Forecasting Economic Activity for the Chicago Region

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The economic forecast developed by the Chicago Area Transportation Study was one of a sequence of forecasts to be used in developing transportation plans for the Chicago area. The primary goal was development of employment forecasts to 1980; secondary goals included an attempt to predict future automobile registration and an attempt to gain some insight into the effects of an expanded highway program on the economy.

A regional input-output model was employed. The factors taken into account in developing forecasts were population increase, growth in real income per consumer unit, changes in consumer expenditure with rising real income per consumer unit, changes in the Chicago area's trade with the outside economy, and differential growth in productivity between industries.

The input-output approach was compared to an alternative forecasting device (fitting trend lines), and some ideas on the strengths and weaknesses of the approach were developed.

• A MODEL developed at the Chicago Area Transportation Study (CATS) to forecast regional economic activity is reported in this paper. A number of papers have been issued by the Chicago Area Transportation Study in connection with this project. A Final Report summarizes results in somewhat more detail than the present paper, and a series of technical reports cover particular problem areas of the model in detailed fashion. Most of the detailed calculations reported on in this paper were performed on the CATS electronic computer. The primary goal was development of individual industry employment forecasts by 5-year increments to 1980. This was done for the Chicago Standard Metropolitan Area (CSMA),[1] then these forecasts were scaled down to the CATS area. The CATS area contains about 85 percent of the population of the metropolitan area, and is approximately defined by the circumference of a circle generated by a 30-mi radius centered in the Chicago Loop. The study area contains all of Cook County, and large fractions of Du Page and Lake Counties, Illinois; its area is approximately 1,250 sq mi.

[1] The CSMA consists of Cook, Du Page, Kane, Lake and Will Counties in Illinois, and Lake County in Indiana.

The employment forecasts were part of a chain of CATS forecasts to be used in drawing up plans and recommendations for highway development in the Chicago area. The CATS population forecast was an input used in developing the economic forecast. The economic forecast was used as an input in the CATS land use forecast, which in turn is to be used in forecasting future traffic generation.

There were a number of secondary goals of the work on the economic model. These included an attempt to predict future automobile registration in the CATS area and an attempt to gain some insight into the effects of an expanded highway program on the economy.

This paper discusses these problem areas in turn. The development of the economic model is described, its primary application in obtaining employment forecasts is discussed, and the byproducts already noted are examined.

DEVELOPMENT OF THE ECONOMIC MODEL

Economic forecasting generally involves obtaining an accurate description of the economic system in the present (or in a base year); specifying important sources of change; and gaging the effects of changes stemming from those sources as the changes are transmitted through the economic system. Some important sources of change the present study attempts to take into account are: population growth, increases in real income per capita, and locational shifts of industry affecting the Chicago area's position within the nation.

The model employed is a regional input-output model. The view of the economy embodied in the model is based to a considerable extent on a study by Cornfield, Evans, and Hoffenberg (*1*). A sequence of forecasts is developed, eventuating in a forecast of "final demand," which consists of expenditure by a group of "causative" or "independent" sectors of the economy. (The term "exogenous" is often used to denote this sort of independence.) When final demand is inserted into an input-output apparatus, estimates of individual industry outputs are obtained. (These industries are termed "endogenous," or determined within the input-output system, as contrasted with the exogenous sectors, which are determined outside the system.) Given estimates of industry output, estimates of industry employment can then be derived.

The specification of sectors belonging in final demand is somewhat arbitrary. The sectors making up final demand in the present study were households, government, investment, and Chicago trade with the outside economy.

In developing household forecasts, population growth and productivity increases were treated as basic forces initiating changes. Per capita and aggregate income were projected on the basis of these growth forces, and an assumption about tax rates yielded disposable income. Forecasts could then be made of total consumption and consumption of particular items.

Previous forecasts of consumption relations tended to overstate savings and understate consumption. In the present study an approach was developed which aimed at avoiding this problem. Forecasts of particular consumption items included consumption by goods type (food, transportation, etc.) and consumption by industry sources (food and kindred, motor vehicles, railroads, etc.). With some minor modification consumption by industry source is equivalent to household expenditures, which was the major component of final demand.

Forecasts of the other components of final demand were then obtained. Government and investment forecasts, like the household forecasts, were based on population growth and productivity increase. The remaining component of final demand consisted of Chicago area trade with the outside economy, including domestic as well as foreign trade.

Trade refers to net imports and exports of the Chicago economy. Forecasts of trade were based on estimates of Chicago area imports and exports obtained for 1939, 1947, and 1954. The procedure used in deriving imports and exports was based on an approach developed by Isard (*2, 3*). These estimates were used to project trade to 1980. The use of explicit trade forecasts is an attempt to account for locational shifts affecting the position of Chicago industries relative to their national counterparts.

Total final demand was obtained by adding its components together, and final demand forecasts (by 5-year increments) were then inserted into the input-output apparatus. This apparatus yields estimates of output by individual industries as a function of final demand. (The apparatus consists of a set of relationships between endogenous industries which is assumed to be stable over time.) Estimates of the rate of productivity increase by individual industry were used to convert output estimates to employment estimates. As a check of the model's internal consistency, these employment estimates were summed and compared to a total employment figure derived from the starting population figure. Finally, as an external check, the employment estimates were compared with employment estimates obtained by an alternative procedure in which all available data on employment by industry were plotted and simple trend lines were drawn. Some revision of input-output results was based on this comparison.

DESCRIPTION OF EMPLOYMENT FORECAST

Two basic problem areas can be distinguished. They are (a) developing the regional input-output apparatus and (b) obtaining final demand forecasts.

Regional Input-Output Apparatus

The 1947 BLS 200-sector study (*4*) was the basic source document used in the development of the input-output apparatus. Table 1 of that study exhibited the flows of inputs and outputs between 200 sectors or industries in the national economy for 1947. In the CATS model, the 200 sectors were consolidated into 50 sectors in order to reduce data problems. In the consolidated flow table the outputs of each of the 50 U.S. industries appear as row entries, the inputs into each industry appear as column entries. Reading along a given row shows the distribution of a given industry's output among all the industries in the economy. Reading down a given column shows the purchases a given industry makes from all the industries in the economy.

Division of a given column's entries by the total output of the industry yields what is termed the "technical coefficient matrix." It is assumed the relationships embodied in the technical coefficient matrix are stable, and those relationships, in combination with final demand forecasts, yield forecasts of future outputs. (The mathematical procedure is as follows: The submatrix of endogenous industries in the technical coefficient matrix is removed; the identity matrix is subtracted from this submatrix; and the resulting matrix is inverted. Final demand times this inverse yields outputs of endogenous industries.) In the input-output approach, an estimate is made of the effects of a change in final demand as it is transmitted through the economic system; thus, an increase of $1 in final demand on a given industry causes expansion not only in that industry, but also in the industries furnishing its inputs, etc. The input-output approach attempts to estimate the ultimate effect of such changes.

There are a number of ways in which a regional input-output model can be developed. The approach employed here was to make use of the national technical coefficient matrix in two ways. First, it was used in developing estimates of regional imports and exports for three time periods. Then, it was employed as the source of the inverse to be multiplied by final demand.

It was assumed in both these uses that the cost structure of a Chicago area industry is the same as the nationwide cost structure. This means that for a given Chicago industry the proportion of its output paid for each of its inputs is the same as the corresponding nationwide industry's proportion. This assumption was used only in the cases of endogenous industries, as it did not seem applicable to exogenous sectors.

Estimates of imports and exports were obtained in the following manner. Estimates of Chicago area production by individual industry were derived for years in which data were available (1939, 1947, 1954). For a given year, multiplication of an endogenous Chicago industry's output by its corresponding column of input proportions yields its column of input requirements. Exogenous sectors' input requirements were derived independently. Summing across rows yields inputs required by the Chicago region from a given industry. Subtracting this row total from the original output estimates yields estimates of net imports and exports by Chicago industry. These ideas may be clarified by an examination of Table 1, which gives a simple numerical example of this procedure.

Table 2 presents estimates of Chicago area production and trade for 1947, using a detailed industry breakdown; Table 3 presents summary statistics on trade for the three periods examined.

Projections of future trade were based on the estimates derived for the years examined; a trend line was obtained by connecting the 1939 and 1954 points; this was modified on the basis of a line connecting the 1947 and 1954 points. Admittedly, this is a fairly crude approach, as only three points were used in devel-

TABLE 1

SIMPLE EXAMPLE SHOWING DERIVATION OF NET IMPORT AND EXPORT ESTIMATES

Steps in procedure listed in alphabetical order.

There are three industries in the economy: I, II, and III.

A. U.S. Input-Output Table

Industry	I	II	III	Total Output
I	2	5	3	(10)
II	4	2	9	(15)
III	4	8	8	(20)
Total Inputs	(10)	(15)	(20)	

B. U.S. Technical Coefficient Matrix

	I	II	III
I	0.20	0.33	0.15
II	0.40	0.13	0.45
III	0.40	0.54	0.40

C. Estimated Outputs by Regional Industries

I	1
II	4
III	4

D. Inputs Required by Regional Industries

From	By I	By II	By III
I	0.20	1.32	0.60
II	0.40	0.52	1.80
III	0.40	2.16	1.60
Total	1.00	4.00	4.00

E. Obtaining Net Exports and Imports

	Inputs Required from Industry (obtained from D by summing across rows)	Regional Output (from C)	Exports (+) Imports (—)
I	2.12	1.00	—1.12
II	2.72	4.00	1.28
III	4.16	4.00	—0.16

TABLE 2

CHICAGO INDUSTRY PRODUCTION AND TRADE IN 1947

(in millions of 1956 dollars)

Industry	Output: CSMA / U.S.	Output: CSMA	CSMA Trade Imports (—) Exports (+)
1. Agriculture and forestry	0.005	236.3	—2042.4
2. Mining	0.005	58.2	—832.8
3. Food and kindred	0.079	3629.7	1224.7
4. Tobacco	0.006	18.2	—59.3
5. Textiles and apparel	0.027	747.0	—496.2
6. Lumber and wood	0.014	104.2	—210.1
7. Furniture and fixtures	0.085	307.9	81.8
8. Paper and allied	0.043	382.3	—230.8
9. Printing and publishing	0.117	955.4	284.6
10. Chemicals	0.072	1249.0	213.7
11. Petroleum and coal	0.090	1025.7	400.2
12. Rubber	0.017	64.4	—89.1
13. Leather	0.043	199.6	—35.8
14. Stone, clay, glass	0.041	191.1	—72.8
15. Primary metal	0.118	2581.3	485.1
16. Fabricated metal	0.101	1357.4	499.2
17. Machinery (except elect.)	0.090	1827.8	680.5
18. Electrical machinery	0.160	1564.4	796.1
19a Motor vehicles	0.024	389.0	—198.9
19b Other transp. equipment	0.070	349.7	187.3
20. Professional instruments	0.114	283.5	138.8
21. Misc. manufacturing	0.083	519.2	129.7
22. Telecomm. and utilities	0.048	540.6	—61.5
23. Railroads	0.066	824.2	156.5
24. Trucking	0.067	327.3	101.6
25. Warehousing	0.070	47.3	15.2
26. Water transport	0.015	55.8	—26.3
27. Air transport	0.049	48.3	—1.0
28. Pipe lines	0.012	5.4	32.1
29. Wholesale trade	0.080	1610.2	644.7
30. Retail trade	0.045	1441.4	21.5
31. Local and highway transp.	0.076	307.4	5.7
32. Eating and drink. places	0.056	925.9	2.9
33. Banking, finance and ins.	0.060	949.0	73.5
34. Hotels	0.063	108.7	21.7
35. Real estate and rentals	0.047	1636.5	2.4
36. Personal services	0.064	351.3	1.2
37. Business services	0.109	693.9	294.7
38. Automobile repair serv.	0.042	207.2	—15.5
39. Other repair services	0.052	103.2	0.6
40. Entertainment	0.058	211.7	9.4
41. Medical, dental, other	0.053	588.6	—4.0
42. Nonprofit	0.041	375.5	13.0
43. Construction	0.047	1677.0	—44.4
45. Foreign trade	——	——	—157.5
46. Federal government	——	——	—1815.3
47. State and local govt.	0.040	789.7	—146.8
48. Capital formation	0.051	2109.7	
49. Households	0.051	12688.0	—125.7

TABLE 3

CSMA IMPORTS (—) AND EXPORTS (+) FOR BROAD INDUSTRY GROUPS

(in millions of 1956 dollars)

Industry Group	1939	1947	1954
Raw materials	—2000.1	—2875.2	—3333.7
Manufactures	1883.1	3729.5	3853.7
All other private	134.6	896.6	1184.5
Government	—60.8	—1962.1	—1365.4
Stat. discrepancy	43.2	211.2	—339.1
Manufactures:			
Metals	625.1	984.4	1705.9
Machinery	526.2	1476.6	1587.0
All others	731.8	1268.5	560.8

oping projections. Data limitations precluded a more refined approach.

Essentially the same technical coefficient matrix employed in obtaining imports and exports was then used in obtaining an inverse matrix (a 44-by-44 inverse was obtained via electronic computer). One of the minor modifications prior to inversion was the elimination of industries assumed to bear a stable relation to output. These industries were byproducts and inventory change.

Final Demand Forecasts

Forecasts were then obtained for the other final demand components to be used with this inverse. Population growth and productivity increases were treated as forces initiating changes. Population forecasts (Table 4) were developed by the CATS population section. Productivity increase is a somewhat nebulous term, and it might be more exact to use a phrase such as "the rate of increase in real income per worker."

The (compound) rate of increase in real income per worker was estimated as approximately 1⅔ percent per year for the period 1929-1956; in the post-war period, 1947-1956, a higher rate of increase of approximately 2 percent prevailed (these rates of increase refer to worker year; that is, besides the increase in real income, average hours worked have decreased). Growth rates were based on data developed by the Department of Commerce, National Income Division. These are U.S. rates, but available evidence (Census of Manufactures and Business) indicates CSMA rates equal U.S. rates (*5*).

In deciding what rate of increase to use in projecting income growth, a hidden problem arose. At first glance, there does not seem to be much difference in the implications of the long-term vs. the post-war growth rate. Thus, average income projected from 1947 to 1980 using the post-war rate is only 10 percent above the average income projection obtained using the long-term rate.

TABLE 4

ACTUAL AND FORECAST POPULATION DATA [1]

Year	Population (1,000's) CSMA	Population (1,000's) U.S.	Ratio, CSMA/U.S.
	(*a*) Actual		
1920	3,522	106,460	0.0330
1930	4,676	123,077	0.0380
1940	4,826	131,954	0.0366
1950	5,495	151,683	0.0362
1955 (Est.)	5,999	165,270	0.0363
	(*b*) Forecast		
1965	7,400	193,300	0.0383
1970	8,100	209,400	0.0387
1975	8,800	228,500	0.0385
1980	9,500	245,000	0.0388

[1] Obtained from Population Section, CATS, on basis of preliminary projections of the Chicago Community Inventory.

TABLE 5

CSMA INCOME DATA AND FORECASTS

(*in 1956 dollars*)

Year	Average Income per Consumer Unit	Aggregate Income in Billions
1939	4929	8.24
1947	6311	11.53
1954	7074	14.56
1956	7836	16.71
1960	7919[a]	18.52
1965	8664[a]	22.38
1970	9483[a]	26.81
1975	10330[a]	31.73
1980	11297[a]	37.45

[a] Projected from 1947 at a growth rate of approximately 1.8 percent.

However, there was a pronounced difference in productivity growth rates in manufactures between the over-all period and the post-war period (the rates were, respectively, 2 percent and 3½ percent). This implied that estimates of manufacturing employment would be greatly affected by the choice of growth rate. Results were obtained using both approaches, and it was decided to hedge by assuming the future growth rate in productivity would be somewhere between the long-term and post-war rates. This is not a particularly satisfying solution, but it seemed the wisest course inasmuch as no clear-cut choice appeared possible.

In forecasting income it was assumed a 1-to-1 correspondence held between workers and consumer units, so that the (hedged) productivity growth rate was applied directly. Constant inequality of income in the Lorenz curve sense was assumed. This assumption implies that the rate of increase in income is the same for different income classes.

Table 5 gives average and aggregate Chicago area income estimates and forecasts obtained. By 1980, the metropolitan area has a predicted aggregate income about 2¼ times the 1956 level, with average income per consumer unit around 145 percent of 1956 levels.

Disposable income was derived by estimating and subtracting taxes from income. It was assumed taxes are a constant proportion of income, so that present effective rates remain stable over time. (This implies a downward shifting of actual tax rates over time, which appeared more reasonable than the alternative assumption of constant actual rates.)

The next step in the forecasting process involved relating consumption to income. Previous studies ran into difficulty at this point because it was not realized that the shortrun income-consumption relation evidently shifts upward over time. As a result, saving forecasts were overstated and consumption forecasts understated as real income increased. The upward shift of the income-consumption relation is associated with a stable ratio of average consumption to income. These results are supported by empirical evidence and theoretical considerations.

The empirical evidence includes the following items:

1. The ratio of aggregate consumption to aggregate disposables income appears stable over time and equals approximately 0.93 of disposable income.
2. Consumption functions fitted to time series data with time appearing as a variable yield a positive coefficient for time.
3. Examination of budget study data indicates an upward shift over time.

In terms of theory, Friedman (*6*) has developed a straightforward explanation for the shift, based on the distinction between transitory and permanent components of income.

To avoid the forecasting difficulties involved in the shifting income-consumption relation, it was argued that average consumption over time was a stable fraction (0.93) of disposable income. Then, consumption of a particular item was related to over-all consumption using an equation of the form

$$Z_g = A_g Z^{B_g} \qquad (1)$$

in which

Z_g = consumption of a given item g;
Z = total consumption; and
A_g, B_g = parameters.

There are some statistical difficulties connected with this form, but they seem outweighed by the advantages. A forecast of consumption of a given item can be based on consumption of that item in the base period and estimates of the parameters in Eq. 1 obtained by regression analysis. It turns out that

$$\overline{Z}_{gt} = (1+r)^{tB_g} \overline{Z}_{g0} \qquad (2)$$

where t measures time in years, 0 is the initial year, r is the growth rate of income, and the bar above indicates the average value of the variable.

The parameters in Eq. 1 were estimated using budget study and time series data, with estimates obtained for consumption by goods type and by industry source (*7, 8*). Variables referred to per capita or per family consumption.

Table 6 gives parameter estimates ob-

TABLE 6

ESTIMATED PARAMETERS OF PREDICTIVE EQUATIONS (*1*) FOR CONSUMPTION BY GOODS TYPE, CONSOLIDATED URBAN SAMPLE

Code	Goods Type	log A_g	B_g	r_g^2	S_{B_g}[1]
A	Food and beverages	0.246	0.784	0.990	0.015
B	Tobacco	−1.278	0.865	0.860	0.066
C	Housing	−0.010	0.793	0.972	0.025
D	Utilities	0.150	0.587	0.782	0.059
E	Household oper.	−2.487	1.324	0.963	0.049
F	Furniture and equip.	−2.419	1.290	0.913	0.075
G	Clothing	−1.927	1.267	0.985	0.029
H	Transportation	−2.868	1.516	0.970	0.050
I	Medical expenses	−1.416	1.020	0.965	0.037
J	Personal expenses	−1.692	1.001	0.977	0.029
K	Recreation, reading, education	−2.725	1.405	0.985	0.033
L	Miscellaneous	−3.303	1.324	0.742	0.147
M	Contributions	−3.704	1.520	0.964	0.055
H_1	Auto purchase	−4.182	1.764	0.902	0.110
H_2	Auto operation	−3.225	1.508	0.947	0.068
H_3	Other transp.	−2.479	1.201	0.918	0.068
K_1	Recreation	−3.185	1.485	0.970	0.049
K_2	Reading	−1.768	0.926	0.963	0.035
K_3	Education	−4.655	1.696	0.882	0.117

[1] Standard error of parameter estimate.

TABLE 7

PREDICTED GROWTH IN CONSUMPTION OVER 1947[1] PER CONSUMER UNIT (1947 = 100)

Industry	Ratio 1980/1947	Industry	Ratio 1980/1947
All Consumption	1.707		
1. Agriculture and forestry	1.499	22. Telecomm. and utilities	1.398
2. Mining	1.707	23. Railroads	0.448
3. Food and kindred	1.499	24. Trucking	3.074
4. Tobacco	1.599	25. Warehousing	3.074
5. Textiles and apparel	2.169	26. Water transport	1.801
6. Lumber and wood	2.038	27. Air transport	8.528
7. Furniture and fixtures	2.608	28. Pipe lines	1.707
8. Paper and allied	1.603	29. Wholesale trade	2.105
9. Printing and publishing	1.601	30. Retail trade	1.566
10. Chemicals	1.489	31. Local and highway transp.	0.454
11. Petroleum and coal	2.211	32. Eating and drink. places	1.771
12. Rubber	2.105	33. Banking, finance and ins.	1.921
13. Leather	1.832	34. Hotels	1.632
14. Stone, clay, glass	2.463	35. Real estate and rentals	1.855
15. Primary metal	1.707	36. Personal services	1.687
16. Fabricated metal	1.939	37. Business services	1.921
17. Machinery (except elect.)	2.540	38. Automobile repair serv.	1.864
18. Electrical machinery	2.225	39. Other repair services	2.106
19a Motor vehicles	2.678	40. Entertainment	2.033
19b Other transportation equip.	3.452	41. Medical, dental and other	1.725
20. Professional instruments	1.872	42. Non-profit	2.195
21. Misc. manufacturing	2.072	43. Construction	1.707

[1] Adjustments made to compensate for distortions caused by using 1947 as base year. Distortions occurred because consumption as a fraction of income was exceptionally high in 1947, and expenditures on housing and automobile purchase were below long-run levels.

tained for consumption by goods type using urban budget study data. Table 7 applies Eq. 2 and exhibits growth rates obtained for consumption by industry source. (Growth values for 1980 are listed; in the study, growth values were obtained for each 5-yr period from 1960 to 1980.) These growth rates predict increases in consumption per consumer unit, the rates were multiplied by predicted population growth rates, and then the combined growth rates were multiplied by base period figures for the household sector. This yielded a forecast of the household sector component of final demand.

Forecasts of government and investment components of final demand were obtained by multiplying base year expenditures by a growth rate combining population and over-all productivity increase. (Some adjustment was made for increased levels of expenditures on construction in the investment sector, and on public education in the government sector, reflecting post-war changes.)

The insertion of total final demand forecasts into the input-output apparatus yielded output estimates. These were scaled to employment estimates using a set of productivity growth rates obtained for each industry. The formula used in estimating employment is as follows:

$$\frac{X_{it}}{X_{io}} \frac{N_{io}}{(1+r_i)} t = N_{it} \quad i = 1, \ldots, 43 \quad (3)$$

where N is employment, X is output, r is the productivity growth rate, t is time with 0 the initial time period, and i is the industry code number.

Table 8 gives the estimates of productivity growth rate obtained for the long-term period, 1929-1956. As noted previously, the post-war manufactures growth rate was well above the long-term rate. It was decided to hedge by obtaining employment forecasts using both the long-term (low productivity) and post-war (high productivity) rates.

Broad categories of non-manufactures had approximately the same long-term and post-war rates, hence the "high productivity" estimates were obtained using "high" estimates for over-all growth in productivity, income, and consumption, and for manufactures (Table 9).

The manufactures forecast varied greatly between the "high" and "low productivity" cases (1,142,000 *vs* 1,667,000). Total employment for both cases is in fairly good agreement with a control total derived from the population fore-

TABLE 8

PRODUCTIVITY GROWTH RATES BY INDUSTRY (1929-1956)[a]

Industry	1 + Growth Rate Geometric Average	Industry	1 + Growth Rate Geometric Average
Broad Categories:			
All industries	1.0166	18. Electrical machinery	1.0201
Mining	1.0263	19a Motor vehicles	1.0322
Agriculture	1.0245	19b Trans. equip. except motor	
Manufactures	1.0204	vehicles	1.0201
Commun. and util.	1.0202	20. Professional instruments	1.0181
Construction	1.0164	21. Misc. manufacturing	1.0039
Transportation	1.0157	22. Telecomm. and utilities	1.0202
Trade	1.0157	23. Railroads	1.0125
Government	1.0132	24. Trucking	1.0299
Services	1.0121	25. Warehousing	1.0299
Fin., ins., real est.	1.0076	26. Water transport	1.0398
		27. Air transport	1.0476
Detailed Breakdown:		28. Pipe lines	1.0129
1. Agriculture and forestry	1.0245	29. Wholesale trade	1.0142
2. Mining	1.0263	30. Retail trade	1.0158
3. Food and kindred	1.0184	31. Local and highway trans.	1.0091
4. Tobacco	1.0324	32. Eating and drink. places	1.0158
5. Textiles and apparel	1.0127	33. Banking, finance and ins.	1.0076
6. Lumber and wood	1.0195	34. Hotels	1.0094
7. Furniture and fixtures	1.0182	35. Real estate and rentals	1.0076
8. Paper and allied	1.0267	36. Personal services	1.0121
9. Printing and publishing	1.0106	37. Business services	1.0111
10. Chemicals	1.0242	38. Automobile repair serv.	1.0158
11. Petroleum and coal	1.0183	39. Other Repair services	1.0107
12. Rubber	1.0227	40. Entertainment	1.0191
13. Leather	1.0096	41. Medical, dental and other	1.0056
14. Stone, clay, glass	1.0252	42. Non-profit	1.0079
15. Primary metal	1.0206	43. Construction	1.0164
16. Fabricated metal	1.0126	46. Federal government	1.0115
17. Machinery (except elect.)	1.0158	47. State and local govt.	1.0137

[a] Data source: National Income Division, U.S. Dept of Commerce.

cast. Thus, for the 1980 forecast both high and low employment totals are within 5 percent of the control total, and the hedged (average) value differs by less than 1 percent from the control total. This appears to establish the internal consistency of the approach used.

Extremely good correspondence was obtained when the hedged values were compared to employment forecasts derived by simple trend analysis. This external check appears in Table 9.

It turned out that non-manufactures estimates differed by about 1 percent, whereas there was no difference to speak of between the manufactures estimates. However, the trend results presented had been derived for 1985; they were compared to the 1980 input-output results because the trend results were implicitly less optimistic with respect to population growth than the CATS population forecast. Thus, the 1985 "trends" employment total agreed with the 1980 employment "control total" derived from the population forecast.

Total Chicago Metropolitan Area employment (in thousands of workers) is

TABLE 9

CSMA EMPLOYMENT, IN THOUSANDS, FOR BROAD INDUSTRIAL GROUPINGS

Item	Pop.	Empl.	Manuf.	Non-Manuf.	Empl. Control Total
1947 Actual	5232	2613.9	989.8	1624.1	—
1956 Actual	6106	2983.7	1038.9	1944.8	—
1980 Control total	9500	4746[a]	—	—	—
1980 "Low" productivity	—	4831.5	1666.6	3164.9	1.018
1980 "High" productivity	—	4599.7	1142.1	3457.6	0.969
1980 Average	—	4715.4	1404.4	3311.0	0.994
Alternative forecast:					
Simple trend analysis		4757.0	1403.0	3352.8	1.002

[a] Control total equals employment consistent with 1980 population forecast; obtained by applying 1947 ratio of employment-to-population to 1980 population forecast.

seen as rising from 2,984 to 4,715 between 1956 and 1980; with a 35 percent rise in manufactures (from 1,039 to 1,404), and a 70 percent rise in non-manufactures (from 1,945 to 3,311).

Employment forecasts for a detailed industry breakdown are given in Table 10. In the few cases where there was strong disagreement between input-output results and trend analysis results, the cases were examined, and when it seemed warranted, the input-output re-

TABLE 10

EMPLOYMENT, IN THOUSANDS

Industry	Employment			CATS Area 1980
	CSMA 1947	1956	CSMA 1980	
1. Agriculture and forestry	21.0	16.5	9.0[a]	4.2
2. Mining	3.0	3.6	3.8	2.5
3. Food and kindred	105.7	103.5	85.5	77.4
4. Tobacco	0.7	0.6	0.6	0.5
5. Textiles and apparel	58.5	46.0	37.1[a]	32.8
6. Lumber and wood	8.4	9.6	3.5	2.9
7. Furniture and fixtures	25.0	24.4	32.8	25.0
8. Paper and allied	23.2	26.0	29.9	25.5
9. Printing and publishing	87.4	87.9	144.3	128.0
10. Chemicals	41.2	41.1	42.3	28.9
11. Petroleum and coal	17.9	19.4	28.2	4.9
12. Rubber	3.4	5.2	7.3	6.3
13. Leather	14.0	10.9	12.6	11.4
14. Stone, clay, glass	17.5	20.0	22.6	14.3
15. Primary metal	129.1	136.0	213.4	94.3
16. Fabricated metal	90.2	108.1	187.1	160.0
17. Machinery (except elect.)	142.0	143.6	229.5	196.9
18. Electrical machinery	122.5	139.5	175.6[a]	161.6
19a. Motor vehicles	13.8	14.5	15.7	12.9
19b. Trans. equip. except motor vehicles	28.4	31.8	33.2	27.0
20. Professional instruments	25.0	26.2	43.6	36.4
21. Misc. manufacturing	35.9	44.6	59.6	50.8
22. Telecomm. and utilities	52.1	62.9	95.2	79.8
23. Railroads	97.0	84.0	69.8[a]	57.3
24. Trucking	40.0	54.0	84.8	75.3
25. Warehousing	9.4	11.3	15.1	13.4
26. Water transport	3.0	3.3	1.6	1.3
27. Air transport	5.6	9.2	16.3	14.3
28. Pipe lines	0.2	0.2	0.4	0.3
29. Wholesale trade	159.0	185.5	280.6	248.9
30. Retail trade	345.0	371.2	573.7	451.3
31. Local and highway transp.	38.1	30.5	26.7	23.9
32. Eating and drink. places	87.0	99.2	158.8	134.3
33. Banking, finance and ins.	90.2	105.4	220.4[a]	194.1
34. Hotels	27.7	29.0	45.8	40.9
35. Real estate and rentals	49.6	55.8	124.0	111.9
36. Personal services	69.1	63.6	137.4	117.2
37. Business services	41.8	64.4	146.0	131.5
38. Automobile repair serv.	9.0	10.4	18.6	15.2
39. Other repair services	8.8	12.0	21.7	18.1
40. Entertainment	18.9	22.6	33.7	28.6
41. Medical, dental and other	66.5	107.7	267.8[a]	224.2
42. Non-profit	86.2	122.5	295.5[a]	243.3
43. Construction	110.0	184.0	304.7[a]	243.5
46. Federal government	60.8	68.4	90.0[b]	75.4
47. State and local govt.	67.3	96.1	170.0[b]	143.0
49. Households	57.8	71.5	100.0[b]	82.3
Manufactures	989.8	1038.9	1404.4	1097.8
Non-manufactures	1624.1	1944.8	3311.0	2776.0
Total employment	2613.9	2983.7	4715.4	3873.8

Source: Illinois Dept. of Labor data and CATS input-output forecast.

[a] Adjustments to original input-output estimate on basis of results obtained by trend analysis:

Industry	Adjustment
1	−7.0
5	−32.0
18	32.0
23	−76.1
33	−80.0
41	91.1
42	25.0
43	25.0

[b] Obtained from trend analysis forecasts because these industries were exogenous in input-output work.

sults were modified. The metropolitan area forecasts were then scaled to the CATS area (Table 10).

Summary of Forecasts

1. The over-all compound growth rate in productivity (and income) was estimated as 1.8 percent per year. The productivity growth rate for manufactures was estimated as approximately 2½ percent, whereas that for non-manufactures was estimated as somewhat under 1½ percent.

2. Average income per consumer unit is seen as rising from $7,836 in 1956 to $11,297 in 1980 (with values measured in 1956 dollars). The 1980 value was obtained by projecting from 1947 income levels using the 1.8 percent growth rate; the 1956 figure is an estimate of actual income for the year. Per capita income growth from 1956 to 1980 is 44 percent.

3. Aggregate Chicago Metropolitan Area income (in 1956 dollars) is seen as rising from $16.7 billion in 1956 to $37.5 billion in 1980. This is a rise of 125 percent.

4. Consumer expenditures on food and beverages, tobacco, housing, and utilities will not increase as much (percentage-wise) as total consumption; consumer expenditures on the other major categories of consumption will have a percentage increase greater than that of total consumption. Among these categories, transportation expenditures will have one of the largest percentage increases.

5. Total employment from 1956 to 1980 will increase by 58 percent. Non-manufactures are seen as increasing twice as much percentage-wise as manufactures (70 percent *vs* 35 percent).

6. The largest percentage growth in Chicago area employment is forecast for (a) finance, insurance, and real estate and (b) services, with professional services leading all categories in growth. Employment in these categories is seen as more than doubling.

Most of the growth in manufactures is concentrated in heavy industry (that is, metals and machinery).

Employment declines are forecast for some industries. These are agriculture, food and kindred, textiles and apparel, railroads, and local and highway transport (buses and mass transit).

BY-PRODUCTS OF ECONOMIC MODEL

Some interesting by-products of the work on the economic model included (a) a forecast of 1980 auto registration in the CATS area and (b) an attempt to gage the impact of highway expenditures on the economy.

Forecast of 1980 Automobile Registration

The first by-product involved an investigation of future automobile registration in the CATS area. Information obtained here stemmed from the work on consumer expenditures.

In preliminary work on the problem, upper and lower bounds were obtained for growth in registration per 100 families (or per capita). For the period 1956 to 1980, the upper bound was an increase of 47 percent, the lower bound was an increase of 11 percent. Further work on the problem, in a sense involving a combination of the approaches used in obtaining the lower and upper bounds, yielded a final forecast of a 33 percent increase in registration.

The preliminary upper bound was obtained on the basis of time-series data. Data on U.S. registration per 1,000 persons and average consumption were obtained for the years 1929 through 1956 (excluding the war years). A trend line was obtained by regression of registration on consumption (*9, 10*). The equation of the trend line is:

$$N = -29.01 + 0.26\,Z \quad (r^2 = 0.96) \qquad (4)$$

in which N is auto registrations per 1,000 persons, and Z is consumption per capita. The insertion of predicted values of consumption yields predicted auto registration. For 1980, this was 47 percent above 1956. This approach will tend (eventually) to overstate registration because it cannot account for a leveling-off that is bound to occur. (Extend the fitted line far enough and registrations will exceed the number of adults.)

The preliminary lower bound was obtained on the basis of budget study data. Data for a sample of Chicago families in 1950 were obtained (*11*). The data consisted of percentage of car ownership for a given income class, and the income distribution in 1950; that is, the percentage of people in each income class. The cumulative multiplication of the two sets of percentages yields an over-all percentage owning cars. The 1980 income distribution was estimated on the basis of predicted growth in income, then the 1980 income class percentages were cumulatively multiplied by the 1950 income-registration percentages. The latter were assumed to be stable. The predicted growth in registration from 1956 to 1980 was 11 percent.

The assumption that registration bears a stable relation to income turned out to be a bad assumption. As a consequence, this forecast is low.

At this point, budget study data for a series of years were obtained from "Survey of Consumer Finances" data. The sample in each year was about 3,000 U.S. families; the years covered were 1948 through 1957. Registration data were broken into two components: percentage of families owning at least one car, and percentage of families owning two or more cars. Auto ownership was then related to income, after income figures had been deflated to constant (1947) dollars. The data are summarized in Table 11. Figure 1 shows ownership of one or more cars against income for selected years; Figure 2 shows multiple-car ownership against income for selected years.

TABLE 11

BUDGET STUDY DATA RELATING AUTO REGISTRATION TO INCOME [a]

Year	Average Income Per Spending Unit (in 1947 Dollars)	Registration Data: % of Spending Units Owning: 1 or More Cars	Registration Data: % of Spending Units Owning: 2 or More Cars	Registration Data: Cars Per 100 Spending Units
(a) Over-All Averages				
1948	3236	51	3	54
1949	3067	55	—	—
1950	3270	60	—	—
1951	3289	60	4	64
1952	3427	61	5	66
1953	3816	66	8	74
1954	3677	67	8	75
1955	3878	70	9	79
1956	4225	72	10	82
1957	4143	70	10	80

TABLE 11—*Continued*

Year	Average Income Per Spending Unit (in 1947 Dollars)	Registration Data: % of Spending Units Owning: 1 or More Cars	Registration Data: % of Spending Units Owning: 2 or More Cars	Registration Data: Cars Per 100 Spending Units
(b) Breakdown by Income Class				
1948	460	23	—[b]	23
	1390	31	—[b]	31
	2320	43	1	44
	3250	59	2	61
	4180	69	2	71
	5570	77	7	84
	12080	87	18	105
1949	470	24	—	—
	1410	37	—	—
	2345	54	—	—
	3280	63	—	—
	4220	74	—	—
	5630	82	—	—
	12190	89	—	—
1952	420	24	—[b]	24
	1260	36	—[b]	31
	2110	46	3	49
	2950	68	4	72
	3790	73	3	76
	5050	84	8	92
	10950	92	25	117
1953	420	26	3	29
	1255	37	1	38
	2090	57	6	63
	2920	64	4	68
	3760	78	8	86
	5010	86	9	95
	10860	94	26	120
1954	415	25	2	27
	1250	41	3	44
	2080	51	2	53
	2910	73	4	77
	3740	80	6	86
	4990	86	10	96
	10820	92	27	119
1955	415	29	1	30
	1250	41	3	44
	2085	59	4	63
	2920	70	6	76
	3750	85	7	92
	5000	89	11	100
	7090	94	20	114
	13760	94	32	126
1956	410	28	1	29
	1230	39	2	41
	2060	59	5	64
	2880	72	3	75
	3700	82	5	87
	4930	90	11	101
	6990	94	23	117
	13560	96	37	133
1957	400	32	1	33
	1205	38	2	40
	2010	57	3	60
	2810	67	6	73
	3610	76	7	83
	4340	84	9	93
	5300	93	14	107
	6830	94	25	119
	13250	93	34	127

[a] Based on data obtained from: "Survey of Consumer Finances," Fed. Res. Bull. (1948-1958).
[b] Less than 0.5 percent.

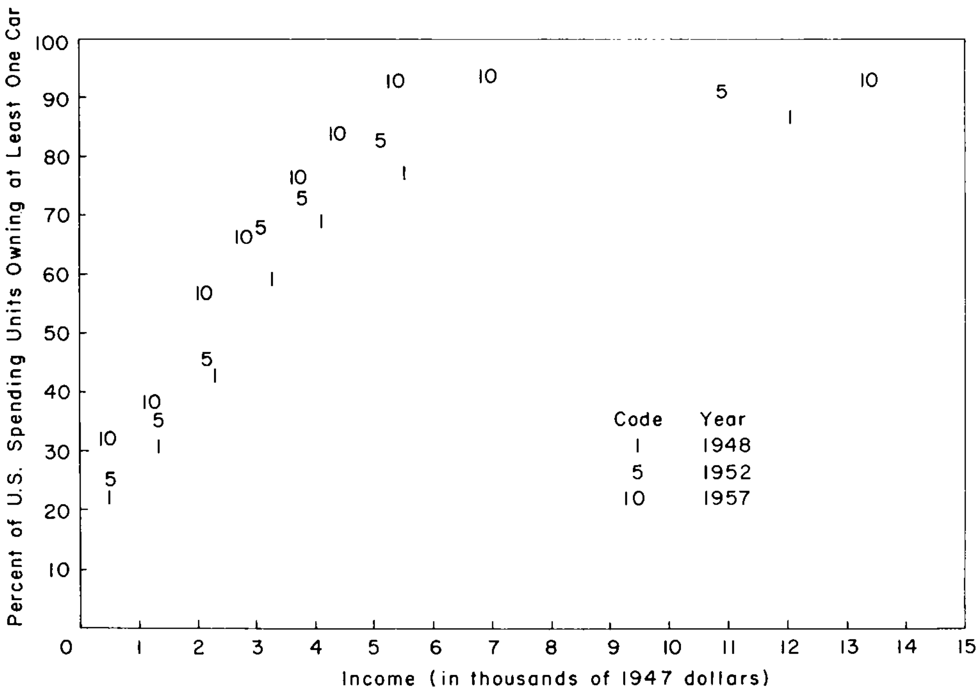

Figure 1.

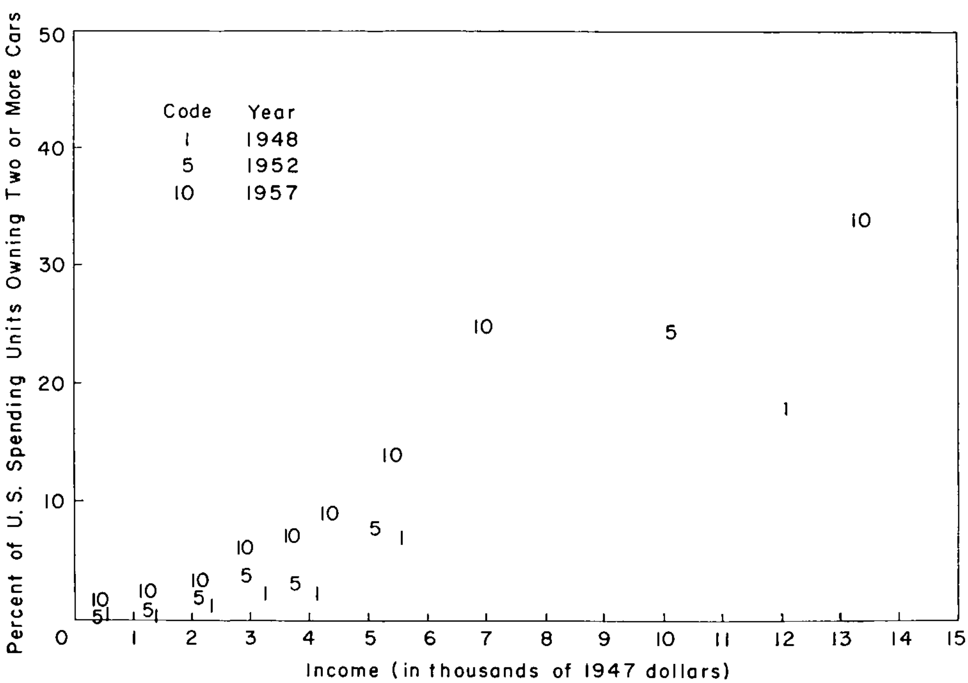

Figure 2.

In both figures, it can be seen that the relationship of registration to income shifts upward over time. This may be explained by two factors:

1. The shift may reflect the effects of increasing suburbanization; that is, a greater percentage of the population living in the suburbs.
2. The shift is probably an example of the shifting short-run income-consumption relation discussed previously.

On the basis of Table 11, a 1980 ownership-income relation was derived for both single-car and multiple-car ownership (Figs. 3 and 4).

In the case of ownership of one or more cars, a linear equation was fitted to the data, with intercept varying between time periods. The value of the intercept was related to average income in the time period, with the 1980 intercept based on predicted average income in 1980.

The equation was assumed to hold only below $5,000, with the curve then assumed to be asymptotic to a value of 97 percent; that is, car ownership was assumed to have a maximum value of 97 percent.

$$C_1 = 0.013Y + 0.212\,(\bar{Y} - 2{,}800)^{0.395} \quad (5a)$$

$$C_1\,(1956) = 0.013Y + 0.29 \quad (5b)$$

$$C_1\,(1980) = 0.013Y + 0.40 \quad (5c)$$

in which C_1 is the percentage of spending units owning one or more cars, Y is income, and $\bar{Y}$ is average income.

A similar procedure was followed for multiple-car ownership, the formulation being

$$\log C_2 = -3.08 + g(\bar{Y}) + 1.08 \log Y \quad (6a)$$

$$\log C_2(1956) = -2.96 + 1.08 \log Y \quad (6b)$$

$$\log C_2(1980) = -2.70 + 1.08 \log Y \quad (6c)$$

in which C_2 is the percentage of spending units owning two or more cars, and $g(\bar{Y})$ is a function relating the intercept to average income, with the 1980 value

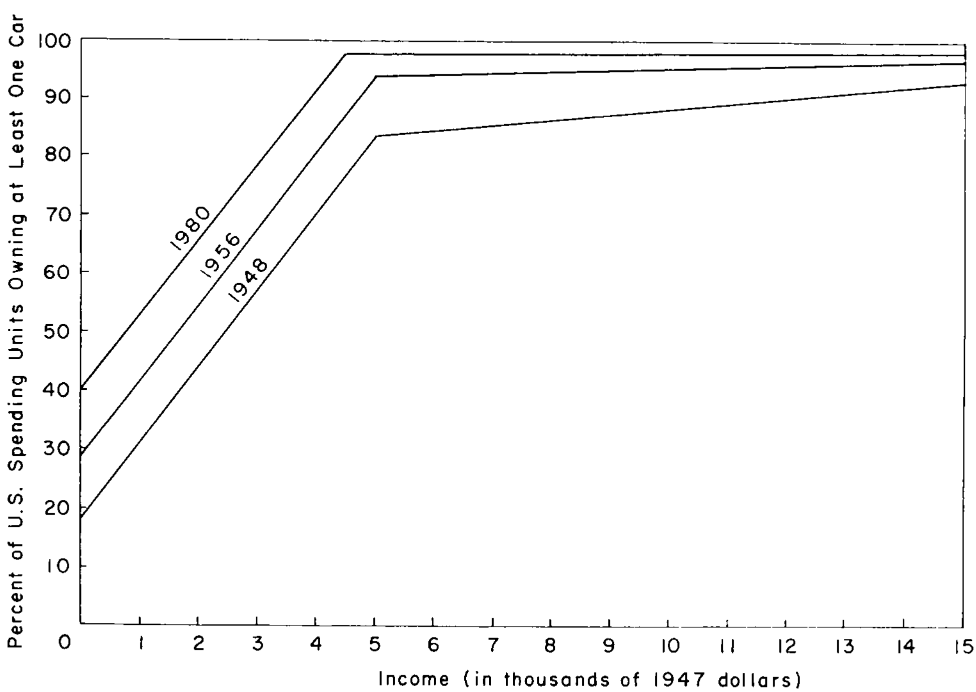

Figure 3.

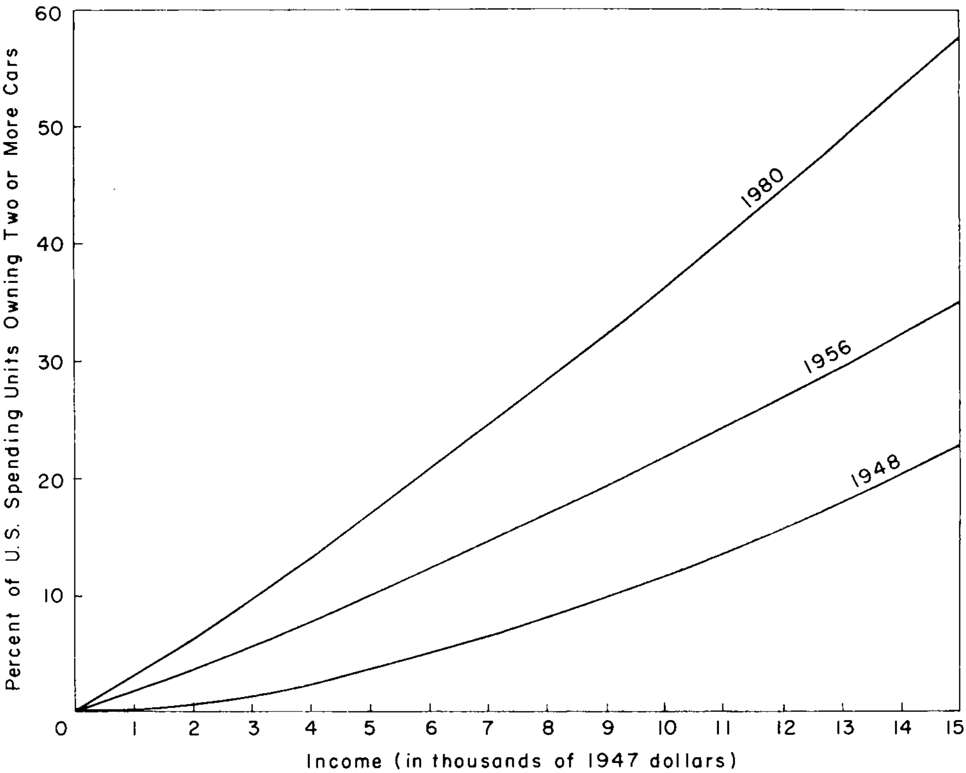

Figure 4.

based on a hand fit of the function. In Figure 4, the 1948 graph is based on the least square equation applicable to that year, rather than Eq. 6*a*. The least squares equation is

$$\log C_2(1948) = -5.41 + 1.62 \log Y \qquad (6d)$$

Inspection indicated that use of Eq. 6*a* was justified in predicting future multiple-car ownership.

Given the 1980 ownership-income relation, cumulative multiplication by the predicted 1980 income distribution yields 1980 car ownership. The components of the cumulative multiplication appear in Table 12, and Table 13 summarizes results obtained.

The percentage of spending units owning at least one car is predicted as rising from 72 percent in 1956 to 87 percent in 1980; the percentage owning two or more

TABLE 12

COMPONENTS OF REGISTRATION FORECAST

Income (1947 Dollars)	1956 Income Distribution (%)	1956 Percentage Owning: One or More Cars	1956 Percentage Owning: Two or More Cars	1980 Income Distribution (%)	1980 Percentage Owning: One or More Cars	1980 Percentage Owning: Two or More Cars
0-999	10.0	35.1	1.0	6.8	46.8	1.5
1000-1999	13.6	47.9	3.0	7.1	59.6	5.0
2000-2999	16.3	60.8	5.0	10.5	72.5	8.0
3000-3999	17.3	73.6	8.0	10.7	85.3	12.0
4000-4999	14.6	86.4	11.0	12.0	97.0	16.0
5000-7499	17.6	94.0	15.0	26.5	97.0	21.0
7500-9999	6.0	96.0	20.0	13.4	97.0	29.0
10000+	4.6	97.0	38.0	13.0	97.0	57.0

TABLE 13
REGISTRATION FORECAST RESULTS

Year	Spending Units (%)		
	Owning at Least One Car	Owning Two or More Cars	Total Cars per 100
1956	72.0	10.0	82.0
1980	87.1	21.4	108.5
1980/1956	1.21[a]	2.14[a]	1.33[a]

[a] Ratio.

cars is predicted as rising from 10 percent to 21 percent. Combining the two forecasts yields a rise in cars per 100 spending units from 82 in 1956 to 108 in 1980, or a 33 percent increase.

Auto registration per 1,000 persons in the CATS area was estimated as 281 in 1956; the CATS area and U.S. growth in registration were about the same between 1950 and 1956. Assuming the U.S. predicted growth is applicable to that of the CATS area yields a predicted 1980 auto registration of 374 per 1,000 persons.

Impact of Highway Expenditures

The second by-product of the economic model involves an attempt to gage the impact of highway expenditures on the economy. Information on this phase was obtained from the input-output apparatus.

A fairly simple approach was used. The distribution of the average dollar of expenditure on highway construction was estimated in terms of the industry source of materials and supplies. It was argued that a dollar of additional highway expenditure must be paid for by consumers, and it was assumed that this would involve an across-the-board reduction of consumer expenditures; that is, each consumption item would be reduced in proportion to its share of total expenditures. The increased dollar of highway expenditures and the compensating decreased dollar of consumer expenditures were treated as final demand and inserted into the input-output apparatus. Table 14 gives the predicted change in output by industry per dollar of increased expenditure; that is, the distribution of increases and decreases in production. Results are presented for an input-output model in which households are endogenous rather than exogenous. (The net change in household output is estimated as a fairly large positive item. This may indicate a net increase in the demand for labor, although this is a highly speculative conclusion.)

Table 14 attempts to gage the impact of construction expenditures only; the impact of new highways on travel and

TABLE 14
ESTIMATED IMPACT OF NEW U.S. HIGHWAY EXPENDITURE FOR EACH DOLLAR OF EXPENDITURE
Production [a] by Industry (in dollars)

Industry	Change in Output	Industry	Change in Output
1. Agriculture and forestry	−0.167	23. Railroads	−0.001
2. Mining	+0.091	24. Trucking	−0.008
3. Food and kindred	−0.166	25. Warehousing	−0.002
4. Tobacco	−0.008	26. Water transport	+0.001
5. Textiles and apparel	−0.075	27. Air transport	−0.008
6. Lumber and wood	+0.024	28. Pipe lines	+0.005
7. Furniture and fixtures	−0.009	29. Wholesale trade	−0.032
8. Paper and allied	−0.003	30. Retail trade	−0.101
9. Printing and publishing	−0.019	31. Local and highway transp.	−0.015
10. Chemicals	−0.016	32. Eating and drink. places	−0.061
11. Petroleum and coal	+0.157	33. Banking, finance and ins.	−0.080
12. Rubber	−0.002	34. Hotels	−0.009
13. Leather	−0.018	35. Real estate and rentals	−0.153
14. Stone, clay, glass	+0.164	36. Personal services	−0.025
15. Primary metal	+0.125	37. Business services	−0.012
16. Fabricated metal	+0.217	38. Automobile repair serv.	−0.011
17. Machinery (except elect.)	+0.180	39. Other repaid services	−0.004
18. Electrical machinery	+0.008	40. Entertainment	−0.011
19a. Motor vehicles	−0.031	41. Medical, dental and other	−0.041
19b. Trans. equip. except motor vehicles	+0.001	42. Non-profit	−0.016
20. Professional instruments	−0.003	43. Construction	−0.010
21. Misc. manufacturing	−0.016	49. Households	+0.195
22. Telecomm. and utilities	−0.024	Total	0.011

[a] + = increase; − = decrease.

sales of the transportation industries is not involved. (Thus the reduction in trucking follows from the reduction of consumer spending in order to pay for new construction.) The construction industry, Item 43, is listed as declining by $0.01; this refers to the net effect of a reduction in consumer spending; since highway construction is up by $1.00, the total impact on construction is an increase of $0.99.

This procedure neglects the investment effects of new highway construction; that is, there will probably be an increase in real income as a consequence of highway construction. However, it may be useful in obtaining a rough measure of the impact of new highway construction.

CONCLUSION

It seems appropriate to weigh the advantages and disadvantages of the input-output approach by comparing it to the alternative forecasting device (simple trend analysis) used in this study. In its most unsophisticated form, trend analysis consists of hand fitting a trend line on the basis of a set of points expressing past experience.

The input-output approach is often criticized because many of the relationships it assumes to be stable probably show some change over time. Thus, changes in technology and in relative prices will cause forecast error. However, this is a general hazard of forecasting, affecting trend analysis as well. If the changes are predictable, they can be incorporated into input-output analysis. However, this may involve changing the technical coefficient matrix as a function of time, so that a particular matrix is applicable to only one time period. This would make forecasting more expensive —or more restricted. In an uncertain world, however, there are bound to be changes that are incapable of prediction by any method, consequently some forecast error is bound to occur.

The important advantage trend analysis has over input-output analysis is that it is relatively inexpensive. The input-output approach can be quite expensive computationally. If interest is only in developing employment forecasts, for instance, then projection by trends is a great deal easier and is probably nearly as reliable as projection by input-output analysis.

However, an input-output model has a number of advantages, as follows:

1. It presents an organizational framework on which an integrated description of an economy can be developed. The filling in of the parts of this framework can yield returns in other problem areas. Thus, the work on the income-consumption relation, developed for final demand forecasts, was a key element in developing the auto registration forecast presented in this paper.
2. Similarly, this type of analysis is "fundamental," so that it helps in distinguishing and isolating important causative variables. As a consequence, the effects of a change in a particular factor can be investigated. Furthermore, some crucial problems in forecasting become illuminated; for example, the problem of the rate of growth in productivity, discussed herein.
3. It involves taking into account the interactions and interrelations of all the sectors of an economy. Put more strongly, the consequences and ramifications of a change in one industry are followed through to their ultimate effects on all the industries in the economy. (This is perhaps the strongest argument for the use of input-output analysis.)
4. It opens up avenues of research and develops information that could not be obtained otherwise. Examples include estimates of imports and exports of a regional economy, and estimates of the impact of a particular economic development, such as the highway impact problem touched on in this paper.

On the basis of these arguments, the additional computational costs of input-output analysis seem to be justifiable.

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