ECON 395
FORECASTING TECHNIQUES
U.S. DOMESTIC AIRLINE TRAFFIC
ECONOMETRIC MODELLING

Brian Browne

ABSTRACT

THE PURPOSE OF THIS PAPER IS TO PROVIDE THE STUDENTS OF ECONOMICS 395 WITH A METHODOLOGICAL PROCEDURE TO FORECAST THE LONG-TERM EVOLUTION OF A PRODUCT AND/OR INDUSTRY. THIS PAPER IS A REPRODUCTION OF A PRIOR STUDY USED TO FORECAST THE U.S. DOMESTIC AIRLINE TRAFFIC. A LOG-LINEAR ECONOMETRIC MODEL WAS DEVELOPED TO EXPLAIN AND FORECAST LONG-TERM GROWTH IN THE TOTAL U.S. DOMESTIC AIRLINE TRAFFIC. IN THIS MODEL, TRAFFIC IS EXPLAINED IN TERMS OF THE SOCIO-ECONOMIC VARIABLES PERTAINING TO THE U.S. ECONOMY AND OPERATIONAL VARIABLES SUCH AS AVERAGE FARES AND PASSENGER TRIP LENGTH. THESE MODELS WERE THEN USED WITH ECONOMETRIC FORECASTS PROVIDED BY VARIOUS FORECASTING SERVICES TO GENERATE AIRLINE TRAFFIC FORECASTS. THESE FORECASTS - AS WITH ANY PRODUCT FORECAST - SHOULD SERVE AS THE UNDERPINNING IN DEVELOPMENT OF A CORPORATION'S LONG - TERM PLAN. THE OVERALL INCORPORATION APPROACH IS PROVIDED IN FIGURE 1[1].

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[1] This model was reproduced using the statistical, database, and graphical capabilities available in LOTUS123. This "constraint" necessitated a number of independent programming procedures be undertaken to provide a full replication.

FIGURE 1
METHODOLOGICAL FLOW CHART
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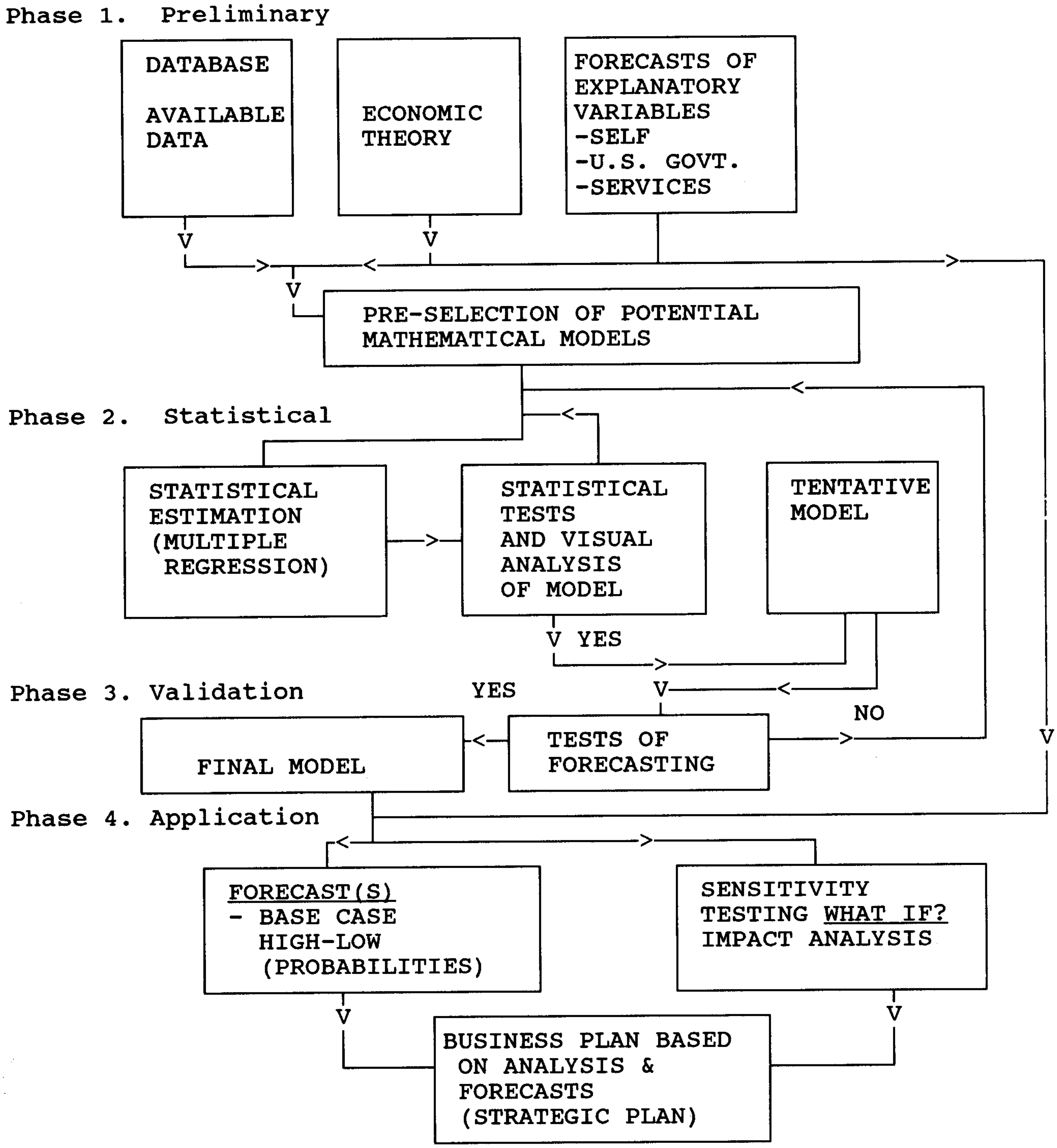

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CHAPTER 1 - METHODOLOGY[2]

This study will provide Econ. 395 students with an actual study of how an airline traffic model was developed. It is hoped that students will be able to use many features of this approach to generate their class projects. Each project will require a unique approach, but the impact of product pricing, exogenous economic events, quality, and other factors must be taken into account in developing a class project. Again, the goal of this class is to teach the students how to integrate;

- Economic theory,
- Mathematical estimation, and
- Corporate planning.

This paper deals with the mathematical estimation section.

Econometric analysis involves a combination of economic theory, mathematics, and statistical methods. The steps of model building, as shown in Figure 1 are:

Step 1
- Pre-selection of explanatory economic and system variables

Step 2
- Specification of the mathematical model which relates the independent variables to the dependent variable

Step 3
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- Forecasting the dependent variable by using forecasts (scenarios) for the independent variables.

The process of building econometric models to explain and forecast the long-term growth of the U.S. domestic airline industry entails three distinct but interrelated problems (1.1, 1.2, and 1.3). After these steps have been rigorously followed, one or more forecasts may be generated (1.4). In this paper, a universe of three hypothetical scenarios are suggested and eventuality probabilities (sum=1) are assigned.

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1.1 Pre-selection of potential causative factors

Schematically airline traffic growth can be explained in terms of several classes of explanatory factors.

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Investigation: Income/wealth[3] exerts a significant influence on demand. In developing this model, several macro-economic variables [correlate with theoretical aspects as covered in Part-I - Econ. 395 handout] such as GNP (GDP), personal income, national income and personal disposable income, total personal consumption expenditures, consumption expenditures on transportation services, and the total wage bill, were investigated as alternative measures of income. All current dollar values were converted to constant dollar values via the appropriate implicit price deflators. Constant dollar values were used to try and eliminate the impact of inflationary illusion on spending patterns.

Selection: Personal consumption expenditure (PCE), expressed in constant 1958 dollars, was selected to characterize the income (wealth) effect on the basis of empirical evidence. Various explanations were considered as to why this variable prevailed over personal disposable income. One explanation was linked to the savings rate fluctuations during World War II. A good analysts must be prepared to link and explain the dynamics of real world events with model estimation.

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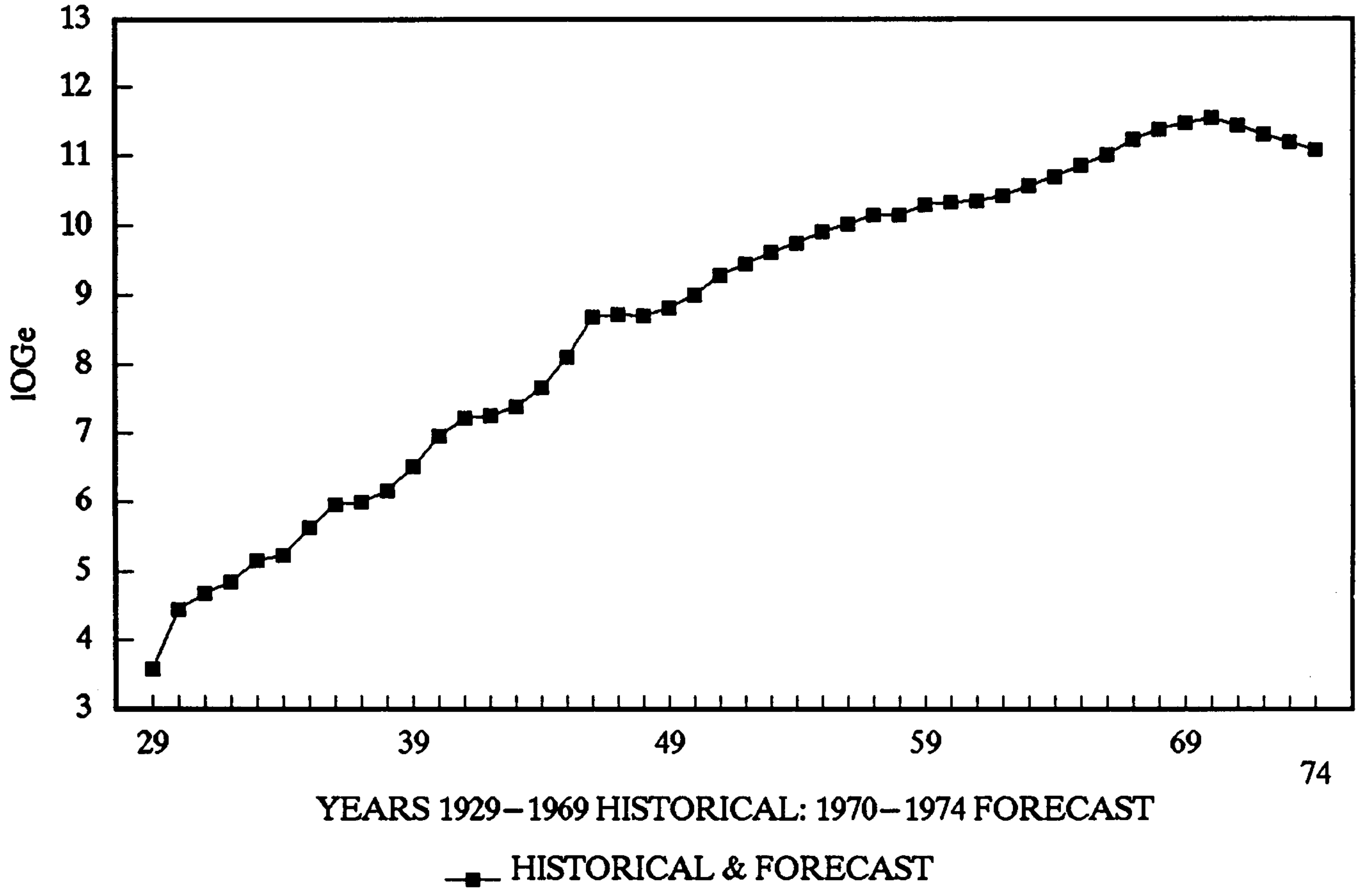
Selection: For the period used in this sample analysis, resulting from the existing regulatory (CAB) structure, trip length was selected as an explanatory variable.

FIGURE 5 – HISTORICAL 1929–1969: FORECAST – 1970 to 1974
U.S. DOMESTIC FORECASTING MODEL SCENARIO No. 3



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1.2 THE MATHEMATICAL MODEL

When the explanatory variables have been selected, it is necessary to specify the general form of the mathematical relationship. For this study, it was decided to confine the quantitative analysis to the class of log-linear models[5] Mathematically, the model selected is expressed in terms of the following general relationship:

$$\text{Log}_E\ (\text{RPM})T = B_0 + B_1\ \text{Log}_E\ (\text{PCE}) + B_2\ \log_E(\text{YLD})_T + B_3\ \text{LOG}_E\ (\text{PTL})_T$$

Where T = Time (years)

RPM = Revenue Passenger Miles

PCE = $\frac{\text{PCE\$}}{\text{PCED}}$ = Personal Consumption expenditure in billions of 1958 dollars

PCED = Implicit price deflator PCE 1958=1.00 (100)

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An advantage of a log-linear specification is that the partial regression coefficients of the model (with the exception of B_0) can be interpreted as elasticities[6]. For example, B_1 is the elasticity of RPM (traffic) with respect to real ($1958) Personal Consumption Expenditure and represents the percent change in RPM attributable to a 1 percent change in Real Personal Consumption Expenditures. The domestic traffic model was estimated by use of Log_e (e=2.71828).

The statistical results obtained are shown in Table 1 (see also Appendix #1 - Figure 5) and Figure 2 presents a graphical representation of the goodness-of-fit of the model.

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The equation was estimated by use of the ordinary least squares method of multiple regression. The model was linearized by performing logarithmic (see Appendix 1, Table 3) transformations on the original variables and then fitting a hyperplane to the sample points associated with the historical observations in the (N+1)

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Table - 5, Appendix 1 - is an overall presentation of the basic data (Log_e) and the estimation results and tests.

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Three basic five year forecast scenarios were chosen. These are shown in tabular form below. They could be thought of as Base, Optimistic, and Pessimistic with a cumulative probability of 1.0. Economist refer to this type of analysis as sensitivity testing. A five year forecast is usually considered a long-term forecast and should, in the context of a corporate plan, be adjusted at monthly/quarterly meetings, which are input for actual market dynamics. Figures 3 - 5, Showing Scenarios 1 through 3, provide a visual presentation of how these forecasts play out in terms of history and impact on demand (RPM).

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1. Numerical estimates of the structural parameters of the model:

Since the true values of these structural coefficients are not known, and since the model involves a random element, the coefficients can be determined in probability. It can be shown that given the hypothesis that the random element is normally distributed, the estimates of the structural coefficients follow a T-Student probability distribution. The number of degrees-of-freedom is equal to the number of observations available minus the total number of coefficients estimated.

These probability distributions can be characterized by their mean and standard deviation. This mean will represent the numerical estimate of the structural coefficient and corresponding standard deviation a measure of the degree of uncertainty attached to this estimate.

These coefficients (partial regression coefficients b_1, b_2, b_3, etc), with the exception of the constant (*A*) have no dimension and represents the elasticities (using log data - see RGD Allen - Mathematics for Economists) of traffic with respect to the corresponding exogenous (independent) variable (b_i). Where i = 1 to N exogenous partial regression coefficients.

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The T-Statistic is a measure for the significance of a particular variable and its contribution to the explanation of the total variation in the dependent variable. It is the ratio of the value of the coefficient (b_i) divided by the standard deviation of this coefficient. The standard error of the estimate is calculated in LOTUS123 (see also page 15, "Business Forecasting on your personal computer," *et al*). A rule of thumb, given the degrees-of-freedom, is that if the T-Statistic exceeds 2.00, then the corresponding variable is significant at a 95% confidence level.

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TABLE 1
ESTIMATION RESULTS OF THE ECONOMETRIC FORECASTING MODEL FOR THE U.S. DOMESTIC TRAFFIC

MODEL

$$LOG_E(RPM)_T = -15.15 + 1.805 LOG_E(PCE)_T - 3.0998 LOG_E(YLD)_T + 0.965(PTL)_T$$ [4]

[-15.1541] [1.805324] [-3.09982] [0.964558]

Standard Error of Coefficients	0.18215	0.238834	0.229791
T-Statistic (37 Degrees of Freedom)	[9.911196]	[-12.9789]	[4.215893]

Durbin Watson 1.142572
F Statistic (3,37) 1757.663

Where T = Time (years)

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= PCE$ = PCE Personal Consumption expenditure in billions of 1958 dollars

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4 See Table 5 - Data and Regression Output

FIGURE 2–GRAPHICAL REPRESENTATION OF THE GOODNESS–OF–FIT
U.S. DOMESTIC FORECASTING MODEL 1929–69

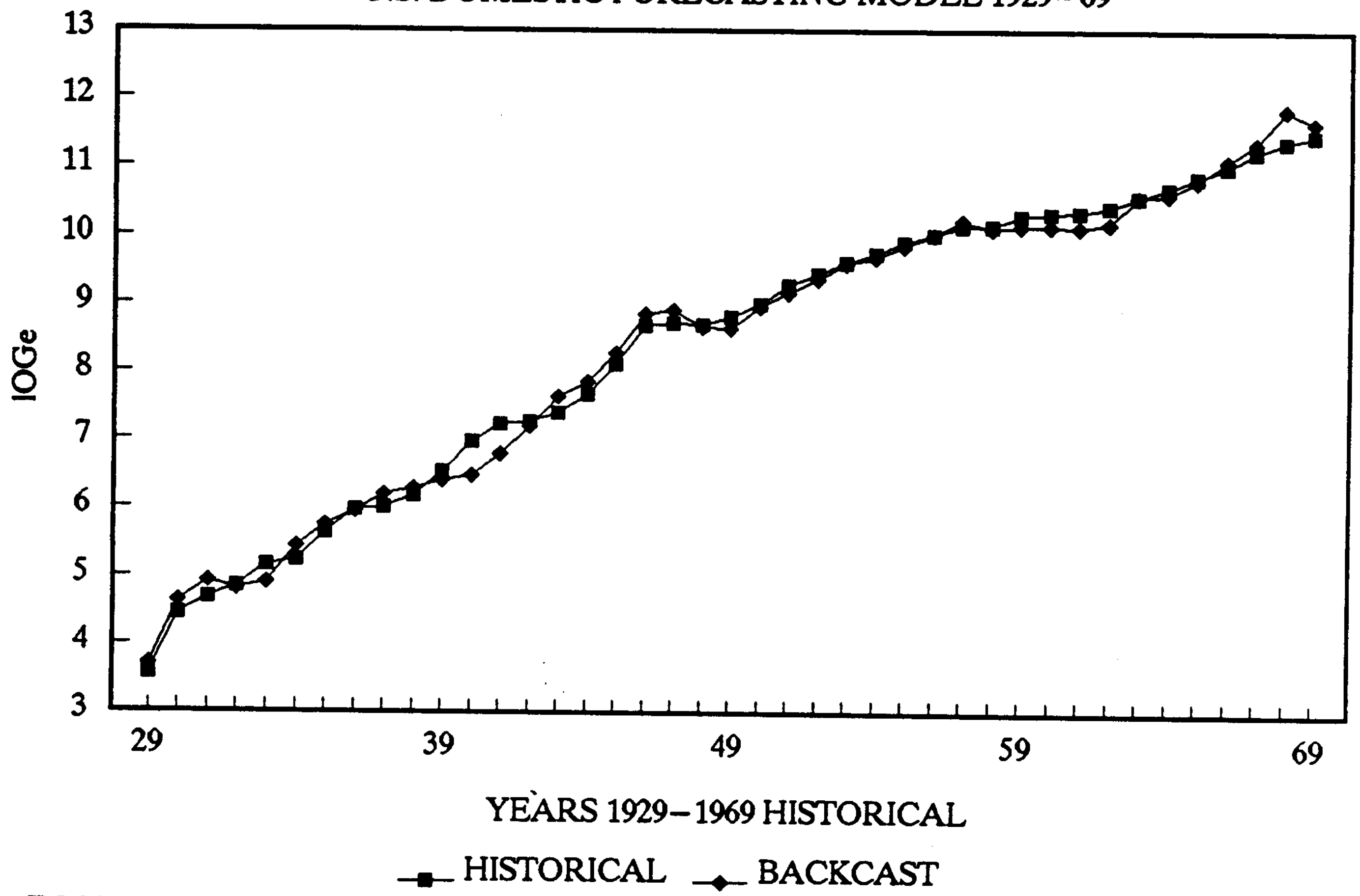

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FIGURE 3 – HISTORICAL 1929–1969: FORECAST – 1970 to 1974
U.S. DOMESTIC FORECASTING MODEL SCENARIO No. 1

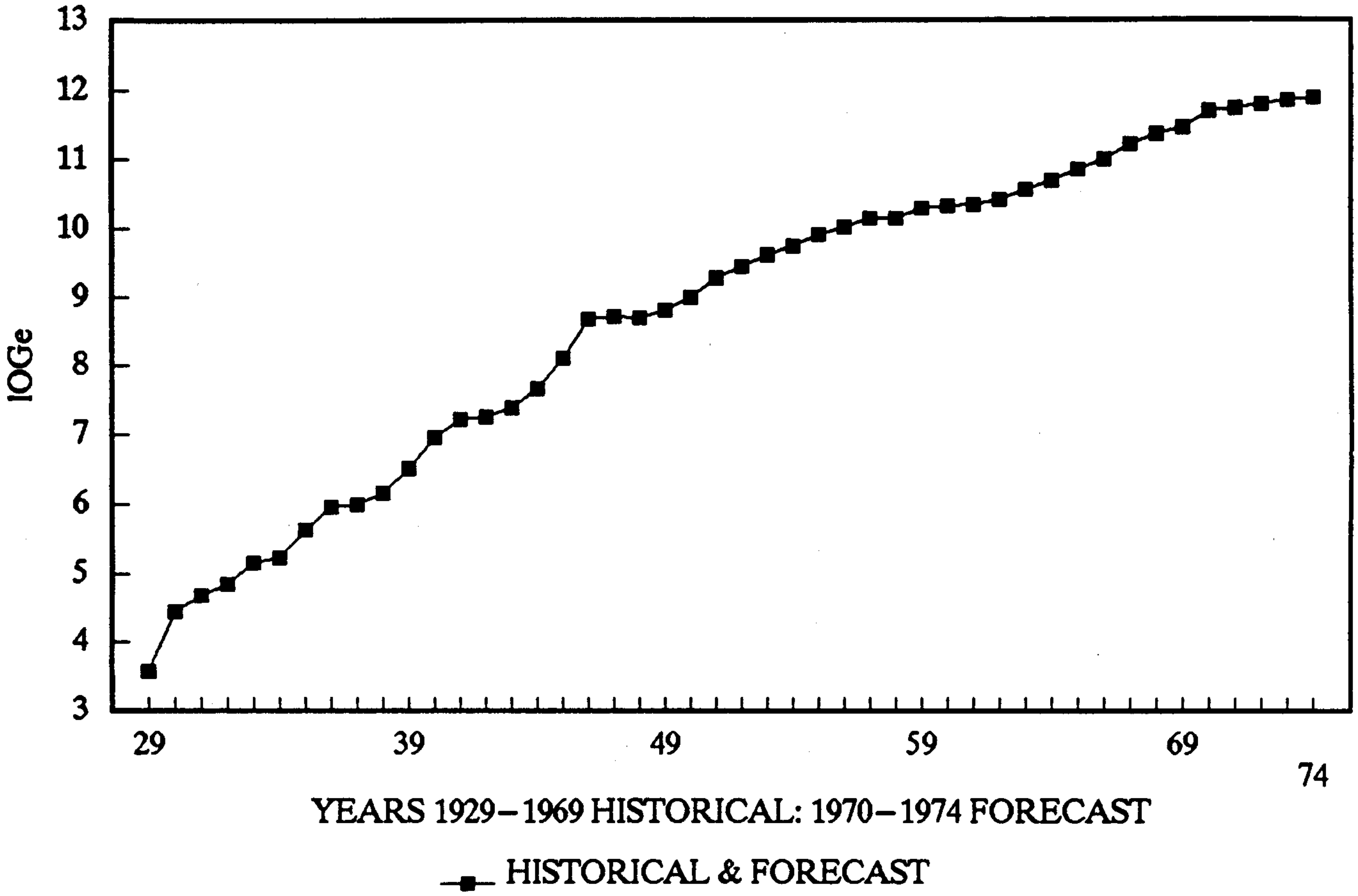

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FIGURE 4 – HISTORICAL 1929–1969: FORECAST – 1970 to 1974
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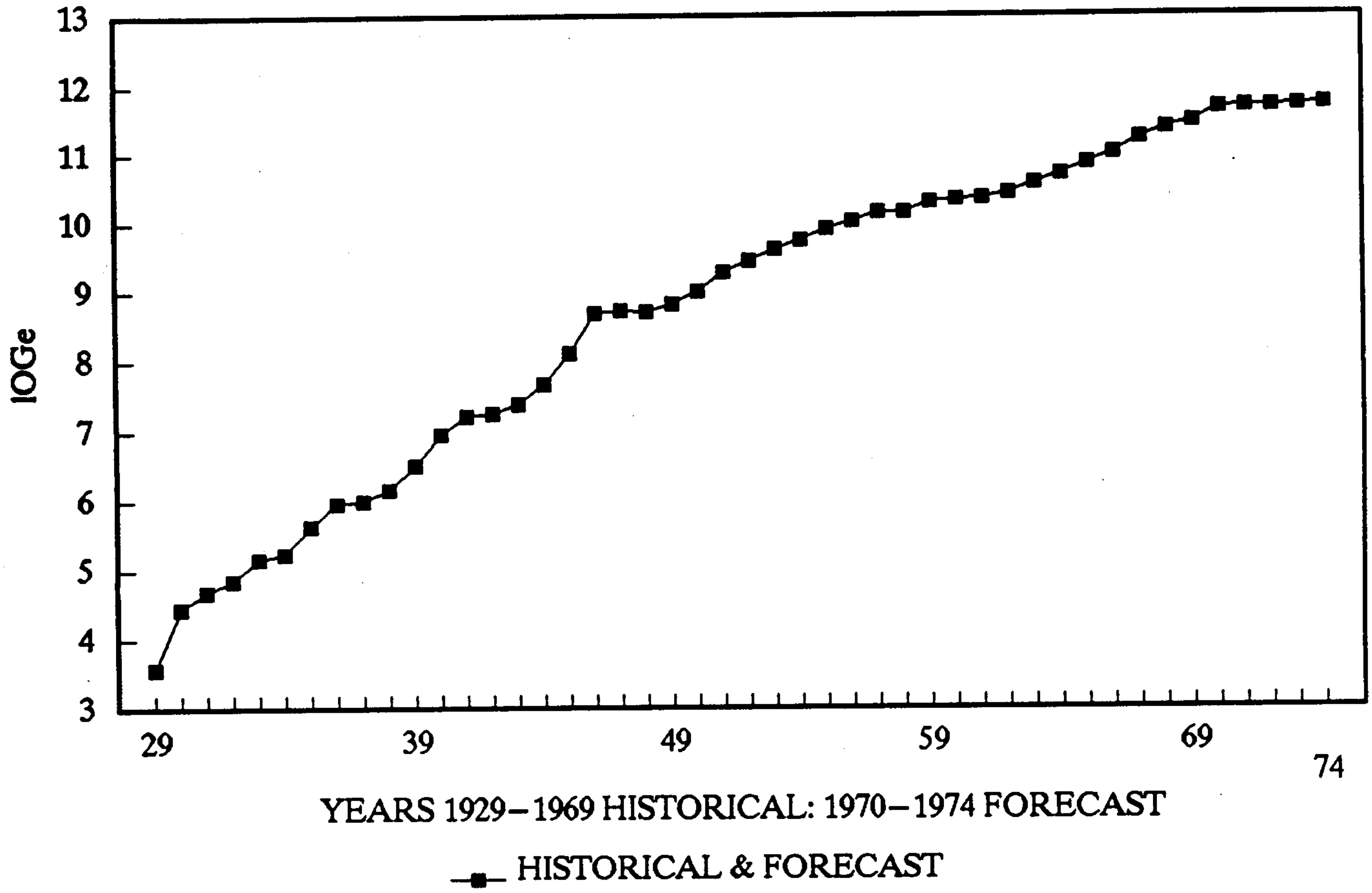

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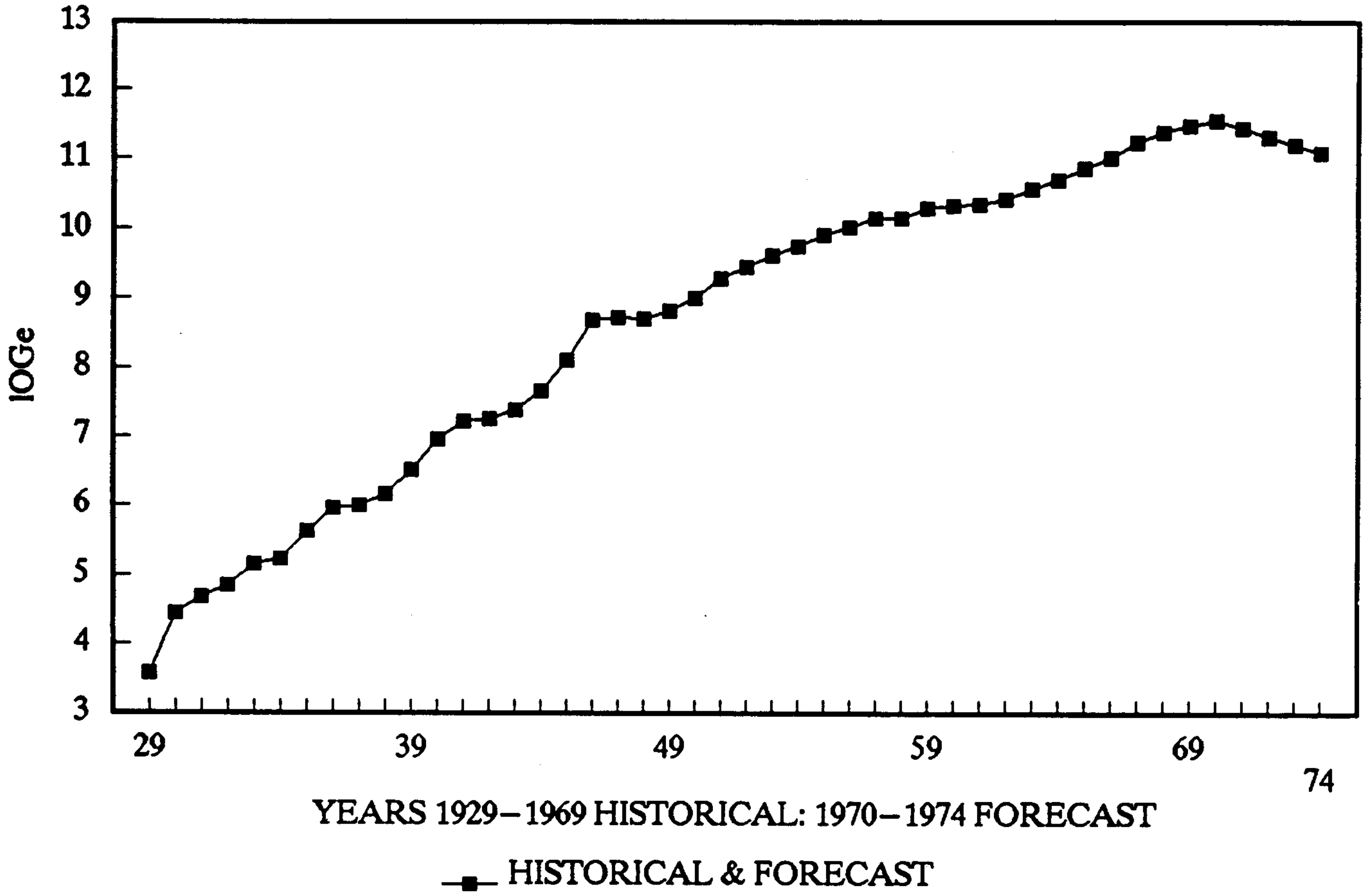

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You can create the T-Statistics directly from the partial regression coefficients (b_i) and standard error of coefficients provided in the LOTUS123 output.

3. R^2 - Coefficient of determination. This statistic measures the overall goodness-of-fit of the estimated hyperplane. More specifically, R2 is the amount of variance of the dependent variable that is explained by the regression equation.

$$R2 = \frac{\text{Amount of variance explained by the regression}}{\text{Total variance of the dependent variable}}$$

The larger the R^2 the better the overall goodness of fit. A r-square of .99301 means that the estimated equation explains 99.301% of the variance of the dependent variable.

The coefficient of determination is the square of the coefficient of correlation between the actual time series of the independent variable and the estimated series obtained by substituting the values of the explanatory variables into the estimated equation. A coefficient of determination of .9981 therefore implies a coefficient of correlation between the actual and estimate sums in the order of .991 (sqrt of .9981=.9991: <u>work it out</u>).

4. The standard error of estimate

This statistic measures the errors associated with the estimated equation. It is defined as the square root of the sum of the squares of the deviations between the actual and the estimated values corrected for the appropriate degrees of freedom.

$$SE = SQRT\ ((SUM(Y-\hat{Y})^{2})\ /N)$$

Y= Observation

$\hat{Y}$ = Computed by equation

5. Durban Watson Statistic -

This statistic measures the existence or absence of auto-correlation of the residuals. Auto-correlation of residuals denotes that the residual (difference between the estimated and actual value) for a period is correlated with the residual(s) of the previous period(s). The statistic is defined in such a manner that a value of 2.00 would imply no auto-correlation of residuals. Please review WK3 class file to see how I estimated this statistic. This file is available from the lab and is labelled ECON395C.WK3.

*

$$D = \frac{\text{Sum } t=2 \text{ to } N \ (e_t - e_{t-1})^2}{\text{Sum } t=1 \text{ to } N \ e_t 2}$$

$(e_t = Y - \hat{Y})$

6. F-Statistic - Fisher-Snedecor Statistic

This statistic is a measure of the goodness-of-fit for the overall model. It is the ratio of the variance of the dependent variable divided by the variance of the residuals. Therefore for smaller residuals, the larger the F-Value. The critical value of the F-Statistic with (5,19) degrees-of-freedom and 99% confidence interval is 4.17. The F-Statistic computed (see ECON395C.WK3) for the airline study was 1757.6628. (R2/Var#)/(1-R2/DF): eg .9961/3/(1-.9961)/4

*

$$D = \frac{\sum_{t=2}^{n} (e_t - e_{t-1})^2}{\sum_{t=1}^{n} (e_t^2)}$$

APPENDIX
2

ECON 395
FORECASTING TECHNIQUES
U.S. DOMESTIC AIRLINE TRAFFIC
ECONOMETRIC MODELLING

Brian Browne

TABLE 1 – BASIC INPUT DATA U.S. DOMESTIC AIRLINES 1929–1969

YEAR	PCED 1958=100	10^9 PCE $CURRENT	($/100) YIELD cCURRENT	10^7 RPM REV. PAX MILES	10^6 PAX REV $CURRENT	AVERAGE TRIP LENGTH	YIELD $CURRENT
1929	55.3274	77.2370	11.972	35.3960	42.3761	218	0.1197
1930	53.5898	69.8811	8.300	85.1250	70.6538	221	0.0830
1931	47.9496	60.4644	6.700	106.9521	71.6579	227	0.0670
1932	42.3258	48.5900	6.100	127.4330	77.7341	268	0.0610
1933	40.5990	45.7957	6.100	174.4291	106.4018	349	0.0610
1934	43.5686	51.4545	5.914	189.2071	111.8971	401	0.0591
1935	44.3821	55.6995	5.700	281.1770	160.2709	414	0.0570
1936	44.7339	61.9117	5.700	390.7822	222.7459	421	0.0570
1937	46.4769	66.5084	5.600	410.2571	229.7440	418	0.0560
1938	45.5905	63.9179	5.180	479.8440	248.5592	401	0.0518
1939	45.0968	66.8335	5.100	682.9033	348.2807	394	0.0510
1940	45.4872	70.8236	5.070	1052.1570	533.4436	375	0.0507
1941	48.7145	80.5738	5.040	1384.7340	697.9059	360	0.0504
1942	54.8330	88.5004	5.270	1417.5260	747.0362	453	0.0527
1943	59.9104	99.3308	5.350	1632.4530	873.3624	542	0.0535
1944	63.1579	108.2526	5.340	2127.8560	1136.2751	541	0.0534
1945	65.4069	119.6946	4.950	3360.3490	1663.3728	514	0.0495
1946	70.3647	143.4032	4.630	5944.9260	2752.5007	489	0.0463
1947	77.8960	160.6994	5.050	6105.3120	3083.1826	476	0.0505
1948	82.3327	173.5573	5.760	5996.6480	3454.0692	458	0.0576
1949	81.6634	176.8012	5.780	6767.5980	3911.6716	448	0.0578
1950	82.8614	190.9956	5.560	8029.1130	4464.1868	460	0.0556
1951	88.5976	206.2553	5.610	10589.6100	5940.7712	466	0.0561
1952	98.5102	235.8335	6.062	12559.1800	7613.3749	499	0.0606
1953	91.6877	229.9528	5.460	14793.8100	8077.4203	512	0.0546
1954	92.4944	236.5081	5.410	16802.2500	9090.0173	517	0.0541
1955	92.7576	254.3413	5.360	19852.0400	10640.6934	519	0.0536
1956	94.7724	266.6894	5.330	22398.3800	11938.3365	534	0.0533
1957	97.6462	281.4163	5.310	25378.7700	13476.1269	562	0.0531
1958	100.0000	290.1001	5.641	25375.2800	14314.1954	567	0.0564
1959	101.2744	311.2160	5.880	29307.2100	17232.6395	575	0.0588
1960	102.8898	325.2348	6.090	30556.6200	18608.9816	583	0.0609
1961	103.9218	335.1478	6.280	31061.9800	19506.9234	589	0.0628
1962	104.9292	355.0803	6.450	33622.4100	21686.4545	601	0.0645
1963	106.1413	374.9975	6.170	38456.6400	23727.7469	692	0.0617
1964	107.3683	401.2353	6.120	44141.2400	27014.4389	605	0.0612
1965	108.8361	432.8412	6.060	51887.4300	31443.7826	614	0.0606
1966	111.5361	466.3325	5.830	60590.4100	35324.2090	620	0.0583
1967	114.4015	492.0323	5.640	75452.0000	42554.9280	636	0.0564
1968	118.5043	535.8098	5.183	87487.1200	45344.5743	651	0.0518
1969	123.4568	577.5072	5.900	95917.3700	56591.2483	674	0.0590

TABLE 2 – BASIC INPUT DATA U.S. DOMESTIC AIRLINES 1929–1969 $1958 (PCED=100)

COL 1 YEAR	COL 2 PCED 1958=100	COL 3 PCED 1958=1	COL 4 PCE $CURRENT	COL 4/COL 3 COL 5 PCE $1958=100	COL 6 YIELD cCURRENT	COL 6/COL 3 COL 7 CONSTANT YIELD $1958=100	COL 8 YIELD $CURRENT	COL 8/ COL 3 COL 9 CONSTANT YIELD $CONSTANT	COL 10 AVERAGE TRIP LENGT	(10^ 7) COL 11 REVENUE PAX MILES RPMs
1929	55.3274	0.5533	77.2370	139.5999	11.972	21.638	0.1197	0.2164	218	35.3960
1930	53.5898	0.5359	69.8811	130.4000	8.300	15.488	0.0830	0.1549	221	85.1250
1931	47.9496	0.4795	60.4644	126.0999	6.700	13.973	0.0670	0.1397	227	106.9521
1932	42.3258	0.4233	48.5900	114.8000	6.100	14.412	0.0610	0.1441	268	127.4330
1933	40.5990	0.4060	45.7957	112.8001	6.100	15.025	0.0610	0.1503	349	174.4291
1934	43.5686	0.4357	51.4545	118.1000	5.914	13.574	0.0591	0.1357	401	189.2071
1935	44.3821	0.4438	55.6995	125.4999	5.700	12.843	0.0570	0.1284	414	281.1770
1936	44.7339	0.4473	61.9117	138.4000	5.700	12.742	0.0570	0.1274	421	390.7822
1937	46.4769	0.4648	66.5084	143.0999	5.600	12.049	0.0560	0.1205	418	410.2571
1938	45.5905	0.4559	63.9179	140.2000	5.180	11.362	0.0518	0.1136	401	479.8440
1939	45.0968	0.4510	66.8335	148.2001	5.100	11.309	0.0510	0.1131	394	682.9033
1940	45.4872	0.4549	70.8236	155.7001	5.070	11.146	0.0507	0.1115	375	1052.1570
1941	48.7145	0.4871	80.5738	165.4000	5.040	10.346	0.0504	0.1035	360	1384.7340
1942	54.8330	0.5483	88.5004	161.3999	5.270	9.611	0.0527	0.0961	453	1417.5260
1943	59.9104	0.5991	99.3308	165.7989	5.350	8.930	0.0535	0.0893	542	1632.4530
1944	63.1579	0.6316	108.2526	171.3999	5.340	8.455	0.0534	0.0845	541	2127.8560
1945	65.4069	0.6541	119.6946	183.0000	4.950	7.568	0.0495	0.0757	514	3360.3490
1946	70.3647	0.7036	143.4032	203.7999	4.630	6.580	0.0463	0.0658	489	5944.9260
1947	77.8960	0.7790	160.6994	206.2999	5.050	6.483	0.0505	0.0648	476	6105.3120
1948	82.3327	0.8233	173.5573	210.8000	5.760	6.996	0.0576	0.0700	458	5996.6480
1949	81.6634	0.8166	176.8012	216.4999	5.780	7.078	0.0578	0.0708	448	6767.5980
1950	82.8614	0.8286	190.9956	230.5001	5.560	6.710	0.0556	0.0671	460	8029.1130
1951	88.5976	0.8860	206.2553	232.8001	5.610	6.332	0.0561	0.0633	466	10589.6100
1952	98.5102	0.9851	235.8335	239.4001	6.062	6.154	0.0606	0.0615	499	12559.1800
1953	91.6877	0.9169	229.9528	250.8001	5.460	5.955	0.0546	0.0595	512	14793.8100
1954	92.4944	0.9249	236.5081	255.6999	5.410	5.849	0.0541	0.0585	517	16802.2500
1955	92.7576	0.9276	254.3413	274.2000	5.360	5.779	0.0536	0.0578	519	19852.0400
1956	94.7724	0.9477	266.6894	281.3999	5.330	5.624	0.0533	0.0562	534	22398.3800
1957	97.6462	0.9765	281.4163	288.2000	5.310	5.438	0.0531	0.0544	562	25378.7700
1958	100.0000	1.0000	290.1001	290.1001	5.641	5.641	0.0564	0.0564	567	25375.2800
1959	101.2744	1.0127	311.2160	307.2998	5.880	5.806	0.0588	0.0581	575	29307.2100
1960	102.8898	1.0289	325.2348	316.1001	6.090	5.919	0.0609	0.0592	583	30556.6200
1961	103.9218	1.0392	335.1478	322.5000	6.280	6.043	0.0628	0.0604	589	31061.9800
1962	104.9292	1.0493	355.0803	338.3999	6.450	6.147	0.0645	0.0615	601	33622.4100
1963	106.1413	1.0614	374.9975	353.3003	6.170	5.813	0.0617	0.0581	692	38456.6400
1964	107.3683	1.0737	401.2353	373.7000	6.120	5.700	0.0612	0.0570	605	44141.2400
1965	108.8361	1.0884	432.8412	397.7000	6.060	5.568	0.0606	0.0557	614	51887.4300
1966	111.5361	1.1154	466.3325	418.1001	5.830	5.227	0.0583	0.0523	620	60590.4100
1967	114.4015	1.1440	492.0323	430.0925	5.640	4.930	0.0564	0.0493	636	75452.0000
1968	118.5043	1.1850	535.8098	452.1438	5.183	4.374	0.0518	0.0437	651	87487.1200
1969	123.4568	1.2346	577.5072	467.7808	5.900	4.779	0.0590	0.0478	674	95917.3700

CONSTANT $1959
PCED=100 IN 1958 (1.000)

TABLE 3 – BASIC INPUT DATA U.S. DOMESTIC AIRLINES 1929–1969 lOGe

COL 1 YEAR	COL 2 PCED 1958=100	COL 3 PCED 1958=1	COL 4 PCE $CURRENT	IND VAR#1 COL 4/COL 3 COL 5 PCE $1958=100	COL 6 YIELD cCURRENT	COL 6/COL 3 COL 7 CONSTANT YIELD $1958=100	COL 8 YIELD $CURRENT	IND VAR#2 COL 8/ COL 3 COL 9 CONSTANT YIELD $CONSTANT	IND VAR #3 COL 10 AVE TRIP LENGTH	DEP VAR. (10^7) COL 11 REVENUE PAX MILES RPMs
1929	4.013268	−0.5919	4.3468786	4.9387805378	2.48257059	3.074472511	−2.1225996	−1.5306977	5.384495	3.56659882
1930	3.981359	−0.62381	4.2467952	4.8706066609	2.116255515	2.740066949	−2.4889147	−1.8651032	5.398163	4.44412076
1931	3.87015	−0.73502	4.1020548	4.8370744888	1.902107526	2.637127253	−2.7030627	−1.9680429	5.42495	4.67238107
1932	3.745397	−0.85977	3.8834177	4.7431911052	1.808288771	2.668062128	−2.7968814	−1.9371081	5.590987	4.84759074
1933	3.703743	−0.90143	3.8241902	4.7256169505	1.808288771	2.709715521	−2.7968814	−1.8954547	5.855072	5.16151836
1934	3.774337	−0.83083	3.9406979	4.7715314006	1.777322421	2.6081559	−2.8278478	−1.9970143	5.993961	5.24284218
1935	3.792836	−0.81233	4.0199712	4.8323051212	1.740466175	2.552800126	−2.864704	−2.0523701	6.025866	5.63896436
1936	3.800732	−0.80444	4.1257092	4.9301477589	1.740466175	2.544904757	−2.864704	−2.0602654	6.042633	5.96815037
1937	3.838955	−0.76621	4.1973283	4.9635430265	1.722766598	2.488981369	−2.8824036	−2.1161888	6.035481	6.01678404
1938	3.819699	−0.78547	4.1575994	4.9430702719	1.644805056	2.430275881	−2.9603651	−2.1748943	5.993961	6.17346105
1939	3.808811	−0.79636	4.2022045	4.9985633473	1.62924054	2.425599435	−2.9759296	−2.1795708	5.976351	6.52635327
1940	3.817431	−0.78774	4.2601923	5.0479314968	1.623340818	2.411080036	−2.9818294	−2.1940902	5.926926	6.95859762
1941	3.885977	−0.71919	4.3891735	5.1083669936	1.617406082	2.336599541	−2.9877641	−2.2685706	5.886104	7.23326334
1942	4.004292	−0.60088	4.4830071	5.0838850553	1.662030363	2.262908346	−2.9431398	−2.3422618	6.115892	7.25666838
1943	4.09285	−0.51232	4.5984557	5.1107757674	1.677096561	2.189416634	−2.9280736	−2.4157536	6.295266	7.39783907
1944	4.145638	−0.45953	4.6844674	5.1439996311	1.675225653	2.134757899	−2.9299445	−2.4704123	6.293419	7.66287018
1945	4.180628	−0.42454	4.7849435	5.2094859273	1.599387577	2.023930005	−3.0057826	−2.5812402	6.242223	8.11980012
1946	4.253692	−0.35148	4.9656602	5.3171387122	1.532556868	1.884035337	−3.0726133	−2.7211348	6.192362	8.69029336
1947	4.355375	−0.2498	5.0795355	5.3293311214	1.619388243	1.869183826	−2.9857819	−2.7359864	6.165418	8.71691449
1948	4.410768	−0.1944	5.1565078	5.3509096346	1.750937475	1.945339305	−2.8542327	−2.6598309	6.126869	8.69895593
1949	4.402606	−0.20256	5.1750259	5.3775902024	1.754403683	1.956967948	−2.8507665	−2.6482022	6.104793	8.8199015
1950	4.417169	−0.188	5.2522504	5.4402512446	1.715598108	1.903598962	−2.8895721	−2.7015712	6.131226	8.99082934
1951	4.484105	−0.12107	5.3291147	5.4501801386	1.72455072	1.845616136	−2.8806195	−2.759554	6.144186	9.26762861
1952	4.59016	−0.01501	5.463126	5.4781361374	1.802039779	1.817049869	−2.8031304	−2.7881203	6.212606	9.43820715
1953	4.518388	−0.08678	5.4378741	5.5246560192	1.69744879	1.784230739	−2.9077214	−2.8209394	6.238325	9.60196413
1954	4.527148	−0.07802	5.4659825	5.5440045407	1.688249093	1.766271177	−2.9169211	−2.838899	6.248043	9.72926808
1955	4.52999	−0.07518	5.5386771	5.613857613	1.678963975	1.754144522	−2.9262062	−2.8510257	6.251904	9.89606205
1956	4.551478	−0.05369	5.5860847	5.6397766437	1.673351238	1.727043197	−2.9318189	−2.878127	6.280396	10.0167439
1957	4.581351	−0.02382	5.6398351	5.6636545116	1.669591835	1.693411279	−2.9355784	−2.9117589	6.331502	10.1416683
1958	4.60517	0	5.670226	5.6702260358	1.730061355	1.730061355	−2.8751088	−2.8751088	6.340359	10.1415308
1959	4.617834	0.012663	5.7404872	5.7278237262	1.771556762	1.758893283	−2.8336134	−2.8462769	6.35437	10.2855888
1960	4.633659	0.028488	5.7845474	5.7560590564	1.806648082	1.778159755	−2.7985221	−2.8270104	6.368187	10.3273366
1961	4.643639	0.038469	5.8145716	5.7761031213	1.83736998	1.798901473	−2.7678002	−2.8062687	6.378426	10.3437398
1962	4.653286	0.048116	5.872344	5.8242283101	1.864080131	1.81596448	−2.7410901	−2.7892057	6.398595	10.4229481
1963	4.664771	0.059601	5.9269194	5.86731832	1.819698838	1.760097799	−2.7854713	−2.8450724	6.539586	10.5572867
1964	4.676265	0.071095	5.994548	5.923453244	1.811562097	1.740467302	−2.7936081	−2.8647029	6.405228	10.6951498
1965	4.689843	0.084673	6.0703709	5.9856980222	1.8017098	1.717036905	−2.8034604	−2.8881333	6.419995	10.8568318
1966	4.714348	0.109178	6.1448989	6.0357207797	1.763017	1.653838881	−2.8421532	−2.9513313	6.429719	11.0118919
1967	4.739714	0.134544	6.1985444	6.06400036	1.729884066	1.595340061	−2.8752861	−3.0098301	6.455199	11.231252
1968	4.774949	0.169779	6.2837792	6.1140001865	1.645384039	1.475604978	−2.9597861	−3.1295652	6.47851	11.3792469
1969	4.815891	0.210721	6.3587209	6.1479997985	1.774952351	1.56423124	−2.8302178	−3.0409389	6.51323	11.4712424

TABLE 4 – BASIC INPUT DATA U.S. DOMESTIC AIRLINES 1929–1969 – ANNUAL PERCENT CHANGES

COL 1	COL 2	COL 3	COL 4	COL 4/COL 3 COL 5	COL 6	COL 6/COL 3 COL 7 CONSTANT	COL 8	COL 8/ COL 3 COL 9 CONSTANT
YEAR	PCED 1958=100	PCED 1958=1	PCE $CURRENT	PCE $1958=100	YIELD cCURRENT	YIELD $1958=100	YIELD $CURRENT	YIELD $CONSTANT
1929		NA	NA	NA	NA	NA	NA	NA
1930	−3.14	−3.14	−9.52	−6.59	−30.67	−28.42	−30.67	−28.42
1931	−10.52	−10.52	−13.48	−3.30	−19.28	−9.78	−19.28	−9.78
1932	−11.73	−11.73	−19.64	−8.96	−8.96	3.14	−8.96	3.14
1933	−4.08	−4.08	−5.75	−1.74	0.00	4.25	0.00	4.25
1934	7.31	7.31	12.36	4.70	−3.05	−9.66	−3.05	−9.66
1935	1.87	1.87	8.25	6.27	−3.62	−5.39	−3.62	−5.39
1936	0.79	0.79	11.15	10.28	0.00	−0.79	0.00	−0.79
1937	3.90	3.90	7.42	3.40	−1.75	−5.44	−1.75	−5.44
1938	−1.91	−1.91	−3.89	−2.03	−7.50	−5.70	−7.50	−5.70
1939	−1.08	−1.08	4.56	5.71	−1.54	−0.47	−1.54	−0.47
1940	0.87	0.87	5.97	5.06	−0.59	−1.44	−0.59	−1.44
1941	7.09	7.09	13.77	6.23	−0.59	−7.18	−0.59	−7.18
1942	12.56	12.56	9.84	−2.42	4.56	−7.10	4.56	−7.10
1943	9.26	9.26	12.24	2.73	1.52	−7.09	1.52	−7.09
1944	5.42	5.42	8.98	3.38	−0.19	−5.32	−0.19	−5.32
1945	3.56	3.56	10.57	6.77	−7.30	−10.49	−7.30	−10.49
1946	7.58	7.58	19.81	11.37	−6.46	−13.06	−6.46	−13.06
1947	10.70	10.70	12.06	1.23	9.07	−1.47	9.07	−1.47
1948	5.70	5.70	8.00	2.18	14.06	7.91	14.06	7.91
1949	−0.81	−0.81	1.87	2.70	0.35	1.17	0.35	1.17
1950	1.47	1.47	8.03	6.47	−3.81	−5.20	−3.81	−5.20
1951	6.92	6.92	7.99	1.00	0.90	−5.63	0.90	−5.63
1952	11.19	11.19	14.34	2.84	8.06	−2.82	8.06	−2.82
1953	−6.93	−6.93	−2.49	4.76	−9.93	−3.23	−9.93	−3.23
1954	0.88	0.88	2.85	1.95	−0.92	−1.78	−0.92	−1.78
1955	0.28	0.28	7.54	7.24	−0.92	−1.21	−0.92	−1.21
1956	2.17	2.17	4.85	2.63	−0.56	−2.67	−0.56	−2.67
1957	3.03	3.03	5.52	2.42	−0.38	−3.31	−0.38	−3.31
1958	2.41	2.41	3.09	0.66	6.23	3.73	6.23	3.73
1959	1.27	1.27	7.28	5.93	4.24	2.93	4.24	2.93
1960	1.60	1.60	4.50	2.86	3.57	1.95	3.57	1.95
1961	1.00	1.00	3.05	2.02	3.12	2.10	3.12	2.10
1962	0.97	0.97	5.95	4.93	2.71	1.72	2.71	1.72
1963	1.16	1.16	5.61	4.40	−4.34	−5.43	−4.34	−5.43
1964	1.16	1.16	7.00	5.77	−0.81	−1.94	−0.81	−1.94
1965	1.37	1.37	7.88	6.42	−0.98	−2.32	−0.98	−2.32
1966	2.48	2.48	7.74	5.13	−3.80	−6.12	−3.80	−6.12
1967	2.57	2.57	5.51	2.87	−3.26	−5.68	−3.26	−5.68
1968	3.59	3.59	8.90	5.13	−8.10	−11.28	−8.10	−11.28
1969	4.18	4.18	7.78	3.46	13.83	9.27	13.83	9.27

TABLE 5 – BASIC INPUT DATA U.S. DOMESTIC AIRLINES 1929–1969 – 123 OUTPUT & AUGMENTED TESTS

				Y	Y(BAR)	(Y–Y(BAR)) ^ 2	Y(HAT)			
				HISTORICAL	AVERAGE		BACKCAST	(Y–Y(HAT))	(Y–Y(HAT)) ^ 2	
	PCE	YIELD	TRP LNG	RPMs	RPMs		RPMs	et	et ^ 2	(et–et–1) ^ 2
1929	4.9388	–1.5307	5.3845	3.5666	8.3810	23.1783	3.7005	–0.1339	0.0179	
1930	4.8706	–1.8651	5.3982	4.4441	8.3810	15.4989	4.6272	–0.1831	0.0335	0.0024
1931	4.8371	–1.9680	5.4250	4.6724	8.3810	13.7537	4.9116	–0.2393	0.0572	0.0032
1932	4.7432	–1.9371	5.5910	4.8476	8.3810	12.4849	4.8064	0.0412	0.0017	0.0786
1933	4.7256	–1.8955	5.8551	5.1615	8.3810	10.3650	4.9003	0.2612	0.0682	0.0484
1934	4.7715	–1.9970	5.9940	5.2428	8.3810	9.8479	5.4320	–0.1891	0.0358	0.2028
1935	4.8323	–2.0524	6.0259	5.6390	8.3810	7.5186	5.7441	–0.1051	0.0110	0.0071
1936	4.9301	–2.0603	6.0426	5.9682	8.3810	5.8218	5.9613	0.0068	0.0000	0.0125
1937	4.9635	–2.1162	6.0355	6.0168	8.3810	5.5894	6.1881	–0.1713	0.0293	0.0317
1938	4.9431	–2.1749	5.9940	6.1735	8.3810	4.8732	6.2930	–0.1196	0.0143	0.0027
1939	4.9986	–2.1796	5.9764	6.5264	8.3810	3.4397	6.3907	0.1356	0.0184	0.0651
1940	5.0479	–2.1941	5.9269	6.9586	8.3810	2.0232	6.4772	0.4814	0.2317	0.1196
1941	5.1084	–2.2686	5.8861	7.2333	8.3810	1.3173	6.7778	0.4555	0.2074	0.0007
1942	5.0839	–2.3423	6.1159	7.2567	8.3810	1.2641	7.1837	0.0730	0.0053	0.1463
1943	5.1108	–2.4158	6.2953	7.3978	8.3810	0.9666	7.6331	–0.2352	0.0553	0.0950
1944	5.1440	–2.4704	6.2934	7.6629	8.3810	0.5157	7.8607	–0.1978	0.0391	0.0014
1945	5.2095	–2.5812	6.2422	8.1198	8.3810	0.0682	8.2731	–0.1533	0.0235	0.0020
1946	5.3171	–2.7211	6.1924	8.6903	8.3810	0.0957	8.8530	–0.1627	0.0265	0.0001
1947	5.3293	–2.7360	6.1654	8.7169	8.3810	0.1128	8.8950	–0.1781	0.0317	0.0002
1948	5.3509	–2.6598	6.1269	8.6990	8.3810	0.1011	8.6607	0.0382	0.0015	0.0468
1949	5.3776	–2.6482	6.1048	8.8199	8.3810	0.1926	8.6516	0.1683	0.0283	0.0169
1950	5.4403	–2.7016	6.1312	8.9908	8.3810	0.3719	8.9556	0.0352	0.0012	0.0177
1951	5.4502	–2.7596	6.1442	9.2676	8.3810	0.7861	9.1658	0.1018	0.0104	0.0044
1952	5.4781	–2.7881	6.2126	9.4382	8.3810	1.1177	9.3708	0.0674	0.0045	0.0012
1953	5.5247	–2.8209	6.2383	9.6020	8.3810	1.4908	9.5813	0.0206	0.0004	0.0022
1954	5.5440	–2.8389	6.2480	9.7293	8.3810	1.8179	9.6813	0.0480	0.0023	0.0007
1955	5.6139	–2.8510	6.2519	9.8961	8.3810	2.2955	9.8487	0.0473	0.0022	0.0000
1956	5.6398	–2.8781	6.2804	10.0167	8.3810	2.6757	10.0070	0.0097	0.0001	0.0014
1957	5.6637	–2.9118	6.3315	10.1417	8.3810	3.1000	10.2037	–0.0620	0.0038	0.0051
1958	5.6702	–2.8751	6.3404	10.1415	8.3810	3.0995	10.1105	0.0311	0.0010	0.0087
1959	5.7278	–2.8463	6.3544	10.2856	8.3810	3.6275	10.1386	0.1470	0.0216	0.0134
1960	5.7561	–2.8270	6.3682	10.3273	8.3810	3.7883	10.1432	0.1842	0.0339	0.0014
1961	5.7761	–2.8063	6.3784	10.3437	8.3810	3.8524	10.1249	0.2188	0.0479	0.0012
1962	5.8242	–2.7892	6.3986	10.4229	8.3810	4.1696	10.1784	0.2446	0.0598	0.0007
1963	5.8673	–2.8451	6.5396	10.5573	8.3810	4.7363	10.5653	–0.0080	0.0001	0.0638
1964	5.9235	–2.8647	6.4052	10.6951	8.3810	5.3554	10.5979	0.0972	0.0095	0.0111
1965	5.9857	–2.8881	6.4200	10.8568	8.3810	6.1298	10.7972	0.0597	0.0036	0.0014
1966	6.0357	–2.9513	6.4297	11.0119	8.3810	6.9217	11.0928	–0.0809	0.0065	0.0197
1967	6.0640	–3.0098	6.4552	11.2313	8.3810	8.1240	11.3497	–0.1185	0.0140	0.0014
1968	6.1140	–3.1296	6.4785	11.3792	8.3810	8.9896	11.8336	–0.4544	0.2065	0.1128
1969	6.1480	–3.0409	6.5132	11.4712	8.3810	9.5497	11.6538	–0.1825	0.0333	0.0739
SUM				343.6203		201.0280			1.4007	1.2259
SUM/N				8.380983		4.9031			0.0342	
DURBIN WATSON				1.142572						
F STATISTIC (3,37)				1757.663						

Regression Output:

Constant		–15.1541	
Std Err of Y Est		0.194568	
R Squared		0.993032	
No. of Observations		41	
Degrees of Freedom		37	
	B(1)	B(2)	B(3)
X Coefficient(s)	1.805324	–3.09982	0.964558
Std Err of Coef.	0.18215	0.238834	0.228791
T–STATISTIC	9.911196	–12.9789	4.215893
(37 DEGREES OF FREEDOM)			
DURBIN WATSON			1.142572
F STATISTIC (3,37)			1757.663

TABLE 1
ESTIMATION RESULTS OF THE ECONOMETRIC FORECASTING MODEL
FOR THE U.S. DOMESTIC TRAFFIC

MODEL

$$LOG_E(RPM)_T = -15.15 + 1.805 LOG_E(PCE)_T - 3.0998 LOG_E(YLD)_T + 0.965 (PTL)_T$$ [4]

[-15.1541] [1.805324] [-3.09982] [0.964558]

Standard Error of Coefficients	0.18215	0.238834	0.229791
T-Statistic (37 Degrees of Freedom)	[9.911196]	[-12.9789]	[4.215893]

Durbin Watson 1.142572

F Statistic (3,37) 1757.663

Where T = Time (years)

RPM = Revenue Passenger Miles

= PCE$ = PCE Personal Consumption expenditure in billions of 1958 dollars

YLD = YLD$ = Average yield per mile in 1958 constant dollars

PTL = Passenger Trip Length

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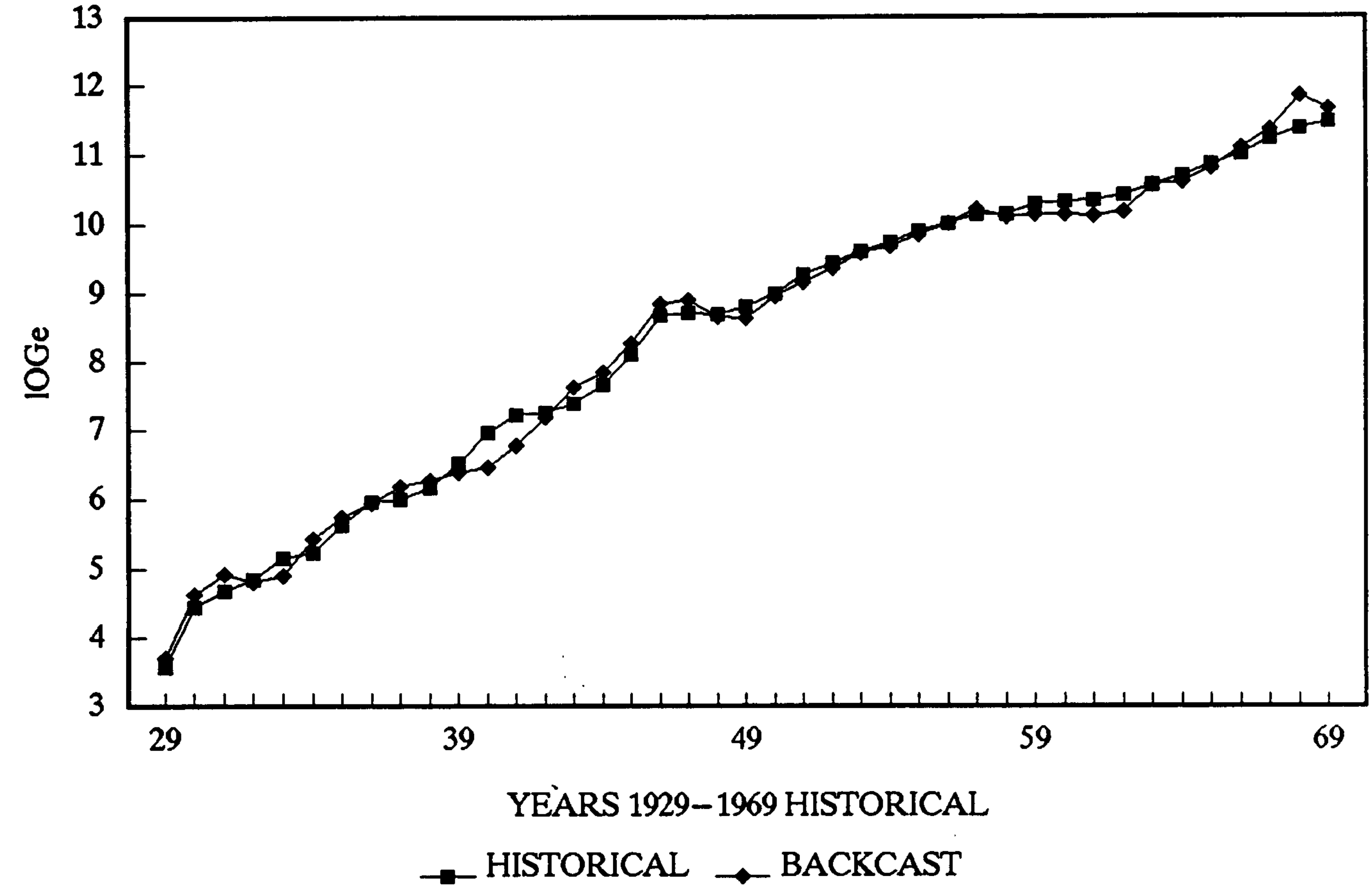
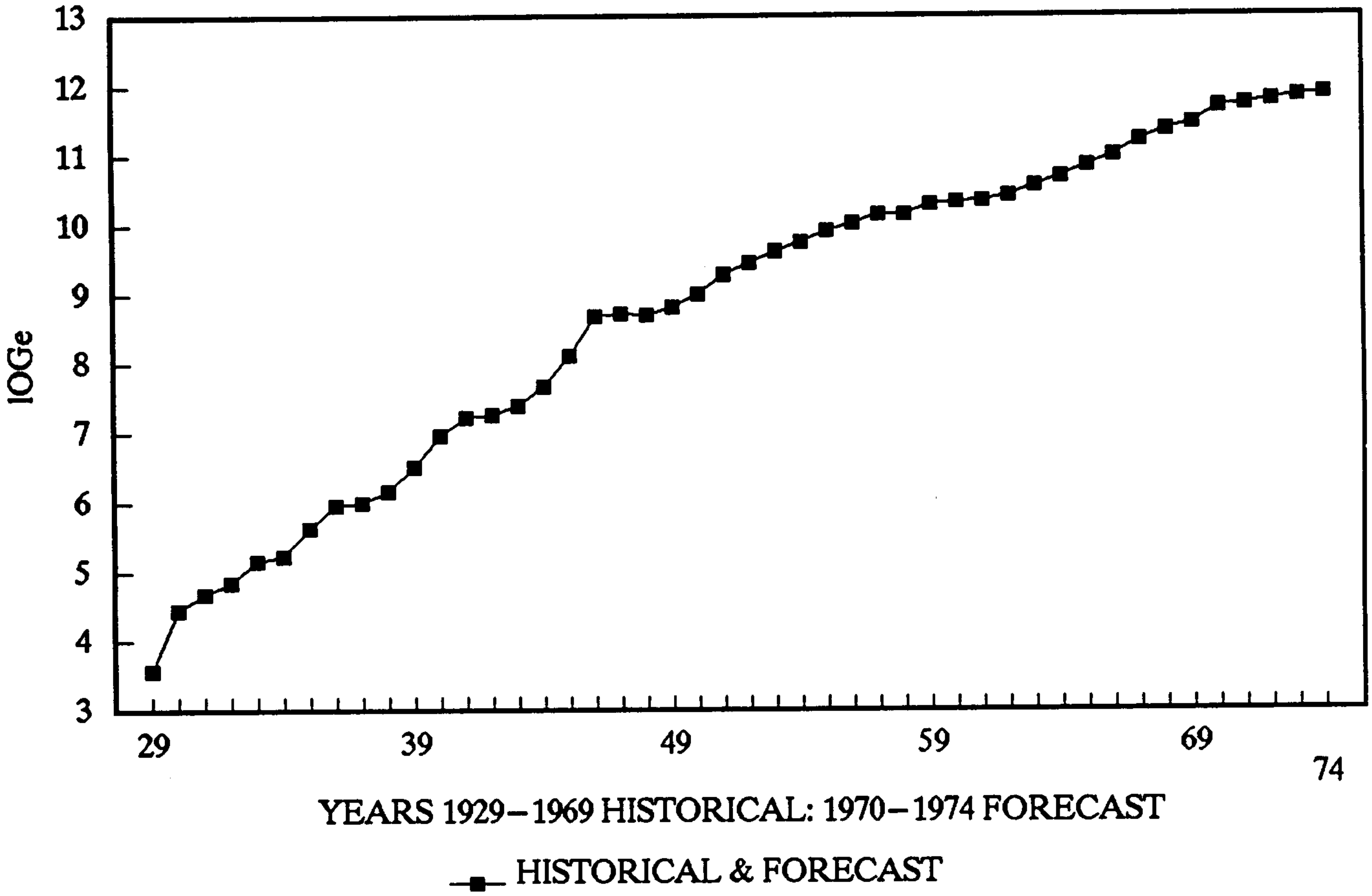
4 See Table 5 - Data and Regression Output

FIGURE 2–GRAPHICAL REPRESENTATION OF THE GOODNESS–OF–FIT
U.S. DOMESTIC FORECASTING MODEL 1929–69



ECON. 395

FIGURE 3 – HISTORICAL 1929–1969: FORECAST – 1970 to 1974
U.S. DOMESTIC FORECASTING MODEL SCENARIO No. 1



ECON. 395