000 + 2.46 (E) + 467,000 (E/D)
\]

where \( E \) = no. revenue enplanements per system year

\( (E/D) \) = average no. enplanements per departure

\[ R = .888, F = 96.7, \text{ Std. Error} = 6.77 \times 10^6 (}$/\text{year}) \]

V.4 Servicing Administration Annual Expenses - Account 6300

(Domestics only)

This account represents only 4% of the total indirect operating costs. The breakdown is given by Figure 7. While a regression equation can be formulated for this account, it is probably best correlated to the sum of expenses in Accounts 6100 and 6200. As Figure 8 shows it generally represents about 10% of the total of these two accounts.

V.5 System Station Costs Annual Expenses - Account 6400

The aggregate of accounts 6100, 6200 and 6300 is called Account 6400 for local airlines, and represents
FIGURE 7 DOMESTIC AIRLINES 1962-1965
BREAKDOWN OF ACCOUNT 6300
SERVICING ADMINISTRATION

FIGURE 8 - TOTAL SERVICING ADMINISTRATION EXPENSE—DOMESTIC AIRLINES—1964
the bulk of costs incurred at the airline terminal or station. Account 6400 represents about 55% of indirect costs for local airlines, and about 41% for domestic trunks. The breakdown for locals is given by Figure 9.

The cost estimating relationships selected are:

**Domestic Trunk Carriers - Account 6400**

\[
\text{Station Costs ($/year)} = -5.74 \times 10^6 + 0.607 \text{ (RM)}
\]

where \( \text{RM} = \text{revenue aircraft miles/year} \)

\( R = 0.993; F = 3660; \text{Std. Error} = 4.34 \times 10^6 \ ($/year) \)

**Local Service Carriers - Account 6400**

\[
\text{Station Costs ($/year)} = -128300 + 0.261 \text{ (RM)} + 2.14 \text{ (E)}
\]

where \( E = \text{system revenue enplanements/year} \)

\( R = 0.980, F = 745, \text{Std. Error} = 389,000 \ ($/year) \)

**Domestic & Local Service Carrier Combined - Account 6400**

\[
\text{Station Costs ($/year)} = -2.51 \times 10^6 + 0.581 \text{ (RM)}
\]

\( R = 0.994, F = 9533, \text{Std. Error} = 3.35 \times 10^6 \)
FIGURE 9  LOCAL AIRLINES 1962–1965
BREAKDOWN OF ACCOUNT 6400
(AIRCRAFT AND TRAFFIC SERVICING)
V.6 Reservations and Sales Annual Expenses - Account 6500
(Domestics only)

This account represents about 21% of indirect costs for domestic airlines, and is predominantly salaries and wages for reservations and sales personnel. The breakdown is indicated in Figure 10.

The cost equation selected is:

\[
\text{Res. and Sales Cost (}$/\text{year}$) = -618,900 + .00385 (\text{RPM}) + .0585 (\text{RM}) + .360 (\text{RPO})
\]

where RPO = revenue passenger originations/year

\[R = .989, F = 769, \text{Std. Error} = 2.56 \times 10^6 ($/year)\]

V.7 Advertising and Publicity Annual Expenses - Account 6600
(Domestics only)

This expense is only 7% of indirect costs, and is almost completely advertising expenses as Figure 11 shows. It is a discretionary cost incurred to increase or maintain revenues for an airline, and is subject to competitive circumstances, and managerial policy. Normally, it is closely linked to expected revenues by budgetary considerations as the analysis in Appendix A.4.2 indicates.
FIGURE 10 DOMESTIC AIRLINES 1962-1965
BREAKDOWN OF ACCOUNT 6500
(RESERVATION AND SALES)

FIGURE 11 DOMESTIC AIRLINES 1962-1965
BREAKDOWN OF ACCOUNT 6600
(ADVERTISING AND PUBLICITY)
The cost equation selected is:

**Advertising Cost ($/year)**

\[ 743500 + 0.00172 \text{ (RPM)} \]

\[ R = 0.950, \ F = 489, \text{ Std. Error} = 1.77 \times 10^6 \text{ ($/year)} \]

7.8 **Promotion and Sales Expenses Annual Expense**

**Account 6700**

The aggregate of Accounts 6500 and 6600 has been called Account 6700 for domestic airlines, and is comparable with the Account 6700 used for local carriers. This account represents about 19% of indirect costs for local carriers, about 28% for domestic carriers. The breakdown of this account for locals is given by Figure 12.

The cost estimating relations selected are:

**Domestic Airlines - Account 6700**

Promotion and Sales Cost ($/year) = 142920

\[ + 0.584 \text{ (RPO)} + 0.00637 \text{ (RPM)} \]

\[ R = 0.988, \ F = 1026, \text{ Std. Error} = 3.58 \times 10^6 \text{ ($/year)} \]

**Local Airlines - Account 6700**

Promotion and Sales Cost ($/year) = -48210

\[ + 0.00947 \text{ (RPM)} \]

\[ R = 0.961, \ F = 766, \text{ Std. Error} = 389,000 \text{ ($/year)} \]
FIGURE 12 LOCAL AIRLINES 1962-1965
BREAKDOWN OF ACCOUNT 6700
(PROMOTION AND SALES)
Domestic and Local Airlines Combined - Account 6700

Promotion and Sales Cost ($/year) = 41270
+ 0.574 (RPO)
+ 0.00640 (RPM)

$R = 0.993, F = 4137, \text{ Std. Error} = 2.4 \times 10^6$

This last equation is recommended since it is a better fit to the data from both domestic and local airlines.

V.9 General and Administrative Annual Expenses - Account 6800

These expenses represent about 10% of indirect costs for domestic trunks, and about 12% for local carriers. Figures 13 and 14 show the breakdown of these costs into subaccounts. Once again salaries and wages of record keeping personnel dominate the account.

Various considerations and analyses of this expense are given in Appendix A.3. The cost estimating relations selected are:

Domestic Carriers - Account 6800

G and A costs ($/year) = 478,600
+ .00172 (RPM)
+ .048 (RM)

$R = .979, F = 389, \text{ Std. Error} = 2.08 \times 10^6 ($/year)
FIGURE 13  DOMESTIC AIRLINES 1962-1965
BREAKDOWN OF ACCOUNT 6800
GENERAL AND ADMINISTRATIVE

FIGURE 14  LOCAL AIRLINES 1962-1965
BREAKDOWN OF ACCOUNT 6800
GENERAL AND ADMINISTRATIVE
Local Service Carriers – Account 6800

G & A Costs ($/year) = 397,340
+ .00360 (RPM)

R = .865, F = 188, Std. Error = 190,000 ($/year)

Domestic and Local Service Carriers Combined – Account 6800

G & A Costs ($/year) = 73,760
+ .00156 (RPM)
+ .0483 (RM)

R = .979, F = 1359 Std. Error = 1.43 x 10^6 ($/year)

This last equation seems a good representation for both locals and domestic trunks separately, and is recommended for general use.

V.10 Total Indirect Operating Expenses

The total indirect operating expenses of an airline can be submitted to a regression analysis as a function of the usual measures of activity. This was carried out for the four year period from 1962-1965, and produced the following results.

Domestic Airlines – Total Indirect Costs

I.O.C. ($/year) = -7.20 x 10^6
+ .0146 (RPM)
+ .645 (RM)
R = .998,  
F = 4111, Std. Error = 5.58 \times 10^6 ($/year)

**Local Airlines - Total Indirect Costs**

\[ \text{I.O.C. ($/year)} = 2.00 \times 10^6 \\
+ 0.43 \ (R) \]

where R = total transport revenues ($/year)

R = 0.966,  
F = 514,  
Std. Error = 0.637 \times 10^6 ($/year)

Figures 15 and 16 are scatter plots for these equations using 1966 data. The scatter is very small and similar results are obtained for 1967 data. This seems to indicate that total system indirect operating costs can be reasonably accurately estimated using these simple equations.
COST ($/YEAR) = -7203180 + 0.01460 (REVENUE PASSENGER-MILES) + 0.6452 (REVENUE AIRCRAFT-MILES)

**FIGURE 15:** DOMESTIC AIRLINES
TOTAL INDIRECT OPERATING COST – 1966
COST ($/YEAR) = 2004000 + 0.4296 (TOTAL TRANSPORT REVENUE)

FIGURE 16: LOCAL AIRLINES
TOTAL INDIRECT OPERATING COST—1966
VI. SUMMARY OF RESULTS - LOCAL STATION EXPENSES

In the previous section, stations costs (Account 6400) were investigated as an annual systems expense. Since this account represents about one half the total indirect costs, and since it is concerned with ground operations occurring at a station, it was decided to study it as a local station annual expense, and relate it to the number of local enplanements, originations, and departures occurring at individual stations. Local expenses for Account 6400 were obtained from Schedule P-9.2 of the Form 41 reports, and measures of local activity from "Airport Activity Statistics of Certified Route Air Carriers" published by the FAA.

Detailed descriptions of various regressions performed on this data are given in Appendix B, and selected cost equations will be presented in this section.

VI.1 The Linear Regression Model

Various forms of regression equations were tested for this expense. The simplest and most effective form is the following linear model result:

**Domestic Carriers**

Local Station Cost ($/year) = 168,000 + 1.76 (E) + 202.8 (C)
where $C = \text{tons of cargo shipped per year from the station}.$

$$R = 0.913, \ F = 1431, \ \text{Std. Error} = .972 \times 10^6 (\$/\text{year})$$

An alternative relation in terms of $E$ and $E/D$ is:

Local Station Cost ($/\text{year}$) = 
\[ -371,200 + 4.94 (E) + 13593 (E/D) \]

where $E/D = \text{average enplanements/departure for the station}.$

$$R = 0.852, \ F = 708, \ \text{Std. Error} = 1.28 \times 10^6 (\$/\text{year})$$

**Local Carriers**

Local Station Cost ($/\text{year}$) = 
\[ 30,400 + 2.84 (E) \]

$$R = .947, \ F = 4492, \ \text{Std. Error} = 61.2 \times 10^3 (\$/\text{year})$$
BIBLIOGRAPHY


APPENDIX A - ANNUAL SYSTEMS EXPENSES

The various sections of this appendix describe the analyses performed on indirect cost categories to produce an estimate of annual operating costs. All the estimating relationships are linear in form, but may vary slightly in one way or another from those selected as a "best" estimating relationship in the summary sections of this report. Because of the stepwise procedure in the regression technique and a desire to keep the cost estimating equations simple, the "best" equations presented in the summary are often a "step" answer not presented in this appendix. Since some interest may exist in the results when regression is performed over different combinations of independent variables, selected results are presented in this Appendix.

A.1 - Passenger Service Account 5500

This category represents about 11% of the total indirect operating costs for the local airlines and about 20% of the indirect operating costs for the domestic trunk carriers. See Figures 1 and 2.

Figures 3 and 4 show that the four main elements which contribute to this functional category are,

<table>
<thead>
<tr>
<th></th>
<th>Locals</th>
<th>Domestic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabin crew salaries</td>
<td>41%</td>
<td>22%</td>
</tr>
<tr>
<td>Passenger food</td>
<td>17%</td>
<td>41%</td>
</tr>
<tr>
<td>Insurance-traffic liability</td>
<td>11%</td>
<td>11%</td>
</tr>
<tr>
<td>Personnel expenses</td>
<td>14%</td>
<td>9%</td>
</tr>
</tbody>
</table>
These four subcategories explain about 83% of the passenger service expense in both groups of carriers.

A.1.1 Variables Tested Graphically

Revenue aircraft-miles
Total revenue departures,
Number of revenue passenger enplanements,
Average hop length,
Revenue passenger-miles,
Number of cabin crew,
Number of flight crew plus cabin crew,
Total revenue ton-miles.

The yearly amount spent on food is determined by managerial policy or the degree of competition more than by any other factor. The allocation of this cost to a specific variable is somewhat arbitrary. The local carriers appear to be operating at different levels of food service. This was noticed for all years, 1962 through 1966 and can only be accounted as a result of managerial policy. However this distinction is not so obvious in the case of domestic trunk carriers. Delta and Trans World are at a little lower level of spending on food than the rest of the domestic trunk carriers. Mohawk and Allegheny, although classified as local carriers, appear to fit better with the domestic trunk carriers as far as food expense is concerned.

The variable revenue aircraft-miles was tested against total passenger service expense. In both, the local and the domestic trunk carriers, revenue aircraft-
miles correlated well with total passenger service expense as shown in Figures A-1 and A-2.

A.1.2 Regression Equations - Passenger Service - Account 5500

Variables Entered

Revenue passenger-miles,
Revenue aircraft-miles,
Number of cabin crew,
Number of flight crew plus cabin crew.

Local Airlines

Total Cost ($/quarter) = -96730
+ 0.04320 (Revenue aircraft miles)
+ 0.001272 (Revenue passenger-miles)
+ 3916.4 (Number of cabin crew)

(1962-65)

R = 0.9745

The variable revenue aircraft-miles explains approximately 92% of the total cost variation and the three variables together explain approximately 95.2% of the cost variation. On inclusion of an extra year's data the following regression equation was obtained.

Total Cost ($/year) = -127200
+ 0.02994 (Revenue aircraft-miles)
+ 0.0015581 (Revenue passenger-miles)
+ 5372.9 (Number of cabin crew)
FIGURE A1  TOTAL PASSENGER SERVICE EXPENSE—LOCAL AIRLINES—1964
FIGURE A2 TOTAL PASSENGER SERVICE EXPENSES—DOMESTIC AIRLINES—1964

FIGURE A3 TOTAL PASSENGER SERVICE EXPENSES—DOMESTIC AIRLINES—1964
We notice that this equation is very similar to the previous one. The R value has in fact improved by a very small percentage.

**Domestic Trunk Carriers**

Total cost ($/year) = - 1047540
+ 0.004193 (Revenue passenger-miles)
+ 0.03690 (Revenue aircraft-miles)
+ 2229 (Number of cabin crew)

\( R = 0.9952 \)

In this category the variable revenue passenger-miles explains most of the cost variation. 99% of the cost variation is explained by the regression equation. On inclusion of an extra year's data, the following regression equation was obtained.

The total cost ($/year) = - 953180
+ 0.0046310 (Revenue passenger-miles)
+ 3386.8 (Number of cabin crew)

\( R = 0.9952 \)

**Domestic Trunk and Local Carriers Combined**

Total cost ($/year) = - 566060
+ 0.003924 (Revenue passenger-miles)
+ 0.04865 (Revenue aircraft-miles)
+ 2020 (Number of cabin crew)

\( R = 0.9952 \)

The variable revenue passenger-miles once again explains almost all of the cost variation (99%). The other two variables explain very
little additional cost variation.

There is justification for the negative sign in front of the constant term in the regression equation. If cost is plotted against a single variable $X$, then we will obtain negative cost when the variable $X$ takes on the value zero. This is obviously not the case. We are, however, placing a lower limit on the value which the variable $X$ can take. This is feasible since the variation referring to both groups of carriers do have a lower limit other than zero. It is possible to obtain, for a given set of data points, a regression line which passes through the origin instead of giving a negative intercept on the cost axis. The new regression line does not, however, make use of the least squares minimization criterion and therefore does not represent the "best" line through a given set of data points.

If we are given observations in the region B of the following sketch and asked to make a regression analysis on this, we will obtain a line which fits best the given data points in the region B. We cannot be held responsible as to what happens when this line is projected. Had we been given data in region A, the line would have been different and may not have produced negative intercept with the "cost axis". However, such data simply does not exist. There is no airline which for example only operates through two stations or carries only ten passengers a year. Therefore, when interpreting the results, it should be kept in mind, that the results only apply within a given range.

Figure A-4 shows a scatter plot of the actual versus estimated cost for passenger service - Account 5500 for domestic airlines. Because of the high correlation indicated by an R value of .995, the scatter is extremely small or in other words the cost equation
is very good.

FITTING REGRESSION LINE

A.2 Aircraft and Traffic Servicing Account 6400

This account for the domestic trunk carriers is segregated into three accounts which will be investigated separately.

Account 6100 - Aircraft Servicing
Account 6200 - Traffic Servicing
Account 6300 - Servicing Administration

A.2.1 Aircraft Servicing - Account 6100 Domestics Only

This cost category represents approximately 21% of the total indirect operating costs for the domestic trunk carriers. Figure 5 shows that the main items contributing to the cost are:

General aircraft & traffic handling personnel (36%)
Landing fees (17%)
Aircraft control personnel (14%)
Other services - outside (8%)
Rentals (6%)
A.2.1.1 Variables Tested Graphically

Total revenue aircraft departures,
Number of stations served,
Number of aircraft in fleet,
Total aircraft hours,
Revenue aircraft-miles.

In the graphical analysis, Figures A-5 to A-7, the three variables which indicated linear relationship with cost are revenue aircraft-miles, revenue aircraft hours and the number of aircraft in fleet.

A.2.1.2 Regression Equation - Aircraft Servicing - Account 6100

Variables Entered

Number of aircraft departures,
Number of employees in this category,
Revenue passenger-miles,
Number of aircraft in fleet,
Revenue aircraft-miles.

Total cost ($/year) = -2949320 + 50160.6 (Number of aircraft in fleet)
+ 18.4824 (Total revenue departures)
+ 0.0033785 (Revenue passenger-miles)
+ 818.5 (Number of employees in this category)

(1962-65)

R = 0.9957

This equation explains approximately 99% of the cost variation.

Figure A-8 shows the small scatter in its calculation of costs.
On inclusion of an extra year's data, the following regression equation was obtained.

Total cost ($/year) = -2519717

+ 56731.3 (Number of aircraft in fleet)
+ 0.00282721 (Revenue passenger-miles)
+ 2104 (Number of employees in this category)
+ 0.46232 (Revenue Enplanements)

(1962-66)
R = 0.9947
COST ($/YEAR) = -1047540 + 0.004193(Revenue Passenger Miles) + 2229(Number of Cabin Crew) + 0.03690(Revenue Aircraft Miles)

FIGURE A4 DOMESTIC AIRLINES—DOMESTIC AIRLINE FORMULA
PASSENGER SERVICE—ACCOUNT 5500
FIGURE A5.1 TOTAL AIRCRAFT SERVICING EXPENSES—DOMESTIC AIRLINES—1962 to 1965

FIGURE A5.2 TOTAL AIRCRAFT SERVICING EXPENSES—DOMESTIC AIRLINES—1964
FIGURE A6 TOTAL AIRCRAFT SERVICING EXPENSES—DOMESTIC AIRLINES—1964

FIGURE A7 TOTAL AIRCRAFT SERVICING EXPENSE—DOMESTIC AIRLINES—1964
COST ($/YEAR) = -2949320 + 50160.6 (NUMBER OF AIRCRAFT IN FLEET) + 18.4824 (NUMBER OF REVENUE DEPARTURES) + 0.003785 (REVENUE PASSENGER MILES) + 818.5 (NUMBER OF EMPLOYEES)

FIGURE A8 : DOMESTIC AIRLINES AIRCRAFT SERVICING - ACCOUNT 6100
A 2.2 Traffic Servicing - Account 6200 (Domestics only)

This cost category represents about 16% of the total indirect operating costs for the domestic carriers. Figure 6 shows that the main items contributing to this account are

- Cargo handling personnel (38%)
- Passenger handling personnel (31%)
- Rentals (8%)
- General aircraft and traffic handling personnel (6%)

A 2.2.1 Variables Tested Graphically

- Number of employees in this category
- Revenue passenger-miles
- Number of revenue departures
- Number of revenue passenger enplanements
- Number of stations served
- Revenue aircraft-miles
- Number of aircraft in fleet

From graphical analysis, cost per passenger enplanement is approximately 2.5 dollars. Figure A-9.1 shows the high correlation of this expense to employees. Figures A 9.2 through A 9.5 show the statistical variations with other variables.

A 2.2.2 Regression Equation - Traffic Servicing - Account 6200

Variables Entered

- Number of revenue passenger enplanements
- Total aircraft departures
- Number of employees in this category
- Revenue aircraft-miles
- Revenue passenger-miles
FIGURE A9.1 TOTAL TRAFFIC SERVICING EXPENSE—DOMESTIC AIRLINES—1964
FIGURE A9.2 TOTAL TRAFFIC SERVICING EXPENSE—DOMESTIC AIRLINES—1964

FIGURE A9.3 TOTAL TRAFFIC SERVICING EXPENSE—DOMESTIC AIRLINES—1962 to 1965
FIGURE A9.4 TOTAL TRAFFIC SERVICING EXPENSES—DOMESTIC AIRLINES—1962 to 1965

FIGURE A9.5 TOTAL TRAFFIC SERVICING EXPENSES—DOMESTIC AIRLINES—1964
Total cost ($/year) = 667259.7
+ 7609.9 (Number of employees in this category)
+ 0.02936 (Number of revenue passenger enplanements)

(1962-65)
\[ R = 0.9407 \]

88.4% of the cost variation is explained by this equation. On inclusion of an extra year's data, the following result was obtained.

Total cost ($/year) = -1241250.7
+ 4355.1 (Number of employees in this category)
+ 0.00228 (Revenue passenger-miles)

(1962-66)
\[ R = 0.9795 \quad F = 615.4 \quad \text{Std. Error} = 2.96 \times 10^6 ($/year) \]

By locking the variable, number of employees, out of the regression, and creating a new independent variable \( E/D = \) enplanements/departure, the following result was obtained:

Cost ($/year) = -12.9 \times 10^6
+ 2.46 (No. of rev. passenger enplanements)
+ 4.67 \times 10^5 (Enplanements/departure)

, (1962-66)
\[ R = .888, \quad F = 96.7, \quad \text{Std. Error} = 6.77 \times 10^6 ($/year) \]

A.2.3 Servicing Administration - Account 6300 (Domestics only)

This account is approximately 4% of the total indirect operating costs of the domestic carriers. Figure 7 shows that it consists mainly of
COST ($/YEAR) = 667259.7 + 7609.9 (NUMBER OF EMPLOYEES IN THIS CATEGORY) + 0.02936(NUMBER OF REVENUE PASSENGER ENPLANEMENTS)

FIGURE A10 DOMESTIC AIRLINES TRAFFIC SERVICING—ACCOUNT 6200
General aircraft and traffic handling personnel (31%)
Rentals (20%)
Other personnel (11%)
Record keeping and statistical personnel (6%)
Communication personnel (5%)

Most of these subaccounts represent salaries of the employees in the various categories.

A. 2.3.1 Variables Tested Graphically

Revenue aircraft-miles,
Number of aircraft in fleet,
Number of revenue departures,
Number of stations served,
Number of employees in this category,
Revenue passenger-miles,
Sum of accounts 6100 and 6200.

A. 2.3.2 Regression Equation - Servicing Administration - Account 6300

Variables Entered *
Revenue aircraft-miles,
Number of aircraft in fleet,
Total aircraft departures,
Number of stations served,
Number of employees in this category,
Revenue passenger-miles.

Total cost ($/year) = -2369025 + 31840 (Number of aircraft in fleet)
+ 0.041806 (Revenue aircraft-miles)
This equation explains about 72% of the total cost variation. This is to be expected, because of imperfect data and reporting procedures in this category. However, since Account 6300 represents only 4% of the total indirect operating costs, even a significant error in allocation will have a minimal effect on total indirect operating costs. On inclusion of an extra year's data the following equation was obtained.

\[
\text{Total cost ($/year)} = -2675653 + 24.3517 \text{ (Aircraft departures)} + 0.028953 \text{ (Aircraft miles)}
\]

(1962-66) \( R = 0.8633 \), \( F = 59.9 \), STD. Error = 2.96 \( \times 10^6 \) ($/year)

A.2-4 Station Costs as a Systems Expense - Account 6400

In previous sections Account 6400 was investigated in three parts for the domestic trunk carriers. This Section will investigate their aggregate together with the corresponding Account 6400 for the local carriers.

A.2.4.1 Local Carriers - Account 6400

For local carriers Account 6400, aircraft and traffic servicing, represents about 55% of the total indirect operating costs. Figure 9 shows that the main elements contributing to this cost category are:

Salaries of general aircraft and traffic handling personnel (36%)  
Salaries of passenger handling personnel (17%)
The remaining 47% of the cost is made up of small items such as:

- Communications purchased (7%)
- Landing fees (7%)
- Other services - outside (6%)
- Rentals (6%)
- Aircraft control personnel (4%)
- Cargo handling personnel (3%)
- Taxes on payroll (2½%)

A.2.4.1 Variables Tested Graphically

- Total revenue ton-miles
- Available seat miles
- Route miles
- Number of revenue departures
- Revenue passenger-miles
- Number of stations served
- Number of revenue passenger enplanements
- Number of aircraft in fleet
- Revenue aircraft hours
- Revenue aircraft-miles

A.2.4.1.2 Regression Equations - Local Carriers - Account 6400

Variables Entered

- Total aircraft departures
- Number of revenue passenger enplanements
COST ($/YEAR) = -295411 + 0.29487 (REVENUE AIRCRAFT MILES) + 2.1407 (NUMBER OF REVENUE PASSENGER ENPLANEMENTS)

FIGURE A11 LOCAL AIRLINES AIRCRAFT AND TRAFFIC SERVICING—ACCOUNT 6400

FIGURE A12 TOTAL AIRCRAFT AND TRAFFIC SERVICING EXPENSE—DOMESTIC AIRLINES—1963 to 1965

-78-
FIGURE A13 TOTAL AIRCRAFT & TRAFFIC HANDLING EXPENSE
DOMESTIC AIRLINES (YEAR 1965)

FIGURE A14 TOTAL AIRCRAFT AND TRAFFIC SERVICING EXPENSE
DOMESTIC AIRLINES - 1963 to 1965
Number of stations served
Revenue ton-miles
Revenue aircraft-miles

Total cost ($/year) = - 295411
+ 0.29487 (Revenue aircraft-miles)
+ 2.1407 (Number of revenue passenger enplanements)

(1962-65)
\[ R = 0.9776 \]

This equation explains approximately 95.5% of the cost variation. The scatter plot is shown in Figure A-11. With an extra year's data the following equation was obtained:

Total cost ($/year) = - 128292
+ 0.26138 (Revenue aircraft-miles)
+ 2.1407 (Number of revenue passenger enplanements)

(1962-66)
\[ R = 0.9798, \quad F = 745.5, \quad \text{STD. Error} = 389,000 \ ($/year) \]

A. 2.4.2 Domestic Trunk Carriers - Account 6400

This cost category was formed by adding Accounts 6100, 6200, and 6300 and represents about 41% of indirect costs. The variables tested are the same as for local airlines, and various plots are shown in Figures A-12 to A-14.
A.2.4.2.1 Regression Equation - Domestic Carriers - Account 6400

Variables Entered

Total aircraft departures
Number of revenue passenger enplanements
Number of stations served
Revenue ton-miles
Revenue aircraft-miles

Total cost ($/year) = - 5409571 + 59735 (Revenue aircraft-miles)

(1962-65)
R = 0.9926

The scatter plot for this result is shown in Figure A-15.

With an extra year's data, the following result was obtained:

Total cost ($/year) = - 5739432 + 0.60662 (Revenue aircraft-miles)

(1962-66)
R = 0.9928, F = 3660, STD. Error - 4.34 x 10^6 ($/year)

This equation explains approximately 98% of the cost variation. Although it is reasonable to expect that all the airlines have the same overall levels of efficiency, some airlines may be more efficient than others in particular fields, which will be revealed in their cost categories. If all airlines obtain approximately the same levels of efficiency in their overall costs, then the particular activity inefficiency will disappear when the categories are aggregated. The
COST ($/YEAR) = -5409571 + 0.59735 (REVENUE AIRCRAFT MILES)

FIGURE A15  DOMESTIC AIRLINES  AIRCRAFT AND TRAFFIC SERVICING—ACCOUNT 6400
scatter which exists in Account 6300, is reduced significantly in Figure A-15, Account 6400, which is the aggregate of Accounts 6100, 6200, and 6300.

A. 2.4.3 Regression Equation for Local and Domestic Trunk Carriers Combined

Variables Entered
Total aircraft departures
Number of revenue passenger enplanements
Number of stations served
Revenue ton-miles
Revenue aircraft-miles

Total cost ($/year) = - 2507736
+ 0.58128 (Revenue aircraft-miles)

(1962-65)

Although 98% of the cost variation is explained by this equation it does not produce as good results as the individual regression equations.

R = .9939, F = 9533
STD. Error = 3.350 x 10^6

A.3 Total General and Administrative Expense - Account 6800

This represents about 10% of the total indirect operating costs for the domestic trunk carriers and about 12% of the total indirect operating costs for the local carriers.
FIGURE A.17 G & A EXPENSES—DOMESTIC AIRLINES—1964

FIGURE A.16 G & A EXPENSE—DOMESTIC AIRLINES—1964
Figure A.18 G&A Expenses - Domestic Airlines - 1964

Figure A.19 G&A Expenses - Local Airlines - 1964
Figures 13 and 14 show that the main elements contributing to this cost are:

<table>
<thead>
<tr>
<th></th>
<th>Locals</th>
<th>Domestic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Record keeping &amp; statistical personnel</td>
<td>25%</td>
<td>29%</td>
</tr>
<tr>
<td>General management personnel</td>
<td>15%</td>
<td>6%</td>
</tr>
<tr>
<td>Taxes—other than payroll</td>
<td>9%</td>
<td>14%</td>
</tr>
<tr>
<td>Rentals</td>
<td>8%</td>
<td>7%</td>
</tr>
<tr>
<td>Other personnel</td>
<td>6%</td>
<td>12%</td>
</tr>
</tbody>
</table>

These subcategories explain on the average 65% of the cost variation for the two groups of carriers. The remaining 35% of the expense is related to items such as stationary, printings, and office supplies, legal supplies, salaries of purchasing personnel, and insurance liability for benefit, and protection of employees.

A.3.1 Variable Tested Graphically

Revenue passenger-miles
Total revenue ton-miles
Revenue aircraft-miles
Total transport revenue

Figures A-16 to A-19 show the variation of cost with the different variables for both groups of carriers, which indicated
some relationship. There is more scatter for local carriers than for the domestic trunk carriers. Piedmont spends less on this account than the average. For example, in 1964 North Central and Piedmont carried approximately the same number of passengers with very nearly equal total revenue ton-miles. Yet Piedmont had a comparably smaller expense in this category than North Central. The explanation is that North Central operated through twice as many stations, employed twice as many employees in the category of record keeping and statistical personnel. The reasons seem feasible, since salaries of the two categories of personnel amount to 40% of the total expense.

Out of the variables tested, only revenue passenger-miles gives a reasonable explanation of the cost for the local carriers. In the case of domestic trunk carriers all variables appear to have a linear relationship with the cost. Piedmont, though classified as a local carrier, appears to fit better with the domestic trunk carriers.

A.3.2 Regression Equations - Account 6800

<table>
<thead>
<tr>
<th>Variable Entered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue aircraft-miles</td>
</tr>
<tr>
<td>Number of revenue passenger originations</td>
</tr>
<tr>
<td>Revenue passenger-miles</td>
</tr>
<tr>
<td>Total transport revenue</td>
</tr>
</tbody>
</table>
Local Carriers

Total Cost ($/year) = 405390 + 0.003398 (Revenue passenger-miles)

(1962-64)
R = 0.8406

Only 72% of the cost variation is explained by this equation.
This is expected since the graphs show a lot of scatter and only a trend is evident in each case. With added data the following was obtained:

Total Cost ($/year) = 397340 + 0.001343 (Revenue passenger-miles) + 0.07255 (Revenue aircraft-miles)

(1962-64)
R = 0.9851

97% of the cost variation is explained by this equation.

With the added data;

Total Cost ($/year) = -478640 + 0.001719 (Revenue passenger-miles) + 0.04825 (Revenue aircraft-miles)

(1962-66)
R = 0.9792  F - Ratio = 389.52  Std. error of Est. = 2.08 x 10^6

Combined Equation for Domestic Trunk and Local Carriers

Total Cost ($/year) = -201020

. + 0.001127 (Revenue passenger-miles)

+ 0.07761 (Revenue aircraft-miles)

(1962-64)
R = 0.9892
With the added data

\[
\text{Total Cost (\$/year)} = 73760 + 0.001556 \times (\text{Revenue passenger-miles}) \nonumber \\
+ 0.04825 \times (\text{Revenue aircraft-miles}) \nonumber 
\]

(1962-66)

\[ R = 0.9792 \]

\[ F - \text{Ratio} = 1359.8 \quad \text{Std. error of est.} = 1.43 \times 10^6 \]

The regression equation for the combined carriers explains 96% of the cost variation. This is probably because not only do the domestic trunk carriers dominate, but because local carriers such as Piedmont fit better with the domestic trunk carriers.

A.4 Promotion and Sales - Account 6700

This account is separated into two accounts for the domestic carriers which will be investigated separately.

Account 6500 - Reservations and Sales

Account 6600 - Advertising and Publicity

Account 6700 will then be treated for both domestics and local carriers.

A.4.1 Reservations and Sales - Account 6500 (Domestics only)

This cost category represents about 21% of the total indirect operating costs. The main elements contributing to this cost are:

Passenger handling personnel (30%)

Commissions - passengers (23%)
FIGURE A20 RESERVATIONS AND SALES EXPENSE-DOMESTIC AIRLINES-1964

FIGURE A21 RESERVATIONS AND SALES EXPENSE-DOMESTIC AIRLINES-1964
COST ($/YEAR) = -809990 + 0.004693(REVENUE PASSENGER MILES) + 0.05065(REVENUE AIRCRAFT MILES)

FIGURE A24  DOMESTIC AIRLINES
RESERVATION AND SALES—ACCOUNT 6500
Communications purchased (10%)
Rentals (6%)
Traffic solicitors (4%)

A. 4.1.1 Variables Tested Graphically

The five variables tested were:
Revenue passenger-miles
Total transport revenue
Total revenue ton-miles
Revenue aircraft-miles
Number of revenue passenger originations

With the exception of passenger originations, the variables seem to have a strong correlation with the cost, as indicated by Figures A-20 to A-23. Total transport revenue and revenue passenger-miles show an extremely good correlation with the cost.

A.4.1.2 Regression Equations - Account 6500

Total Cost ($/year) = - 809990 + 0.004693 (Revenue passenger-miles)
+ 0.05065 (Revenue aircraft-miles)

(1962-64)
R = 0.9958

These two variables explain approximately 99% of the cost variation. The scatter plot is shown in Figure A-24.

With the extra year's data:
FIGURE A25 ADVERTISING EXPENSE—DOMESTIC AIRLINES—1964
FIGURE A26 ADVERTISING EXPENSE—DOMESTIC AIRLINES—1964

FIGURE A27 ADVERTISING EXPENSE—DOMESTIC AIRLINES—1964
Total Cost ($/year) = - 618890 + 0.003848 (Revenue passenger-miles)
+ 0.05845 (Revenue aircraft-miles)
+ 0.3600 (Revenue passenger originations)

(1962-66)  
R = 0.9891  F - Ratio = 769.90 Std. error of est. = 2.56 x 10^6

A.4.2 Advertising and Publicity - Account 6600 (Domestics Only)

This expense represents about 7% of the total indirect operating costs. Approximately 82% of this cost is associated with advertising. See Figure 11. This is a discretionary cost, that is, it is incurred by management policies with a view to increasing the revenue of their airline. Advertising expenditure is usually a budgeted fixed percentage of the total revenue but this percentage varies from one airline to another due to differences in managerial policy.

A.4.2.1 Variables Tested Graphically

Revenue passenger-miles
Number of revenue passenger originations
Total transport revenue
Revenue aircraft-miles
Total revenue ton-miles

All the variables appear to be well correlated to the cost category, as indicated by Figures A-25 to A-27
COST ($/YEAR) = 1027450 + 0.001509(REVENUE PASSENGER MILES)

FIGURE A28 DOMESTIC AIRLINES
ADVERTISING AND PUBLICITY—ACCOUNT 6600
A.4.2.2 Regression Equation - Account 6600 (Domestics Only)

Variables Entered

- Revenue passenger-miles
- Revenue aircraft-miles
- Number of revenue passenger originations
- Total transport revenue
- Total aircraft departures

Total Cost ($/year) = 1027450 + 0.001509 (Revenue passenger-miles)

(1962-64)
R = 0.9558

Almost 90% of the cost variation is explained by the single variable, revenue passenger miles. This was expected from the graphical analysis Figure A-25. Figure A-28 shows the scatter plot for this category. The regression equation appears to over estimate the costs for this year. With an extra two year's data added, the following regression equation was obtained:

Total Cost ($/year) = 743480 + 0.001718 (Revenue passenger-miles)

(1962-66)
R = 0.9499  F - Ratio = 489.79  Std. error of est. = 1.77 x 10^-6

A.4.3 Promotion and Sales - Account 6700

In the previous sections Account 6700 was investigated in two parts for the domestic carriers. This section shall
study their aggregate along with the corresponding Account 6700 for local carriers.

A.4.3.1 Local Carriers—Promotion and Sales—Account 6700

For local carriers this account represents about 19% of the total indirect operating costs. The costs are not incurred in the direct handling of traffic but exist principally to increase revenue. The total amount spent is determined by managerial policy or the degree of competition more than by any other factor. The aim is to increase profits by increasing demand, the strategy being that hopefully, the resulting increase in revenues will exceed the net additional expense incurred.

Figure 12 shows that the major components in this category are:

- Passenger handling personnel (27%)
- Advertising (26%)
- Commissions (10%)
- Communications purchased (8%)

The remaining 29% of the expense is related to items such as traffic solicitors, ground management personnel, other personnel, tariffs, schedules, time tables, and rentals.

A.4.3.1.1 Variables Tested Graphically

- Revenue aircraft-miles
- Number of revenue passenger originations
**FIGURE A29** PROMOTION AND SALES EXPENSE—LOCAL AIRLINES—1964

**FIGURE A30** PROMOTION AND SALES EXPENSE—LOCAL AIRLINES—1964
Number of revenue passenger enplanements
Total transport revenue
Total available ton-miles
Total revenue ton-miles
Revenue passenger-miles

Figure A-29 and A-30 show plots of cost against Total Revenue and Passenger originations.

A.4.3.1.2 Regression Equation - Local Carriers - Account 6700

\[
\text{Total Cost (\$/year)} = 157560 + 0.10208 \times (\text{Total transport revenue})
\]

(1962-64)
\[R = 0.9021\]

\[
\text{Total Cost (\$/year)} = -48210 + 0.009468 \times (\text{Revenue passenger-miles})
\]

(1962-66)
\[R = 0.9613\]
\[F - \text{Ratio} = 766.46\]
\[\text{Std. error of est.} = 0.389 \times 10^6\]

This equation explains about 92% of the total cost variation simply in terms of revenue passenger miles.

A.4.3.2 Domestic Trunk Carriers - Promotion & Sales - Account 6700

Account 6700, the aggregate of Accounts 6600 and 6500, is investigated in this section. This cost category represents approximately 28% of the total indirect operating costs.
A.4.3.2.1 Graphical Analysis

The variables total transport revenue, revenue aircraft-miles and revenue passenger-miles show a distinct linear relationship with the cost. The variable revenue passenger-miles appears to be extremely good in explaining the cost.

A.4.3.2.2 Regression Equation - Account 6700

Variable Entered

Revenue passenger-miles
Revenue aircraft-miles
Number of revenue passenger originations
Total transport revenue
Total aircraft departures

Total Cost ($/year) = 332390 + 0.007211 (Revenue passenger-miles)

(1962-64)
\[ R = 0.9948 \]

On inclusion of two year's extra data, the following equation was determined:

Total Cost ($/year) = 142920

+ 0.5844 (Revenue passenger originations)

+ 0.006374 (Revenue passenger-miles)

(1962-66)
\[ R = 0.9876 \]
\[ F - \text{Ratio} = 1026.17 \]
\[ \text{Std. error of est.} = 3.58 \times 10^6 \]
A.4.3.3 Promotion and Sales - Account 6700 - Combined Domestic and Local

On combining the local and domestic trunk carriers, the following regression equation is obtained to describe Account 6700.

\[
\text{Total Cost ($/year)} = 350170 + 0.007208 \times (\text{Revenue passenger-miles})
\]

(1962-64)
\[R = 0.9970\]

This equation is very similar to the equation describing the cost variation for the domestic trunk carriers alone. Once again approximately 99% of the cost variation is explained by the variable revenue passenger-miles. When an extra two year's data is added, the following equation was determined:

\[
\text{Total Cost ($/year)} = 41270 + 0.5744 \times (\text{Revenue passenger originations}) + 0.006403 \times (\text{Revenue passenger-miles})
\]

(1962-66)
\[R = 0.9930\] , \[F - \text{Ratio} = 4137.12\], \[\text{Std. error of est.} = 2.4 \times 10^6\]
APPENDIX B - LOCAL STATION EXPENSES

This appendix describes the analyses performed on local station expenses as an annual cost. Various regression models and years of data are described for the data covering selected carrier terminals given in Part I of this report.

The measures of individual station activity which are easily available are:

1) Enplanements/year
2) Originations/year
3) Number of station employees
4) Tons of cargo shipped/year
5) Aircraft departures/year

Because of the high degree of correlation between enplanements and originations, it was decided to only use data on enplanements as a preferable measure of station passenger flow. A secondary measure enplanements/departure was also used in some regressions.

The data used in these analyses is rather suspect to deficiencies or non-standardization of airline reporting practice. On very close inspection of the data, it is possible to spot that two stations may have the same number of aircraft departures and/or enplanements, yet their station costs may vary by as much as a factor of four. There are a number of reasons for this:

1) Airlines tend to spend different amounts at different stations for competitive reasons. American may spend more at JFK on passenger service than say at Houston, or employ more
baggage handlers or ramp attendants per departure.

(2) Some large stations are bases for the flight crews. These stations would have extra expense which cannot be correlated to any of the traffic statistics under investigation.

(3) The landing fees are different at different stations. For a Boeing 707 or DC-8 aircraft, the landing charges are shown for a few terminals.

<table>
<thead>
<tr>
<th>Station</th>
<th>Landing Charges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anchorage</td>
<td>$ 95</td>
</tr>
<tr>
<td>Baltimore</td>
<td>$ 35</td>
</tr>
<tr>
<td>Boston</td>
<td>$ 55</td>
</tr>
<tr>
<td>Chicago (O'Hare)</td>
<td>$ 95</td>
</tr>
<tr>
<td>Honolulu</td>
<td>$450</td>
</tr>
<tr>
<td>Houston</td>
<td>$ 28</td>
</tr>
<tr>
<td>Miami</td>
<td>$ 94</td>
</tr>
<tr>
<td>New York (JFK)</td>
<td>$ 88</td>
</tr>
<tr>
<td>San Francisco</td>
<td>$ 48</td>
</tr>
<tr>
<td>Washington, DC</td>
<td>$ 68</td>
</tr>
</tbody>
</table>
B.1 Linear Regression Models

In this section, a linear regression model will be used to estimate yearly station expenses (Aircraft and Traffic Servicing, Account 6400) in terms of the output data available for the individual stations.

B.1.1 Variables Tested Graphically

Number of revenue passenger enplanements/station year
Number of revenue passenger originations/station year
Total revenue departures/station year
Number of station employees
Tons of cargo handled/station year

Local Service Airlines

Figures B-1 and B-2 are the plots of local station expense versus total departures and number of revenue passenger enplanements, respectively. Station expense per revenue departure is approximately $53 and station expense per passenger enplanement is approximately $2.75.

Domestic Trunk Carriers

For graphical analysis, the domestic trunk carriers were divided into two groups.

<table>
<thead>
<tr>
<th>The Big Four</th>
<th>The Other Seven</th>
</tr>
</thead>
<tbody>
<tr>
<td>American</td>
<td>Braniff</td>
</tr>
<tr>
<td>Eastern</td>
<td>Continental</td>
</tr>
<tr>
<td>Trans World</td>
<td>Delta</td>
</tr>
<tr>
<td>United</td>
<td>National</td>
</tr>
<tr>
<td></td>
<td>Northwest</td>
</tr>
<tr>
<td></td>
<td>Northeast</td>
</tr>
<tr>
<td></td>
<td>Western</td>
</tr>
</tbody>
</table>
FIGURE B1  STATION EXPENSES—LOCAL AIRLINES—1965

FIGURE B2  STATION EXPENSES—LOCAL AIRLINES—1965
Plots of local station expense versus revenue passenger enplanements and total revenue departures are shown in Figures B-3 to B-6 for both groups of domestic trunk carriers. There is no obvious correlation, but a trend does exist in each case.

The "Big Four" Domestic Trunk Carriers

From Figures B-3 and B-4, station expense per departure $220. and station expense per passenger enplanement is approximately $6.

It is instructive to note the following example from the data reported by airlines on local station expense in a multi-airport city such as New York. Eastern, in 1965, carried 20% more passengers with 3% more departures at John F. Kennedy than at Newark. Yet their reported total station expense was more than 100% greater at John F. Kennedy.

The "Other Seven" Domestic Trunk Carriers

From Figures B-5 and B-6, station expense per revenue departure is approximately $130 and station expense per passenger enplanement is approximately $4.

B.1.2 Regression Equations - Local Station Expense

Local Carriers

Station Cost ($/year) = 29080
+ 272 (Station Employees)
+ 2.73 (Enplanements/year)

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By locking out station employees, we get

\[ \text{Station Cost ($/year)} = 30,400 + 2.84 \text{ (Enplanements/year)} \]

(1962-65)

\[ R = .947, \; F = 4492, \; \text{Std. Error} = 61.2 \times 10^3 \text{ ($/year)} \]

**Domestic Carriers**

\[ \text{Station Cost ($/year)} = 168060 + 1.76 \text{ (Enplanements/year)} + 202.8 \text{ (Tons of cargo/year)} \]

(1962-65)

\[ R = 0.918, \; F = 1431, \; \text{Std. Error} = .972 \times 10^6 \text{ ($/year)} \]

By locking out Tons of Cargo/year as an independent variable, and introducing E/D = enplanements/departure as a new variable, the following equation is obtained.

\[ \text{Station Cost ($/year)} = -371,240 + 4.94 \text{ (Enplanements/year)} + 13593 \text{ (Enpl./departure)} \]

(1962-1966)

\[ R = 0.852, \; F = 708, \; \text{Std. Error} = 1.28 \times 10^6 \text{ ($/year)} \]
B.2 Logarithmic Regression Models

It was decided that other possible forms of cost estimating equations should also be investigated. Here we present a linear regression on the logarithm of the values:

\[
\ln (\text{Cost}) = a_0 + a_1 \ln(\text{Departures/year} = D) \\
+ a_2 \ln(\text{Enplanements/year} = E) \\
+ a_3 \ln(\text{No. Station Employees} = N) \\
+ a_4 \ln(\text{Tons of cargo/year} = C)
\]

which results in a cost estimating equation of the form

\[
\text{Cost} = A_0 (D)^{a_1} (E)^{a_2} (N)^{a_3} (C)^{a_4}
\]

For the five year period 1962-66, the results are:

\[
\text{Cost/\text{year}} = 2020 (E)^{.174} (N)^{.472} (C)^{.207}
\]

\[
R = 0.927, \quad F = 1087
\]

With this form of equation, the best fit equations for cost/departure or cost/enplanement are easily found by dividing through by these variables.

B.3 Regression Classified by Station Size

It was proposed that it might be possible to obtain higher accuracy if we were to study the terminals according to their size. This suggested that we might run two
regressions, one on the very large terminals and another on the medium sized terminals.

The first difficulty which arises is the definition of a large terminal and a medium sized terminal. Reference was made to the Federal Aviation Administration classification on this point. This did not produce satisfactory answers since all it showed was a list of airports (not stations or terminals) to be considered large. At a given airport, a station A may be very large for airline X and medium or even small for airline Y. Hence a different solution was sought.

It was suggested that the only reasonable way was to examine each case individually and make an arbitrary judgement as to which of the stations were large for any airline. The rule used for any airline station was:

<table>
<thead>
<tr>
<th>Station</th>
<th>Departures/year</th>
<th>Enplanements/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>10,000 and/or</td>
<td>300,000</td>
</tr>
<tr>
<td>Medium</td>
<td>4,000 and/or</td>
<td>100,000</td>
</tr>
<tr>
<td>Small</td>
<td>4,000 and/or</td>
<td>30,000</td>
</tr>
</tbody>
</table>

On this basis of classification the large stations were separated out from the list of total stations. A linear model regression analysis was then carried out. The result is as shown below.
Large Station Costs - Domestic Airlines - 1962

Station Cost ($/year) = 12064
  + 10.36 (Station Employees)
  - 1.325 (Departures)
  + 15.824 (Enplanements)
  + 59.92 (Tons of Cargo)

R = .871
F-Test (4,54) = 42.67
D-W = 1.7975

or, in logarithmic form, for cost per departure

Y = 5.190387 + 0.213526 X4 - 0.000208 X3
   + 0.315188 X5 + 0.329530 X6

Where Y = log of station cost per departure
  C = constant
  X3 = log of departures
  X4 = log of enplanements per departure
  X5 = log of tons of cargo per departure
  X6 = log of station employees per departure
  R = 0.820
F-Test (4,54 = 27.548
D-W = 1.5869