FORECASTING GENERAL AVIATION ACTIVITY IN MICHIGAN

report to

AERONAUTICS COMMISSION
MICHIGAN DEPARTMENT OF COMMERCE

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Arthur D. Little, Inc.

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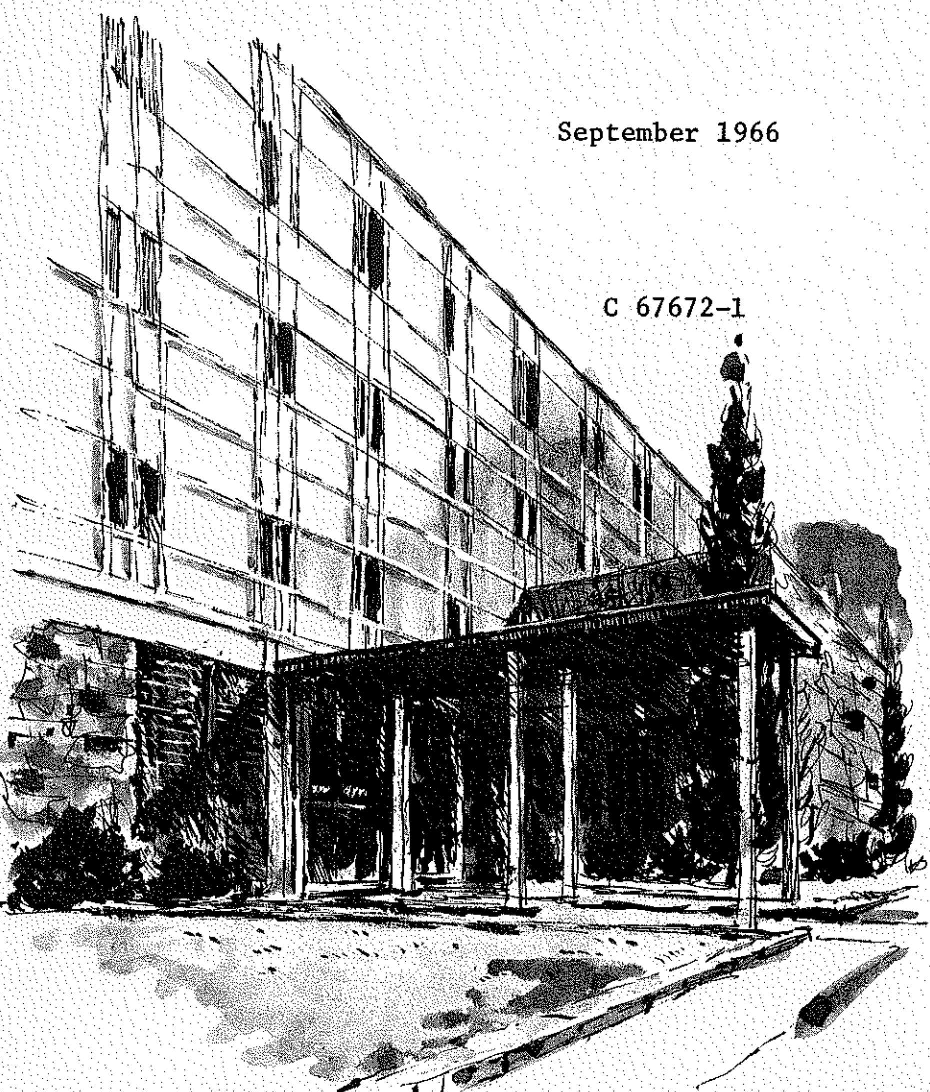

Arthur D. Little, Inc.

This is one of several studies and reports prepared as part of the State Resource Planning Program. This program is an inter-departmental planning function to assist the State of Michigan in taking advantage of the opportunities and meeting the needs arising from future growth.

The preparation of this document was financially aided through a Federal grant from the Urban Renewal Administration of the Housing and Home Finance Agency, under the Urban Planning Assistance Program authorized by Section 701 of the Housing Act of 1954, as amended, and as authorized by the Governor's Interdepartmental Resource Development Committee of the State of Michigan, administered by the Michigan Department of Commerce, Office of Economic Expansion.

TABLE OF CONTENTS

INTRODUCTION

This report is prepared for the Michigan Department of Economic Expansion under Contract Number P-52-(4A), dated September 1, 1965. It is the result of consulting services provided to the Department of Aeronautics to achieve:

1. The application of extrapolation and projection techniques to Fact-Finder and other data to forecast the demand for aviation facilities in Michigan.
2. The continued development of Fact Finder Survey Techniques.

ACKNOWLEDGMENTS

The research program undertaken under this contract presented one major difficulty: nothing comparable had been undertaken before. As a result many different ideas had to be tested and rejected before meaningful relationships between aviation and other factors could be established. This fact meant that enormous amounts of data had to be collected and analyzed.

In both the planning and the execution of this work the contribution of Mr. Edward Mellman was invaluable. Without his assistance the project could not have been completed. We also wish to thank Mr. James Ramsey, Mr. Lester Andrews, and Mr. William Hamlen of the Aeronautics Commission for their hospitality and unfailing encouragement throughout the course of the research.

At Arthur D. Little, Inc., the regression program was in the hands of Mr. Thomas Domencich and Miss Patricia Cawunder whose persistence in the face of adversity is responsible for the final success of our efforts.

CONCLUSIONS

1. The number of aircraft based in a county can be expressed as a function of the population over 25 years old with some college education, or of disposable income.

2. The number of operations, both local and itinerant, correlates with the number of based aircraft. The correlations vary for the two types of flying, and they also vary depending on whether or not the airport is served by an airline.

3. The forecasting techniques developed in this study will yield serviceable forecasts for the level of general aviation in Michigan counties. However, practical improvements in data in the future will substantially refine these forecasts and increase their reliability.

4. Statistics can be developed to identify airports and counties which appear to be deficient in aviation facilities.

Background to the Forecast Problem

At the time that this study began there was no successful method for forecasting aviation activity. Even in the case of airline traffic, for which admirable data are available, forecasts have been right more by luck than good judgment. For example, the latest regression analysis of airline traffic by the Civil Aeronautics Board, produced maximum annual growth rates for domestic air travel of just over 10% for 1965 and 1966. The actual growth rates have been over 16%. It ought to have worked, but it did not. Conversely, a forecast made by Canadair in 1956, using a new approach, proved almost exactly accurate in 1965.

In the field of general aviation the record is even worse. The so-called Curtis Report[1/] published in 1957, forecast a total general aviation fleet of 73,000 aircraft in 1965; whereas, it was in fact 88,742. However, the amount of general aviation flying hours forecast by that report for 1965 was, by chance, extremely accurate. The Federal Aviation Agency admits to the simple projection of time series, and the data in the time series are, themselves, seriously open to question.

The problem of forecasting general aviation activity was discussed with Mr. Herbert Guth, Chief, Economics Division, Office of Policy Development of the Federal Aviation Agency. The consulting company Mathematica is currently conducting a cost-benefit analysis of general aviation for the FAA, but at the time of our visit, no results of the study were yet available.

The most serious problem to be overcome when forecasting general aviation acitivity is the lack of data. Records of general aviation are only kept at airports where there are FAA control towers. In Michigan where there are 136 licensed airports, only 11 have towers, and 3 of these serve Detroit.

1/ "National Requirements for Aviation Facilities: 1956-1957," prepared by Aeronautical Research Foundation for Mr. Edward P. Curtis, Special Assistant to The President for Aviation Facilities Planning.

Recognizing this statistical gap, the Michigan Aeronautics Commission launched its Fact Finder Survey in the summer of 1962. Although one of the purposes of the survey was to determine the economic contribution of general aviation, from the point of view of forecasting its attempt to quantify general aviation activity at each airport was of greater importance. The counts were made during the Fact Finder Week, July 28-August 3, at which a team of 2000 individuals counted all operations at every airport. Operations were divided into "local" and "itinerant," and the immediate origin and destination of itinerant operations were recorded.

One obvious problem facing the Commission was the fact that the operations counted in the Fact Finder Week at each airport could not be directly compared. Weather may have been bad in one part of the State and good in another. One airport might be serving a coastal summer resort, with a high level of activity during a week in mid-summer; whereas, another might serve a ski resort with its peak activity in the winter when the first airport might be completely closed down. Due to the unknown effects of both weather and seasonal factors, which varied from airport to airport, the survey suffered from a lack of control. This weakness is inherent in the technique, and there was nothing the Commission could have done to alleviate the problem beyond recognizing its existence.

A second problem appeared when analyzing the data on itinerant operations. Very often the number of flights reported by the observer at airport A to have departed for airport B was different from the number reported by the observer at airport B to have arrived from airport A. A method was formulated by Dr. Feldman at Michigan State University to make corrections for these discrepancies, but, although the attempt had to be made, we question whether the quality of the data was in fact improved. Dr. Feldman's method was discussed and amendments to it suggested in our Working Memoranda KKM-5 and TAD-6 of October 16, 1964. In our successful regressions, we used raw fact finder data, annualized by multiplying by 37, but without Dr. Feldman's corrections. It is uncertain whether the results would have been better with the corrections; we do know they were very satisfactory without them.

In summary, then, although some general aviation information now existed, as a result of the Fact Finder Survey, where previously there had been none, its quality in terms of accuracy and comparability was far from ideal.

The Regressions

Because data were available from the Fact Finder Survey concerning general aviation throughout Michigan, it was first decided to attempt to correlate these data with various socio-economic data on a county basis.[1/] Local and itinerant operations in each county, as obtained from the survey, corrected by Dr. Feldman's program, and expanded by a factor of 37, were correlated separately with the following variables:

- Population
- White population
- Population in professional employment
- Population over 25 years old
- Population over 25 years old with some college
- Median school years completed
- Number of employed
- Disposable income
- Households with incomes over $10,000
- Retail sales
- Value added by manufacture
- Diversification index.

In other words, we tried to find a cause and effect relationship between factors which could logically be expected to affect the level of flying, on the one hand, and the actual level of flying on the other hand. A list of the attempts, and their results, is shown in Appendix A.

In these attempts either the signs of the coefficients were contrary to logic (e.g., in the first example the number of operations is shown as correlating negatively with percent of household with incomes over $10,000), or the r^2's [2/] were too low. Although the value of r^2

1/ These correlations were made by means of multiple linear regressions. For a brief explanation of this technique see Appendix C.

2/ The square of the coefficient of correlation, which is a reflection of the degree to which all the independent variables are related to the dependent variables.

alone is not an adequate test of the fit of a regression, generally speaking an r^2 less than 0.7 means that the fit is unsatisfactory.

What is wrong? First of all, this was a so-called cross-section regression in which the effect of the passage of time was not included. (It could not be included because we only had measurements for one point in time--the Fact Finder Week.) Difficulties 1/ in relating the data collected in 1964 for 10 airports, and in 1965 for 36 airports, to the data for the same airports collected in 1962, precluded the possibility of obtaining useful growth rates over time.

Secondly, the annualized data for the dependent variable were questionable. And thirdly, we omitted an important independent variable--based aircraft.

In order to attempt to measure the affect of time, we decided to sample tower airports throughout the country where consistent records are kept from year to year of general aviation operations. The eleven tower airports in Michigan did not constitute a big enough sample for our purposes.

Accordingly, a sample of 66 2/ tower airports was selected at random across the continental United States, and data were collected from 1953 to 1964 on their local and itinerant general aviation activities, as well as on 12 different socio-economic characteristics of the counties they served. Our hope was that we could at least derive a formula from these tower data to enable us to predict growth rates to be applied to better, basic non-tower data as they become available. Unfortunately, despite a tremendous effort on the part of the Commission staff in collecting the data, the results were again unuseable. Probably the causes of the low r^2's were the great variations in climate and "wide-openness" across the United States, whose affect on flying could not be taken into account. At any rate, the various time series seemed to form clusters rather than one clear pattern.

1/ The weather during the week surveyed was not the same in each year, and in 1965 the survey was conducted throughout the summer, not just during the Fact Finder Week.

2/ This number was eventually reduced to 43 by the elimination of those airports which had not had towers for the whole period.

Meanwhile hand plots of based aircraft against population and other data, and of operations against based aircraft, were beginning to show good results. (See our Working Memorandum MDD-3 of 21 January 1966.) At a meeting in Lansing on January 25, 1966, it was decided to make one more effort to find meaningful relationships between the socio-economic characteristics of Michigan counties and the level of general aviation activity. A program was laid out in our Working Memorandum MDD-4A, the data were collected, and the regressions were run at the Computer Laboratory of Michigan State University. Briefly, the program was designed first to relate based aircraft to time (1954-1964) and socio-economic data, and then to relate operations, local and itinerant separately at tower airports in Michigan and her five contiguous states, to based aircraft, for the latest year for which data were available, i.e., 1964. The socio-economic characteristics tested in the first part were reduced to those which had shown some promise in the past, i.e., population, population over 25 years old with some college, and disposable income.

The first part of this program was extremely successful, with r^2's running over 0.9. (See Appendix B, Tables I through VIII.) Population over 25 years old with some college and disposable income proved to be very significant, and, surprisingly, the passage of time seemed to be swamped by these two variables.

Although no one formula in the series can be unquestionably selected as the best, we have selected two as being very promising:

IV.13 $$X(3) = \underset{(0.621)}{5.61} + \underset{(0.00226)}{0.217}\, X(5)$$

$$r^2 = 0.9110; \quad F = 91651; \quad \overline{X}(3) = 32; \quad \sigma X(3) = 16.65$$

IV.14 $$X(3) = \underset{(0.639)}{4.51} + \underset{(0.000105)}{0.00980}\, X(6)$$

$$r^2 = 0.9071; \quad F = 8752; \quad \overline{X}(3) = 32; \quad \sigma X(3) = 17.01$$

where

X(3) = Based Aircraft

X(5) = Disposable Income (Millions)

X(6) = Population over 25 years with some college

Either of these two formulae could be used alone to forecast based aircraft, but if forecasts become available for both of the independent variables, i.e., disposable income and population over 25 years with some college, then both formulae could be used and the results compared.

Formula IV.1 had a very slightly higher r^2 (0.9157) than the two chosen, but the coefficient for X(1), i.e., time, was negative, which is contrary to logic.

The regressions of operations against based aircraft, the second part of the program run at Michigan State, proved to be a disappointment, with r^2's below 0.4. These were regressions designed to relate operations at tower airports in Michigan, and her five contiguous states, with aircraft based at these airports. A regression of itinerant operations against based aircraft and county socio-economic data in the six states did yield high r^2's, but on closer examination these proved to be false correlations. To simplify what happened, there were two clusters of observations which it was possible to join with a line, like a dumbbell, and this pattern gave the statistical appearance of a well-defined trend which in fact did not exist. The results were therefore discarded.

In Cambridge, we decided to try again and see if any relationships could be found between local and itinerant operations in Michigan counties, as measured by the Fact Finder Survey, and some eight other factors, including based aircraft. The factors tested were:

- Based aircraft
- Households with incomes over $25,000
- Population over 25 years with some college
- Retail sales
- Number of airports in county 1/
- Sqaure miles of county per airport
- Miles to nearest air carrier airport
- Number of scheduled flights per day at nearest air carrier airport.

1/ The influence of the number of airports in a county on the level of operations in that county could not be assessed from this regression. This is not to say that this factor is not significant, but only that we cannot prove it from the data.

The most successful results were obtained when the counties were separated into two groups: those having air carrier airports, and those without air carrier airports. However, it was found that the number of based aircraft in a county was the only really significant variable. Although slightly higher r^2's were obtained, if one or more of the other variables were included, we decided against adopting the resultant formulae in view of the uncertainties introduced by the requirement that additional forecasts be derived for these other variables in order to forecast the independent variable. The formulae adopted are as follows:

TABLE 1

OPERATIONS vs BASED AIRCRAFT

Local Operations - Non-Air Carrier Airports

$y = 552\ X(1)$

$F = 235.5 \quad \bar{y} = 7805; \quad \sigma y = 5{,}104; \quad r^2 = 0.858$

Local Operations - Air Carrier Airports

$y = 866 + 656\ X(1)$

$F = 145{\cdot}6; \quad \bar{y} = 696{,}701; \quad \sigma y = 35{,}100; \quad r^2 = 0.858$

Itinerant Operations - Non-Air Carrier Airports

$y = 1536 + 338\ X(1)$

$F = 164.0; \quad \bar{y} = 7{,}282; \quad \sigma y = 2{,}740; \quad r^2 = 0.800$

Itinerant Operations - Air Carrier Airports

$y = 525 + 411\ X(1)$

$F = 347.6; \quad \bar{y} = 4{,}333; \quad \sigma y = 1{,}424; \quad r^2 = 0.935$

Notes: 1. X(1) = Based aircraft
y = Operations

2. Macomb and Washtenaw Counties were included in "Air Carrier" counties in view of their nearness to Ann Arbor and Detroit.

For the Future

The most pressing need for the future is to refine the data relating to general aviation activity at non-tower airports. Differences in seasonality, variations in the weather, and human error, make the technique of a periodic one-week survey statistically vulnerable as an indicator of the annual level of traffic. Our Working Memorandum KKM-1 of January 3, 1966, dealt with this problem and we have little to add to it at this time, save to reemphasize that for at least the first year of their availability, the counters should be left for a full year at airports chosen at random. The one-week survey is a much more reliable technique for sampling expenditures, purpose of trip, et cetera and should be continued for this purpose.

It would also be interesting to rate Michigan airports, in terms of their facilities, and to compare each score to the annual operations. The airports could thus be ranked in order of need, those airports with the lowest score: operations ratios being in the greatest apparent need. The Michigan ratios could also be compared with those of contiguous states; one would expect that this exercise would demonstrate Michigan's airport superiority. This subject was discussed in our Working Memorandum written in Lansing on October 14, 1965. Another useful exercise would be to identify those counties which have fewer aircraft than the norm on the basis of disposable income or the adult college population. This information could be used as an argument that, perhaps, these counties should be doing more to provide facilities for aircraft.

We should like to repeat here that the forecasts and the score ratios cannot prove that a certain improvement or addition is needed in a given county or at a specific airport. All the statistics will do is indicate which airports or counties, either now or at some forecast year, appear to be deficient by today's standards. This is as far as the figures can take you. Once a county or an airport is identified by the statistics as requiring attention, your own knowledge or a local inspection should indicate what needs to be done.

One final note: The research program commenced by the Department of Aeronautics is a valuable step forward. However, it is most important that continuity be maintained. If the work does not continue under the direction of those who are familiar with it, then it might as well not have been begun.

APPENDIX A

APPENDIX A

DISCARDED REGRESSIONS - MICHIGAN COUNTIES

		R^2
1.	Itinerant operation vs population, retail sales, % households with incomes over $10,000(-), population over 25 years with some college, disposable income (-).	0.317
2.	Ditto, excluding counties served by airlines	0.166
3.	Itinerant operations vs population, retail sales, % of households with incomes over $10,000(-), professional employment(-) (counties served by airlines only).	0.845
4.	Itinerant operations vs population, retail sales and % of households with incomes over $10,000(-) (counties served by airlines only, but excluding Pellston).	0.636
5.	Itinerant operations vs. population, population of 25 years old with some college, households with incomes over $10,000, retail sales, diversification index, disposable income(-), (excluding counties served by airlines).	0.570
6.	Ditto, but also excluding tourist counties.	0.365
7.	Itinerant operations vs. population, population over 25 years old with some college, and % of households with incomes greater than $10,000.	0.501
8.	All operations vs. population, retail sales, and disposable income (-).	0.746

APPENDIX B

APPENDIX B

TABLE I

MICHIGAN AERONAUTICS COMMISSION

Regression Results

Based Aircraft vs. Time and County Socio-Economic Factors in Michigan

I - "All 83 Counties"

Regression Number

I. 1 $X(3) = 7.53 + 0.588\,X(1) + 0.0000858\,X(4) - 0.000119\,X(5) + 0.00984\,X(6)$

(2.23) (0.283) (0.0000355) (0.0000210) (0.000612)

$r^2 = 0.8501$ $F = 1401$ $\bar{X}(3) = 35.51$ $\sigma X(3) = 29.67$

I. 2 $X(3) = 13.8 + 0.516\,X(1)\ 0.00000191\,X(4) + 0.0000998\,X(5)$

(2.47) (0.318) (0.0000394) (0.0000179)

$r^2 = 0.8108$ $F = 1413$ $\bar{X}(3) = 35.51$ $\sigma X(3) = 33.31$

I. 3 $X(3) = 9.78 + 0.404\,X(1) - 0.0000759\,X(5) + 0.00962\,X(6)$

(2.03) (0.273) (0.0000112) (0.000606)

$r^2 = 0.8492$ $F = 1856$ $\bar{X}(3) = 35.51$ $\sigma X(3) = 29.74$

I. 4 $X(3) = 11.6 + 0.0000661\,X(4) - 0.000109\,X(5) + 0.00982\,X(6)$

(1.11) (0.0000342) (0.0000205) (0.000613)

$r^2 = 0.8494$ $F = 1860$ $\bar{X}(3) = 35.51$ $\sigma X(3) = 29.72$

I. 5 $X(3) = 12.7 + 0.241\,X(1) - 0.0000842\,X(4) + 0.00759\,X(6)$

(2.07) (0.281) (0.0000192) (0.000473)

$r^2 = 0.8452$ $F = 1800$ $\bar{X}(3) = 35.51$ $\sigma X(3) = 30.13$

I. 6 $X(3) = 8.37 + 0.996\,X(1) + 0.000221\,X(4)$

(2.30) (0.310) (0.00000346)

$r^2 = 0.8049$ $F = 2042$ $\bar{X}(3) = 35.51$ $\sigma X(3) = 33.81$

I. 7 $X(3) = 13.8 + 0.512\,X(1) + 0.000101\,X(5)$

(2.26) (0.306) (0.00000155)

$r^2 = 0.8108$ $F = 2122$ $\bar{X}(3) = 35.51$ $\sigma X(3) = 33.30$

I. 8 $X(3) = 11.3 + 0.441\,X(1) + 0.00555\,X(6)$

(2.06) (0.279) (0.0000764)

$r^2 = 0.8422$ $F = 2642$ $\bar{X}(3) = 35.51$ $\sigma X(3) = 30.41$

APPENDIX B

TABLE I, Cont'd

MICHIGAN AERONAUTICS COMMISSION

Regression Results

Based Aricraft vs. Time and County Socio-Economic Factors in Michigan

I - "All 83 Counties"

Regression Number

I. 9 $X(3) = \underset{(1.17)}{17.3} - \underset{(0.0000380)}{0.0000153}\ X(4) + \underset{(0.0000173)}{0.000108}\ X(5)$

$r^2 = 0.8103 \quad F = 2115 \qquad \bar{X}(3) = 35.51 \quad \sigma X(3) = 33.34$

I. 10 $X(3) = \underset{(1.000)}{14.2} - \underset{(0.0000190)}{0.0000868}\ X(4) + \underset{(0.000466)}{0.00765}\ X(6)$

$r^2 = 0.8451 \quad F = 2700 \qquad \bar{X}(3) = 35/5; \quad \sigma X(3) = 30.13$

I. 11 $X(3) = \underset{(1.02)}{12.4} - \underset{(0.0000112)}{0.0000763}\ X(5) + \underset{(0.000607)}{0.00964}\ X(6)$

$r^2 = 0.8489 \quad F = 2780 \qquad \bar{X}(3) = 35.51 \quad \sigma X(3) = 29.76$

I. 12 $X(3) = \underset{(1.13)}{14.8} + \underset{(0.00000347)}{0.000221}\ X(4)$

$r^2 = 0.8029 \quad F = 4036 \qquad \bar{X}(3) = 35.51 \quad \sigma X(3) = 33.97$

I. 13 $X(3) = \underset{(1.09)}{17.1} + \underset{(0.00000155)}{0.000101}\ X(5)$

$r^2 = 0.8103 \quad F = 4233 \qquad \bar{X}(3) = 35.51 \quad \sigma X(3) = 33.33$

I. 14 $X(3) = \underset{(1.01)}{14.2} + \underset{(0.0000764)}{0.00555}\ X(6)$

$r^2 = 0.8418 \quad F = 5274 \qquad \bar{X}(3) = 35.51 \quad \sigma X(3) = 30.43$

I. 15 $(3) = \underset{(5.16}{27.0} + \underset{(0.701)}{1.31}\ X(1)$

$r^2 = 0.0035 \quad F = 3 \qquad \bar{X}(3) = 35.51 \quad \sigma X(3) = 76.38$

APPENDIX B

TABLE II

MICHIGAN AERONAUTICS COMMISSION

Regression Results

Based Aircraft vs. Time and County Socio-Economic Factors in Michigan

II - "All 83 Counties Minus Wayne"

Regression Number

II. 1

$$X(3) = 4.26 - 0.00293\,X(1) + 0.000112\,X(4) + 0.000131\,X(5) + 0.00138\,X(6)$$

(1.69) (0.203) (0.0000392) (0.0000269) (0.000800)

$r^2 = 0.8450$ F = 1330 $\bar{X}(3) = 29.29$ $\sigma X(3) = 20.46$

II. 2

$$X(3) = 4.95 - 0.0616\,X(1) + 0.000101\,X(4) + 0.000167\,X(5)$$

(1.64) (0.200) (0.0000387) (0.0000175)

$r^2 = 0.8445$ F = 1769 $\bar{X}(3) = 29.29$ $\sigma X(3) = 20.48$

II. 3

$$X(3) = 6.84 - 0.192\,X(1) + 0.000190\,X(5) + 0.00100\,X(6)$$

(1.43) (0.192) (0.0000176) (0.000792)

$r^2 = 0.8437$ F = 1758 $\bar{X}(3) = 29.29$ $\sigma X(3) = 20.54$

II. 4

$$X(3) = 4.23 + 0.000112\,X(4) + 0.000131\,X(5) + 0.00139\,X(6)$$

(0.865) (0.0000370 (0.0000253) (0.000788)

$r^2 = 0.8450$ F= 1776 $\bar{X}(3) = 29.29$ $\sigma X(3) = 20.45$

II. 5

$$X(3) = 0.212 + 0.326\,X(1) + 0.000257\,X(4) + 0.00435\,X(6)$$

(1.49) (0.193) (0.0000258) (0.000527)

$r^2 = 0.8412$ F = 1726 $\bar{X}(3) = 29.29$ $\sigma X(3) = 20.70$

II. 6

$$X(3) = -2.71 + 0.547\,X(1) + 0.000464\,X(4)$$

(1.50) (0.198) (0.00000674)

$r^2 = 0.8301$ F = 2390 $\bar{X}(3) = 29.29$ $\sigma X(3) = 21.40$

II. 7

$$X(3) = 7.16 - 0.222\,X(1) + 0.000211\,X(5)$$

(1.41) (0.191) (0.00000292)

$r^2 = 0.8435$ F = 2635 $\bar{X}(3) = 29.29$ $\sigma X(3) = 20.54$

II. 8

$$X(3) = 4.48 + 0.0914\,X(1) + 0.00944\,X(6)$$

(1.50 (0.201) (0.000139)

$r^2 = 0.8251$ F = 2306 $\bar{X}(3) = 29.29$ $\sigma X(3) = 21.72$

TABLE II, Cont'd

MICHIGAN AERONAUTICS COMMISSION

Regression Results

Based Aircraft vs. Time and County Socio-Economic Factors in Michigan

II - "All 83 Counties Minus Wayne"

Regression Number

II. 9 $X(3) = \underset{(0.851)}{4.52} + \underset{(0.0000368)}{0.000104}\ X(4) + \underset{(0.0000166)}{0.000165}\ X(5)$

$r^2 = 0.8445$ $F = 2656$ $\bar{X}(3) = 29.29$ $\sigma X(3) = 20.47$

II. 10 $X(3) = \underset{(0.794)}{2.34} + \underset{(0.0000257)}{0.000252}\ X(4) + \underset{(0.000522)}{0.00448}\ X(6)$

$r^2 = 0.8408$ $F = 2582$ $\bar{X}(3) = 29.29$ $\sigma X(3) = 20.72$

II. 11 $X(3) = \underset{(0.739)}{5.61} + \underset{(0.0000174)}{0.000187}\ X(5) + \underset{(0.000786)}{0.00110}\ X(6)$

$r^2 = 0.8436$ $F = 2637$ $\bar{X}(3) = 29.29$ $\sigma X(3) = 20.54$

APPENDIX B

TABLE III

MICHIGAN AERONAUTICS COMMISSION

Regression Results

Based Aircraft vs. Time and County Socio-Economic Factors in Michigan

III- "71 Counties Plus 5 Groups"

Regression No.

III. 1

$$X(3) = 15.9 + 0.000224X(4)$$
$$(1.21)(0.00000353)$$
$r^2 = 0.8153$ $F = 4003$ $\bar{X}(3) = 38.79$ $\sigma X(3) = 34.72$

III. 2

$$X(3) = 18.4 + 0.000102X(5)$$
$$(1.18)(0.00000158)$$
$r^2 = 0.8212$ $F = 4166$ $\bar{X}(3) = 38.79$ $\sigma X(3) = 34.16$

III. 3

$$X(3) = 15.1 + 0.00565X(6)$$
$$(1.05)(0.0000754)$$
$r^2 = 0.8609$ $F = 5614$ $\bar{X}(3) = 38.79$ $\sigma X(3) = 30.13$

III. 4

$$X(3) = 29.6 + 1.41X(1)$$
$$(5.69)(0.774)$$
$r^2 = 0.0037$ $F = 3$ $\bar{X}(3) = 38.79$ $\sigma X(3) = 80.63$

III. 5

$$X(3) = 6.95 + 0.642X(1) + 0.000101X(4) - 0.000154X(5)\ 0.0115X(6)$$
$$(2.23)(0.284)\quad (0.0000325)\quad (0.0000190)\quad (0.000576)$$
$r^2 = 0.8761$ $F = 1597$ $\bar{X}(3) = 38.79$ $\sigma X(3) = 28.49$

III. 6

$$X(3) = 13.9 + 0.628X(1) + 0.0000379X(4) + 0.0000849X(5)$$
$$(2.64)(0.340)\quad (0.0000388)\quad (0.0000177)$$
$r^2 = 0.8219$ $F = 1393$ $\bar{X}(3) = 38.79$ $\sigma X(3) = 34.12$

III. 7

$$X(3) = 9.78 + 0.405X(1) - 0.000105X(5) + 0.0113X(6)$$
$$(2.05)(0.275)\quad (0.0000107)\quad (0.000576)$$
$r^2 = 0.8747$ $F = 2107$ $\bar{X}(3) = 38.79$ $\sigma X(3) = 28.62$

III. 8

$$X(3) = 11.3 + 0.0000808X(4) - 0.000145X(5) + 0.0114X(6)$$
$$(1.11)(0.0000314)\quad (0.0000186)\quad (0.000578)$$
$r^2 = 0.8754$ $F = 2118$ $\bar{X}(3) = 38.79$ $\sigma X(3) = 28.55$

APPENDIX B

TABLE III Cont'd.

MICHIGAN AERONAUTICS COMMISSION

Regression Results

Based Aircraft vs. Time and County Socio-Economic Factors in Michigan

III- "71 Counties Plus 5 Groups"

Regression No.

III. 9 $X(3) = 14.2 + 0.151X(1) - 0.000118X(4) + 0.00850X(6)$
(2.12) (0.287) (0.0000188) (0.000462)
$r^2 = 0.8671$ F = 1968 $\bar{X}(3) = 38.79$ $\sigma X(3) = 29.49$

III. 10 $X(3) = 8.92 + 1.076X(1) + 0.000223X(4)$
(2.46) (0.331) (0.00000352)
$r^2 = 0.8174$ F = 2028 $\bar{X}(3) = 38.79$ $\sigma X(3) = 34.54$

III. 11 $X(3) = 14.9 + 0.538X(1) + 0.000102X(5)$
(2.42) (0.328) (0.00000158)
$r^2 = 0.8218$ F = 2088 $\bar{X}(3) = 38.79$ $\sigma X(3) = 34.12$

III. 12 $X(3) = 12.1 + 0.457X(1) + 0.00564X(6)$
(2.14) (0.289) (0.0000754)
$r^2 = 0.8613$ F = 2813 $\bar{X}(3) = 38.79$ $\sigma X(3) = 30.10$

III. 13 $X(3) = 18.2 + 0.0000185X(4) + 0.0000938X(5)$
(1.26) (0.0000374) (0.0000170)
$r^2 = 0.8213$ F = 2082 $\bar{X}(3) = 38.79$ $\sigma X(3) = 34.17$

III. 14 $X(3) = 15.1 - 0.000119X(4) + 0.00854X(6)$
(1.03) (0.0000185) (0.000455)
$r^2 = 0.8670$ F = 2954 $\bar{X}(3) = 38.79$ $\sigma X(3) = 29.47$

III. 15 $X(3) = 12.4 - 0.000105X(5) + 0.0113X(6)$
(1.03) (0.0000107) (0.000577)
$r^2 = 0.8744$ F = 3155 $\bar{X}(3) = 38.79$ $\sigma X(3) = 28.64$

APPENDIX B

TABLE IV

MICHIGAN AERONAUTICS COMMISSION

Regression Results

Based Aircraft vs. Time and County Socio-Economic Factors in Michigan

IV- "71 Counties Plus 5 Groups Minus Wayne"

Regression No.

IV. 1

$X(3) = 5.19 - 0.0958X(1) + 0.0316X(4) + 0.111X(5) + 0.00420X(6)$
(1.37) (0.168) (0.0279) (0.0200) (0.000622)
$r^2 = 0.9157$ $F = 2421$ $\bar{X}(3) = 32.02$ $\sigma X(3) = 16.24$

IV. 2

$X(3) = 7.30 - 0.278X(1) + 0.00547X(4) + 0.215X(5)$
(1.37) (0.170) (0.0284) (0.0131)
$r^2 = 0.9114$ $F = 3060$ $\bar{X}(3) = 32.02$ $\sigma X(3) = 16.64$

IV. 3

$X(3) = 5.97 - 0.156X(1) + 0.128X(5) + 0.00410X(6)$
(1.19) (0.159) (0.0136) (0.000616)
$r^2 = 0.9155$ $F = 3227$ $\bar{X}(3) = 32.02$ $\sigma X(3) = 16.25$

IV. 4

$X(3) = 4.52 + 0.0367X(4) + 0.107X(5) + 0.00426X(6)$
(0.692)0.0265 (0.0189) (0.000614)
$r^2 = 0.9156$ $F = 3230$ $\bar{X}(3) = 32.02$ $\sigma X(3) = 16.24$

IV. 5

$X(3) = 1.69 + 0.206X(1) + 0.145X(4) + 0.00686X(6)$
(1.24) (0.161) (0.0194) (0.000405)
$r^2 = 0.9127$ $F = 3113$ $\bar{X}(3) = 32.02$ $\sigma X(3) = 16.51$

IV. 6

$X(3) = -2.89 + 0.600X(1) + 0.463X(4)$
(1.39) (0.183) (0.00560)
$r^2 = 0.8848$ $F = 3432$ $\bar{X}(3) = 32.02$ $\sigma X(3) = 18.97$

IV. 7

$X(3) = 7.43 - 0.288X(1) + 0.217X(5)$
(1.19) (0.162) (0.00227)
$r^2 = 0.9113$ $F = 4595$ $\bar{X}(3) = 32.02$ $\sigma X(3) = 16.63$

IV. 8

$X(3) = 4.19 + 0.0507X(1) + 0.00980X(6)$
(1.23) (0.165) (0.000105)
$r^2 = 0.9072$ $F = 4372$ $\bar{X}(3) = 32.02$ $\sigma X(3) = 17.02$

TABLE IV, Cont'd

MICHIGAN AERONAUTICS COMMISSION

Regression Results

Based Aircraft vs. Time and County Socio-Economic Factors in Michigan

IV- "71 Counties Plus 5 Groups Minus Wayne"

Regression No.

IV. 9 $X(3) = 5.38 + 0.0196X(4) + 0.208X(5)$
(0.699)(0.0270) (0.0125)
$r^2 = 0.9111$ $F = 4580$ $\bar{X}(3) = 32.02$ $\sigma X(3) = 16.66$

IV. 10 $X(3) = 3.03 + 0.142X(4) + 0.00693X(6)$
(0.652)(0.0192) (0.000401)
$r^2 = 0.9126$ $F = 4665$ $\bar{X}(3) = 32.02$ $\sigma X(3) = 16.52$

IV. 11 $X(3) = 4.97 + 0.126X(5) + 0.00418X(6)$
(0.613)(0.0135) (0.000612)
$r^2 = 0.9154$ $F = 4840$ $\bar{X}(3) = 32.02$ $\sigma X(3) = 16.24$

IV. 12 $X(3) = 0.948 + 0.463X(4)$
(0.740) (0.00563)
$r^2 = 0.8834$ $F = 6779$ $\bar{X}(3) = 32.02$ $\sigma X(3) = 19.07$

IV. 13 $X(3) = 5.61 + 0.217X(5)$
(0.621 (0.00226
$r^2 = 0.9110$ $F = 9165$ $\bar{X}(3) = 32.02$ $\sigma X(3) = 16.65$

IV. 14 $X(3) = 4.51 + 0.00980X(6)$
(0.639) (0.000105)
$r^2 = 0.9072$ $F = 8752$ $\bar{X}(3) = 32.02$ $\sigma X(3) = 17.00$

IV. 15 $X(3) = 23.59 + 1.30X(1)$
(3.96) (0.538)
$r^2 = 0.0065$ $F = 5.8275$ $\bar{X}(3) = 32.02$ $\sigma X(3) = 55.65$

APPENDIX B

TABLE V

MICHIGAN AERONAUTICS COMMISSION

Regression Results

Based Aircraft vs. Time and County Socio-Economic Factors in Michigan V - "Non-Tourist, I.E. 71 Counties Plus 5 Groups Minus Wayne Minus 47 Tourist Counties (Aeronautics Choice)"

Regression No.

V. 1

$$X(3) = 14.9 - 0.783\,X(1) - 0.0481\,X(4) + 0.150\,X(5) + 0.00380\,X(6)$$

(3.45) (0.407) (0.0476) (0.0324) (0.000937)

$r^2 = 0.9017$ $F = 839$ $\bar{X}(3) = 62.23$ $\sigma X(3) = 23.69$

V. 2

$$X(3) = 18.7 - 1.18\,X(1) - 0.0869\,X(4) + 0.251\,X(5)$$

(3.39) (0.403) (0.0476) (0.0214)

$r^2 = 0.8973$ $F = 1069$ $\bar{X}(3) = 62.23$ $\sigma X(3) = 24.19$

V. 3

$$X(3) = 12.8 - 0.604\,X(1) + 0.125\,X(5) + 0.00399\,X(6)$$

(2.73) (0.366) (0.0204) (0.000918)

$r^2 = 0.9014$ $F = 1119$ $\bar{X}(3) = 62.23$ $\sigma X(3) = 23.69$

V. 4

$$X(3) = 9.21 - 0.00823\,X(4) + 0.122\,X(5) + 0.00424\,X(6)$$

(1.80) (0.0430) (0.0291) (0.000913)

$r^2 = 0.9007$ $F = 1110$ $\bar{X}(3) = 62.23$ $\sigma X(3) = 23.78$

V. 5

$$X(3) = 6.08 + 0.0666\,X(1) + 0.123\,X(4) + 0.00711\,X(6)$$

(2.96) (0.373) (0.0308) (0.000623)

$r^2 = 0.8959$ $F = 1053$ $\bar{X}(3) = 62.23$ $\sigma X(3) = 24.34$

V. 6

$$X(3) = -3.26 + 0.826\,X(1) + 0.462\,X(4)$$

(3.31) (0.427) (0.00982)

$r^2 = 0.8589$ $F = 1120$ $\bar{X}(3) = 62.23$ $\sigma X(3) = 28.30$

V. 7

$$X(3) = 15.0 - 0.882\,X(1) + 0.212\,X(5)$$

(2.74) (0.369) (0.00379)

$r^2 = 0.8963$ $F = 1591$ $\bar{X}(3) = 62.23$ $\sigma X(3) = 24.26$

V. 8

$$X(3) = 10.2 - 0.158\,X(1) + 0.00950\,X(6)$$

(2.83) (0.376) (0.000174)

$r^2 = 0.8914$ $F = 1511$ $\bar{X}(3) = 62.23$ $\sigma X(3) = 24.83$

V. 9

$$X(3) = 10.3 - 0.0301\,X(4) + 0.224\,X(5)$$

(1.83) (0.0439) (0.0196)

$r^2 = 0.8949$ $F = 1566$ $\bar{X}(3) = 62.23$ $\sigma X(3) = 24.43$

TABLE V, Cont'd

MICHIGAN AERONAUTICS COMMISSION

Regression Results

Based Aircraft vs. Time and County Socio-Economic Factors in Michigan
V - "Non-Tourist, I.E. 71 Counties Plus 5 Groups Minus Wayne Minus 47 Tourist Counties (Aeronautics Choice)"

Regression No.

V. 10

$$X(3) = \underset{(1.72)}{6.51} + \underset{(0.0304)}{0.122}\,X(4) + \underset{(0.000612)}{0.00713}\,X(6)$$

$r^2 = 0.8959$ F = 1584 $\bar{X}(3) = 62.23$ $\sigma X(3) = 24.31$

V 11

$$X(3) = \underset{(1.54)}{9.04} + \underset{(0.0201)}{0.118}\,X(5) + \underset{(0.000906)}{0.00426}\,X(6)$$

$r^2 = 0.9007$ F = 1669 $\bar{X}(3) = 62.23$ $\sigma X(3) = 23.75$

V. 12

$$X(3) = \underset{(8.27)}{46.9} + \underset{(1.12)}{2.36}\,X(1)$$

$r^2 = 0.0118$ F = 4 $\bar{X}(3) = 62.23$ $\sigma X(3) = 74.81$

V. 13

$$X(3) = \underset{(1.95)}{1.91} + \underset{(0.00983)}{0.463}\,X(4)$$

$r^2 = 0.8575$ F = 2221 $\bar{X}(3) = 62.23$ $\sigma X(3) = 28.41$

V. 14

$$X(3) = \underset{(1.58)}{9.66} + \underset{(0.00376)}{0.211}\,X(5)$$

$r^2 = 0.8947$ F = 3136 $\bar{X}(3) = 62.23$ $\sigma X(3) = 24.42$

V. 15

$$X(3) = \underset{(1.61)}{9.24} + \underset{(0.000173)}{0.00949}\,X(6)$$

$r^2 = 0.8914$ F = 3028 $\bar{X}(3) = 62.23$ $\sigma X(3) = 24.80$

APPENDIX B

TABLE VI

MICHIGAN AERONAUTICS COMMISSION

Regression Results

Based Aircraft vs. Time and County Socio-Economic Factors in Michigan

VI- "Non-Tourist I.E. 71 Counties Plus 5 Groups Minus Wayne

15 Tourist Counties (ADL Choice)"

Regression No.

VI. 1 X(3) = 7.00 -0.200X(1) + 0.0110X(4) + 0.122X(5) + 0.00406X(6)
(1.76) (0.212) (0.0322 (0.0228) (0.000695)
r^2 = 0.9115 F = 1834 $\bar{X}(3)$ = 38.94 σX(3) = 18.03

VI. 2 X(3) = 9.56 -0.426X(1) - 0.0192X(4) + 0.224X(5)
(1.75) (0.213) (0.0325) (0.0149)
r^2 = 0.9073 F = 2326 $\bar{X}(3)$ = 38.94 σX(3) = 18.44

VI. 3 X(3) = 7.33 -0.226X(1) + 0.128X(5) + 0.00402X(6)
(1.48) (0.198) (0.0152) (0.000686)
r^2 = 0.9115 F = 2449 $\bar{X}(3)$ = 38.94 σX(3) = 18.02

VI. 4 X(3) = 5.56 +0.0218X(4)+ 0.115X(5) + 0.00418X(6)
(0.903)(0.0301) (0.0212) (0.000683)
r^2 = 0.9114 F = 2446 $\bar{X}(3)$ = 38.94 σX(3) = 18.03

VI. 5 X(3) = 2.27 +0.209X(1) + 0.140X(4) + 0.00693X(6)
(1.56) (0.201) (0.0219 (0.000454)
r^2 = 0.9080 F = 2345 $\bar{X}(3)$ = 38.94 σX(3) = 18.38

VI. 6 X(3) = 3.50 +0.693X(1) + 0.462X(4)
(1.74) (0.229) (0.00648)
r^2 = 0.8779 F = 2568 $\bar{X}(3)$ = 38.94 σX(3) = 21.15

VI. 7 X(3) = 9.01 -0.383X(1) + 0.216X(5)
(1.48) (0.200) (0.00259)
r^2 = 0.9073 F = 3493 $\bar{X}(3)$ = 38.94 σX(3) = 18.43

VI. 8 X(3) = 5.26 +0.0301X(1)+0.00974X(6)
(1.53) (0.205) (0.000120)
r^2 = 0.9027 F = 3311 $\bar{X}(3)$ = 38.94 σX(3) = 18.89

TABLE VI Cont'd.

MICHIGAN AERONAUTICS COMMISSION

Regression Results

Based Aircraft vs. Time and County Socio-Economic Factors in Michigan
VI- "Non-Tourist I.E. 71 Counties Plus 5 Groups Minus Wayne
15 Tourist Counties (ADL Choice)"

Regression No.

VI. 9

$X(3) = 6.57 + 0.00265X(4) + 0.214X(5)$
$(0.910)(0.0307) \quad (0.0140)$
$r^2 = 0.9068 \quad F = 3473 \quad \bar{X}(3) = 38.94 \quad \sigma X(3) = 18.48$

VI. 10

$X(3) = 3.63 + 0.137X(4) + 0.00700X(6)$
$(0.845)(0.0217) \quad (0.000448)$
$r^2 = 0.9078 \quad F = 3516 \quad \bar{X}(3) = 38.94 \quad \sigma X(3) = 18.38$

VI. 11

$X(3) = 5.89 + 0.126X(5) + 0.00413X(6)$
$(0.781)(0.0150) \quad (0.000679)$
$r^2 = 0.9114 \quad F = 3671 \quad \bar{X}(3) = 38.94 \quad \sigma X(3) = 18.02$

VI. 12

$X(3) = 28.8 + 1.56X(1)$
$(4.79) \quad (0.651)$
$r^2 = 0.0080 \quad F = 6 \quad \bar{X}(3) = 38.94 \quad \sigma X(3) = 60.25$

VI. 13

$X(3) = 0.920 + 0.464X(4)$
$(0.957) \quad (0.00651)$
$r^2 = 0.8764 \quad F = 5068 \quad \bar{X}(3) = 38.94 \quad \sigma X(3) = 21.27$

VI. 14

$X(3) = 6.61 + 0.215X(5)$
$(0.791)(0.00258)$
$r^2 = 0.9068 \quad F = 6956 \quad \bar{X}(3) = 38.94 \quad \sigma X(3) = 18.47$

VI. 15

$X(3) = 5.45 + 0.00974X(6)$
$(0.816)(0.000120)$
$r^2 = 0.9027 \quad F = 6630 \quad \bar{X}(3) = 38.94 \quad \sigma X(3) = 18.87$

TABLE VII

MICHIGAN AERONAUTICS COMMISSION

Regression Results

Based Aircraft vs. Time and County Socio-Economic Factors in Michigan

VII - "47 Tourist Counties (Aeronautics Choice)"

Regression Number

VII. 1

$$X(3) = \underset{(0.849)}{1.11} - \underset{(0.0941)}{0.0199}\,X(1) - \underset{(0.0893)}{0.136}\,X(4) + \underset{(0.0483)}{0.269}\,X(5) + \underset{(0.00159)}{0.00490}\,X(6)$$

$r^2 = 0.7684$ $F = 462$ $\bar{X}(3) = 10.5$ $\sigma X(3) = 5.89$

VII. 2

$$X(3) = \underset{(0.855)}{1.01} + \underset{(0.0927)}{0.0404}\,X(1) - \underset{(0.0802)}{0.0120}\,X(4) + \underset{(0.0475)}{0.302}\,X(5)$$

$r^2 = 0,7645$ $F = 604$ $\bar{X}(3) = 10.05$ $\sigma X(3) = 5.94$

VII. 3

$$X(3) = \underset{(0.608)}{0.208} + \underset{(0.0733)}{0.0704}\,X(1) + \underset{(0.0315)}{0.213}\,X(5) + \underset{(0.00142)}{0.00379}\,X(6)$$

$r^2 = 0.7674$ $F = 614$ $\bar{X}(3) = 10.05$ $\sigma X(3) = 5.90$

VII. 4

$$X(3) = \underset{(0.423)}{0.959} - \underset{(0.0694)}{0.125}\,X(4) + \underset{(0.0404)}{0.263}\,X(5) + \underset{(0.00156)}{0.00483}\,X(6)$$

$r^2 = 0.7684$ $F = 617$ $\bar{X}(3) = 10.05$ $\sigma X(3) = 5.89$

VII. 5

$$X(3) = \underset{(0.618)}{-2.22} + \underset{(0.0808)}{0.267}\,X(1) + \underset{(0.0597)}{0.241}\,X(4) + \underset{(0.00160)}{0.00686}\,X(6)$$

$r^2 = 0.7555$ $F = 575$ $\bar{X}(3) = 10.05$ $\sigma X(3) = 6.05$

VII. 6

$$X(3) = \underset{(0.602)}{-2.97} + \underset{(0.0750)}{0.408}\,X(1) + \underset{(0.0123)}{0.492}\,X(4)$$

$r^2 = 0.7474$ $F = 827$ $\bar{X}(3) = 10.05$ $\sigma X(3) = 6.14$

VII. 7

$$X(3) = \underset{(0.550)}{0.916} + \underset{(0.0732)}{0.0489}\,X(1) + \underset{(0.00702)}{0.295}\,X(5)$$

$r^2 = 0.7645$ $F = 907$ $\bar{X}(3) = 10.05$ $\sigma X(3) = 5.93$

VII. 8

$$X(3) = \underset{(0.586)}{-1.34} + \underset{(0.0754)}{0.140}\,X(1) + \underset{(0.000328)}{0.0132}\,X(6)$$

$r^2 = 0.7484$ $F = 831$ $\bar{X}(3) = 10.05$ $\sigma X(3) = 6.13$

TABLE VII, Cont'd

MICHIGAN AERONAUTICS COMMISSION

Regression Results

Based Aircraft vs. Time and County Socio-Economic Factors in Michigan
VII - "47 Tourist Counties (Aeronautics Choice)"

Regression Number

VII. 9 $X(3) = 1.34 - 0.0334\ X(4) + 0.315\ X(5)$
(0.407) (0.0634) (0.0371)
$r^2 = 0.7644$ $F = 907$ $\bar{X}(3) = 10.05$ $\sigma X(3) = 5.93$

VII. 10 $X(3) = -0.564 + 0.164\ X(4) + 0.00900\ X(6)$
(0.365) (0.0555) (0.00147)
$r^2 = 0.7507$ $F = 842$ $\bar{X}(3) = 10.05$ $\sigma X(3) = 7.10$

VII. 11 $X(3) = 0.657 + 0.217\ X(5) + 0.00364\ X(6)$
(0.388) (0.0312) (0.00141)
$r^2 = 0.7671$ $F = 920$ $\bar{X}(3) = 10.05$ $\sigma X(3) = 5.90$

VII. 12 $X(3) = 6.67 + 0.521\ X(1)$
(1.08) (0.147)
$r^2 = 0.0218$ $F = 12$ $\bar{X}(3) = 10.05$ $\sigma X(3) = 12.08$

VII. 13 $X(3) = -0.373 + 0.495\ X(4)$
(0.375) (0.0126)
$r^2 = 0.7341$ $F = 1546$ $\bar{X}(3) = 10.05$ $\sigma X(3) = 6.30$

VII. 14 $X(3) = 1.212 + 0.295\ X(5)$
(0.325) (0.00693)
$r^2 = 0.7643$ $F = 1816$ $\bar{X}(3) = 10.05$ $\sigma X(3) = 5.93$

VII. 15 $X(3) = -0.487 + 0.0132\ X(6)$
(0.367) (0.000326)
$r^2 = 0.7469$ $F = 1652$ $\bar{X}(3) = 10.05$ $\sigma X(3) = 6.15$

APPENDIX B

TABLE VIII

MICHIGAN AERONAUTICS COMMISSION

Regression Results

Based Aircraft vs. Time and County Socio-Economic Factors in Michigan
VIII- "15 Tourist Counties (ADL Choice)"

Regression No.

VIII. 1 $X(3) = -1.02 - 0.0386X(1) + 0.367X(4) + 0.716X(5) - 0.0116X(6)$
(0.965) (0.107) (0.265) (0.212) (0.00342)
$r^2 = 0.4966$ $F = 43$ $\bar{X}(3) = 4.48$ $X(3) = 2.87$

VIII. 2 $X(3) = -1.62 - 0.0100X(1) + 0.254X(4) + 0.483X(5)$
(0.976) (0.110) (0.270) (0.207)
$r^2 = 0.4636$ $F = 51$ $\bar{X}(3) = 4.48$ $X(3) = 2.95$

VIII. 3 $X(3) = 0.0162 - 0.150X(1) + 0.969X(5) - 0.110X(6)$
(0.615) (0.0712) (0.108) (0.00341)
$r^2 = 0.4911$ $F = 57$ $\bar{X}(3) = 2.88$

VIII. 4 $X(3) = 1.29 + 0.439X(4) + 0.655X(5) - 0.0115X(6)$
(0.599) (0.175) (0.129) (0.00341)
$r^2 = 0.4962$ $F = 58$ $\bar{X}(3) = 4.48$ $X(3) = 2.86$

VIII. 5 $X(3) = 3.30 + 0.248X(1) + 1.14X(4) - 0.00790X(6)$
(0.705) (0.0672) (0.139) (0.00333)
$r^2 = 0.4639$ $F = 51$ $\bar{X}(3) = 4.48$ $X(3) = 2.95$

VIII. 6 $X(3) = 3.20 + 0.199X(1) + 0.860X(4)$
(0.713) (0.0648) (0.0764)
$r^2 = 0.4468$ $F = 71$ $\bar{X}(3) = 4.48$ $X(3) = 2.99$

VIII. 7 $X(3) = -0.872 - 0.0896X(1) + 0.669X(5)$
(0.565) (0.0705) (0.0577)
$r^2 = 0.4608$ $F = 76$ $\bar{X}(3) = 4.48$ $X(3) = 2.95$

VIII. 8 $X(3) = -0.654 + 0.129X(1) + 0.0150X(6)$
(0.735) (0.0769) (0.00213)
$r^2 = 0.2595$ $F = 31$ $\bar{X}(3) = 4.48$ $X(3) = 3.46$

TABLE VIII (Cont'd.

MICHIGAN AERONAUTICS COMMISSION

Regression Results

Based Aircraft vs. Time and County Socio-Economic Factors in Michigan

VIII- "15 Tourist Counties (ADL Choice)"

Regression No.

VIII. 9 $X(3) = 1.69 + 0.273X(4) + 0.467X(5)$
(0.605) (0.173) (0.120)
$r^2 = 0.4634$ F = 76 $\bar{X}(3) = 4.48$ X(3) = 2.94

VIII. 10 $X(3) = 1.95 + 1.02X(4) - 0.00409X(6)$
(0.625) (0.140) (0.00328)
$r^2 = 0.4223$ F = 65 $\bar{X}(3) = 4.48$ X(3) = 3.05

VIII. 11 $X(3) = -0.613 + 0.869X(5) - 0.00914X(6)$
(0.544) (0.0983) (0.00332)
$r^2 = 0.4782$ F = 81 $\bar{X}(3) = 4.48$ X(3) = 2.90

VIII. 12 $X(3) = 2.05 + 0.880X(4)$
(0.621) (0.0779)
$r^2 = 0.4173$ F = 127 $\bar{X}(3) = 4.48$ X(3) = 3.06

VIII. 13 $X(3)\ -1.18 + 0.638X(5)$
(0.513) (0.0523)
$r^2 = 0.4558$ F = 149 $\bar{X}(3) = 4.48$ X(3) = 2.96

VIII. 14 $X(3) = -0.0590 + 0.0159X(6)$
(0.647) (0.00207)
$r^2 = 0.2477$ F = 59 $\bar{X}(3) = 4.48$ X(3) = 3.48

VIII. 15 $X(3) = 2.79 + 0.259X(1)$
(0.621) (0.0843)
$r^2 = 0.0504$ F = 9 $\bar{X}(3) = 4.48$ X(3) = 3.91

NOTES TO APPENDIX B

1. Code:
   - X(1) Time (1954 = 1)
   - X(2) County
   - X(3) Registered aircraft
   - X(4) Population (Thousands)
   - X(5) Disposable income (Millions)
   - X(6) Population over 25 years old with some college

2. Groups

   a) In five instances an airport in one county is primarily for the use of a town or towns in another county or other counties e.g., Capital City Airport in Ingham County is primarily for the use of Lansing, and Lansing is in both Clinton and Eaton counties. In these instances the airport and county statistics have to be summed for the overlapping counties. The five groups are:

      i) Ingham, Clinton, Eaton

      ii) Bay, Midland, Saginaw

      iii) Muskegon, Ottawa

      iv) Emmett, Cheboygan

      v) Iron, Dickinson

   b) Tourist counties, by Aeronautics Commission definition are 47:

Alcona	Crawford	Leelanau	Ogemaw
Alger	Dickinson	Luce	Ontonagan
Allegan	Emmett	Mackinac	Osceola
Alpena	Gladwin	Marquette	Oscoda
Antrim	Gogebic	Manistee	Otsego
Arenac	Grand Traverse	Mason	Ottawa
Baraga	Houghton	Mecosta	Presque Isle
Benzie	Iosco	Menominee	Roscommon
Charlevoix	Iron	Missaukee	Schoolcraft
Cheboygan	Kalkaska	Montcalm	Van Buren
Chippewa	Keweenaw	Newaygo	Wexford
Clare	Lake	Oceana	

c) Tourist counties, by Arthur D. Little, Inc. definition, are 15:

Alcona	Kalkaska	Montmorency
Antrim	Lake	Ogemaw
Benzie	Keweenaw	Oscoda
Clare	Leelanau	Otsego
Gladwin	Mackinac	Roscommon

Based on seasonal residential units in the county as a fraction of total residential units.

Note: It was believed that ownership of aircraft in resort or tourist counties might relate differently to socio-economic factors than in non-resort counties. Therefore, experimental regressions were run separately for tourist and for non-tourist counties. However, the best results actually came in Series IV where tourist and non-tourist counties were not differentiated.

APPENDIX C

APPENDIX C

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The Technique of Multiple Linear Regression

A regression seeks to establish relationships between a number of causal factors (independent variables) and one result of these factors (the dependent variable). The regression equation "explains" the behavior of one variable in terms of the factors that influence it. Thus in this report we explained the number of based aircraft in a county by the level of personal income or the numbers of people with some college education. The use of the regression technique is particularly useful when controlled experiments are not possible. For example, we are not able to alter the level of income in a Michigan county and observe its effect on based aircraft.

The simplest form of regression relates one variable to one other variable linearly in the form $y = a + bx$. The formula fits a straight line through a number of observed values of y for given values of x, so that the sum of the squares of the deviations of the observations from the line are minimized. If there are two independent variables, one can visualize how one dimension (the dependent variable) can be measured against the other two dimensions (the independent variables) and a line drawn in space to minimize the sum of the squares of the deviations of the observations from the line. If there are more than two independent variables, the ability to visualize the process breaks down and we can only refer to the formula.

Regression methods not only fit a line or a curve to a series of observations, thus permitting forecasting, but they also provide numerical measures of confidence or reliability.

The reliability of the fit of the line is measured by the function r^2. In terms of the sums generated from n values of x_i and y_i:

The Technique of Multiple Linear Regression - Cont'd

$$r^2 = \frac{\sum_{i=1}^{n} [(x_i - \bar{x})(y_i - \bar{y})]^2}{\sum_{i=1}^{n} (x_i - \bar{x})^2 \times \sum_{i=1}^{n} (y_i - \bar{y})^2}$$

If $r^2 = 0.92$, then 92% of the variation of y (about mean, $\bar{y}$) is accounted for by the straight line fit (the other 8% is residual variation about the line of fit). It is also possible to calculate the confidence limits of the equation. If, from the regression equation, we find a value for y of y = 10, then we can say, for example, that we can be 95% sure that the true value of y lies between 8 and 12. Or, we might be able to say that we can be 80% sure that the true value of y lies between 9 and 11.