THE EFFECTS OF ENVIRONMENTAL REGULATION AND ENERGY PRICES ON U.S. ECONOMIC PERFORMANCE

A thesis presented

by

Peter Jensen Wilcoxen

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Appendix C

C. CONSTRUCTING THE INPUT-OUTPUT DATA SET

This appendix describes in detail how a time series of input-output tables was constructed for the model. The data set was composed of 39 tables−one each for the years 1947 through 1985−which were based on a single set of accounting conventions and industry definitions. In addition to containing figures on the current dollar value of transactions between sectors, the data set also included a full set of prices of both industry and commodity output.

Before plunging into the details of how the tables were constructed, it's useful to discuss their overall structure. Each annual table had several distinct components: transactions of intermediate goods between industries, sales of goods to final demand, purchases of primary factors, and the allocation of industry output to various goods. The last category arose because industries and commodities were treated separately, allowing joint production of several commodities by a single industry.

For convenience, let the number of commodities in the economy be N^C and the number of industries be N^I. In the data set both N^I and N^C were 35, but using the variable names eliminates ambiguities that would otherwise arise in the following discussion. Interindustry transactions can be arranged into an array known as the "use" table (narrowly-defined), in which rows correspond to commodities, and columns to industries. If the use table is an $N^C \times N^I$ array U, then element U_{ij} is the value of commodity i used by industry j. In contrast, industry output of different commodities can be represented by an $N^I \times N^C$ array M, usually referred to as the "make" table, where element M_{ij} is the value of commodity j produced by industry i.

Five final demand vectors were used: consumption, investment, government spending, exports and imports. Because the vectors are demands for commodities, each was of length N^C. There were five components in the value added portion of the table: noncompeting imports, capital, labor, net taxes and the rest of the world. Since these are purchased by industries, each vector was of length N^I. In addition, there was a 5×5 table of flows of value added directly to final demand. Finally, there were vectors of total industry and commodity output. The structure of the broadly-defined use table (including final demands and value added) is shown in figure C.1, and that of the make table is shown in figure C.2. The industry and commodity output vectors are also shown for convenience. Table C.1 provides definitions of the variables.

Three principal sources of data were used: the benchmark input-output transactions tables produced by the Bureau of Economic Analysis for years 1947, 1958, 1963, 1967, 1972, and 1977; the annual National Income and Product Accounts statistics; and the industry output data set prepared by the Bureau of Labor Statistics. To keep the following discussion from becoming tedious, they will often be referred to as the "IO", "NIPA", and "BLS" data sets. Many additional sources were also used, and will be noted where applicable. Subsequent sections describe the construction of each part of the data set.

Figure C.1: Organization of the Use Table

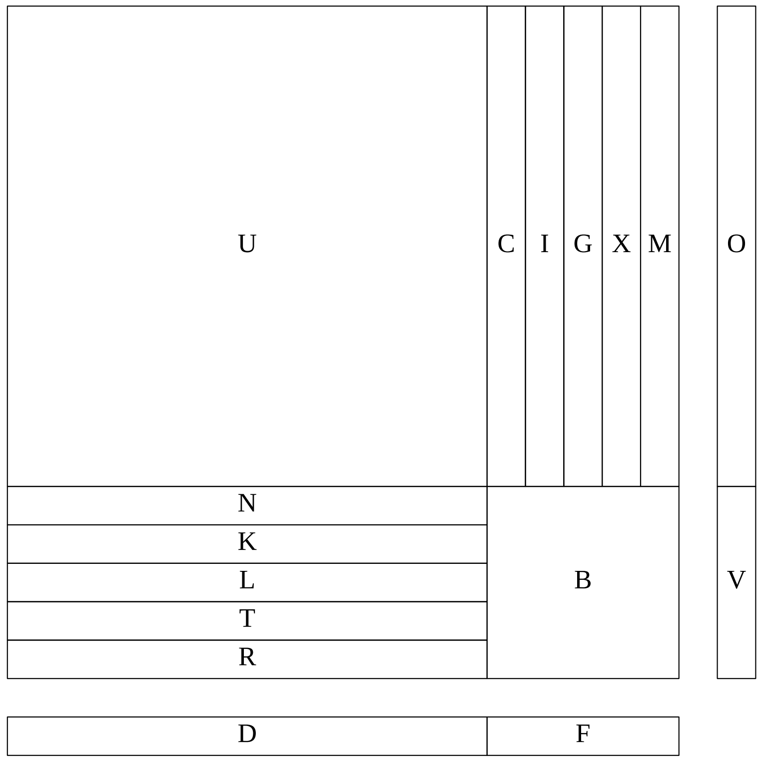


Figure C.2: Organization of the Make Table

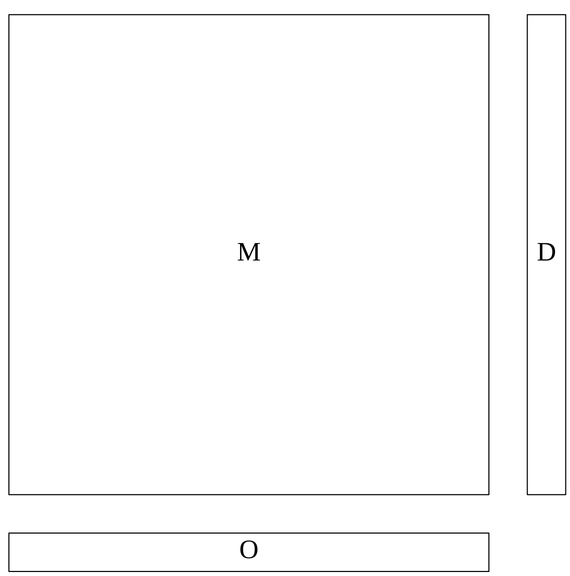


Table C.1: Make and Use Table Variables

Category	Variable	Description
Industry-Commodity Flows:		
	U	Commodities *Used* by Industries (use table)
	M	Commodities *Made* by Industries (make table)
Final Demand Columns:		
	C	Personal Consumption
	I	Gross Private Domestic Investment
	G	Government Spending
	X	Exports
	M	Imports
Value Added Rows:		
	N	Noncompeting Imports
	K	Capital
	L	Labor
	T	Net Taxes
	R	Rest of the World
Commodity and Industry Output:		
	O	Commodity Output
	D	Industry Output
Other Variables:		
	B	Value Added Sold Directly To Final Demand
	V	Total Value Added
	F	Total Final Demand

C.1. Gross Output by Industry

The source of gross output by industry was the 226 sector time series data set prepared by the Bureau of Labor Statistics, Office of Economic Growth, hereafter referred to as the BLS data. For each industry, both current and constant dollar values of output were available from 1958 to 1985. The accounting conventions and industry definitions used were consistent with those used by the Bureau of Economic Analysis in constructing the benchmark input-output tables. However, since the BLS data was more detailed than necessary, it had to be aggregated up to the model's 35 sectors. This was accomplished by using the current and constant dollar series to construct price and quantity indicies for each industry. The 226 sectors were then reduced to 35 using Divisia aggregation.

Because the BLS series began in 1958, for earlier years a data set developed by Fraumeni was used (Fraumeni (1988)). It contained data on 51 industries, and was originally constructed from an earlier version of the BLS data. Divisia aggregation was used to reduce the data to 35 sectors. However, the two data sets were constructed using slightly different conventions, and to make them comparable it was necessary to scale up the earlier price and quantity series to match the newer data in 1958. Table C.2 shows the relationship between the model's industry definitions and those of the BLS and Fraumeni.

Table C.2: Industry Definitions and the BLS and Fraumeni Data

Model Sector	BLS Sector	Fraumeni Sector
1	1-3	1-2
2	4	3
3	5	4
4	6	5
5	8	6
6	7,9-27	7
7	107-115	8
8	116	9
9	117,119,120	10
10	118,121,122	11
11	28-32,34	18
12	35-7	19
13	123-125	12
14	126-133	13
15	134,136-140	14
16	141,142	15
17	135,143-145	16
18	146,147	17
19	38-41	20
20	42-52,58	21
21	53-57,59-61,63	22
22	64-75	23
23	76-88	24
24	89-91	26
25	33,62,92-97	25
26	98-103	27
27	104-106	28
28	148-155	29-35
29	156,157	36,37
30	158,213,218	38
31	159	39
32	161-163	41,42
33	164-169	43
34	160,171-208,210,211	40,44,46
35	212,214,215,217,219	48,51
NA	170,209,216,220-222	45,47,49,50

C.2. Interindustry Data

The basic source of data on interindustry transactions is the series of benchmark input-output tables produced by the Bureau of Economic Analysis. Tables are available for six years: 1947, 1958, 1963, 1967, 1972 and 1977. Unfortunately, the conventions used by the BEA have changed over time, so the raw tables are not completely comparable. In addition, the level of industry detail available on magnetic tape varies from about 80 sectors for early tables to about 500 sectors for the later ones. The first step in constructing the data set was to convert the older benchmark tables to the 1977 conventions and to a uniform number of sectors. Once the tables were consistent, they were aggregated to 35 sectors, converted to shares of industry output and the intervening years were interpolated. Then, the tables were reinflated to current dollar values using the gross output data described above. This produced the final set of interindustry data. The sections below describe each step in detail.

C.2.1. Standardization

The goal of standardization was to produce a set of benchmark tables at roughly a 100 sector level of aggregation which conformed to the conventions used in producing the 1972 and 1977 benchmarks. This involved two principal revisions. First, because the 1972 data included both make and use tables for the first time, make tables had to be generated for all of the earlier years. This task was relatively straightforward, and is described in the next section. Second, a large number of relatively minor industry reclassifications had to be made. This was necessary because BEA's treatment of certain sectors changed over the years, and because a few of the model's sectors did not correspond exactly to IO industries. Some examples of this are that BEA's treatment of ordinance changed in 1972 with the revision of SIC classifications, and that in the model, electric utilities include those operated by the government, but these are placed in government enterprises by the BEA.

Standardization was accomplished by bringing all of the tables to a special aggregation based on BEA's 80 sector classification, but with extra industries to accomodate the small components that had to be moved. Extra sectors were defined for the following four-digit IO classifications:

13.04: *Sighting and Fire Control Equipment.* This was a component of ordnance until 1972, when it was split between SIC 3662, radio and television equipment, and SIC 3832, optical instruments and lenses. To be consistent with later data, the sector had to be eliminated from the tables before 1972.

68.01: *Electric Utilities.* Because the model gives special treatment to energy producing sectors, electric utilities had to be kept separate, rather than being grouped together with gas utilities and water and sanitary services. Moreover, secondary production of electricity by other sectors was moved by the BEA to electric utilities beginning in 1972. Keeping utilities separate facilitated making the same transformation to the earlier data.

68.02: *Gas Utilities.* As with electric utilities, this sector was separated from other utilities to improve the model's treatment of energy.

69.01: *Wholesale Trade.* Beginning in 1972, secondary production of wholesale trade by other sectors was redefined to the trade sector by the BEA. By keeping it separate initially, appropriate redefinitions could be made for the earlier tables.

71.02: *Real Estate and Rental.* Like wholesale trade, secondary production of real estate was redefined in 1972.

78.02: *Federal Electric Utilities.* Under the industry definitions used in the model, this industry belonged with the rest of electric utilities, and not with government enterprises.

79.02: *State and Local Electric Utilities.* Also kept separate from government enterprises to allow it to be included in electric utilities.

For most years, the benchmark tables were available at the four-digit level of aggregation, so isolating these sectors was simply a matter of putting them into different industries during aggregation of the data to the 80 sector level. The following section describes how the missing make tables were produced, and subsequent sections discuss a number of idiosyncratic changes that had to be made to the data in different years.

C.2.1.1. Constructing Make Tables

Prior to 1972, benchmark tables produced by the BEA were on an industry by industry basis. Most secondary products were treated as though they were sold to the industry for which they were primary for distribution to actual users. This was implemented by constructing a "transfers" matrix which moved output from one industry to another, and then supplementing the receiving industry's output to account for the difference. Consequently, the transfers matrix contained exactly the data that would have appeared in a make matrix, except that the diagonal elements were zero. However, adding up a row of the transfers table gave the total value of secondary products produced by a given industry. By subtracting this from total industry output left the value of the sector's primary production, and hence the corresponding diagonal make table entry. Inserting these values into the transfers table produced the desired make matrix.

C.2.1.2. Special Adjustments for 1947 and 1958

The first adjustment made to these tables (actually prior to constructing the make matricies) was to standardize the treatment of imports. Before 1972 exports, but not imports, appeared as a final demand column in the benchmark tables. Imports were placed instead in their own row, and added to industry input. Later tables treated imports as a (negative) final demand. Converting the early tables to this convention required changing the row into a column of the appropriate sign, and making a few other small adjustments. In particular, the large negative entry in the old import row of the export column had to be set to zero. In the early table, it had been used to make the total of the export column equal to net exports.

The 1947 and 1958 tables were only available at the two-digit level of aggregation. This meant that none of the special sectors discussed above could be isolated easily. For example, only data on all of sector 13 (ordnance) was present, with no information on the portion of it originating in sector 13.04 (fire control). This made it necessary to separate out the special sectors using data from the 1963 table. To see how this was accomplished, consider decomposing the production of ordnance in 1958 into two parts: fire control (13.04) and everything else (13.xx). In 1963, vectors of inputs to both sectors were available; let these be called U_a^{63} and U_b^{63}. In 1958, only the total, U_{a+b}^{58}, was present, where $U_{a+b}^{58} = U_a^{58} + U_b^{58}$. This suggests splitting each element of U_{a+b}^{58} in proportion to the division of the corresponding element of U_{a+b}^{63} into U_a^{63} and U_b^{63}:

$$(U_a^{58})_i = \frac{(U_a^{63})_i}{(U_{a+b}^{63})_i} \;, \qquad (U_b^{58})_i = \frac{(U_b^{63})_i}{(U_{a+b}^{63})_i} \tag{1.1}$$

However, it was also desirable to impose an additional constraint on the decomposition: the share of each subindustry in the total output of ordnance was held constant at the 1963 levels. This prevented splitting the 1958 vector element by element because the resulting vectors would not necessarily have satisfied the condition on their totals.

This meant that decomposition of the 1958 vectors was subject to two sets of constraints: for each commodity, the sum of the values used by the subindustries had to equal the corresponding value in the 1958 vector; and the share of each subindustry in total value of 1958 output had to be the same as that of 1963. This suggested using the Kuroda adjustment method to produce disaggregated vectors which satisfied the constraints, but which were as similar as possible to the 1963 data. The algorithm was applied by using the two vectors from 1963 as the initial matrix and the 1958 vector as the set of row targets. Column targets were constructed by splitting the total 1958 value using the shares of the subindustries in 1963. This process could be used to construct the missing data for each of the special industries.

In practice, the adjustment algorithm was applied to generate data on industry inputs (columns of the use table), and on the use of industry outputs (rows of the use table) simultaneously. This was necessary to treat an industry's use of its own output correctly. Furthermore, the same process was applied to produce the missing make table data. This approach was used to disaggregate almost all of the special sectors in the years 1947 and 1958.

Unfortunately, for certain types input Kuroda's method can introduce negative numbers into inappropriate places in the output array. This occurs primarily where most of the elements of the initial matrix are zero, and the targets are substantially different from the initial row and column sums. These conditions occurred primarily in the make table, and the problem arose in disaggregation of the make vector of certain industries. For those sectors it was necessary to use a different adjustment algorithm: the method of simulated annealing.

Simulated annealing is a simple but slow procedure. An initial matrix is constructed which satisfies the row and column constraints, but which need not be very similar to the target array. The algorithm then chooses random pairs of elements in the array and moves a given magnitude between them in a way that preserves the initial row and column totals. The value of an appropriate objective function is computed using the new matrix, and if it has improved, the swap is kept; otherwise, the swap is discarded. The process continues until the program has difficulty finding any more beneficial swaps. At that point, the magnitude to be moved in each swap is decreased and the process begun again. The algorithm terminates when the swap size decreases below a predetermined level.

In the present application of annealing, the objective function was defined to be exactly that used for Kuroda's method. However, using annealing makes it easy to impose the sign constraint: any swaps that would produce negative entries are rejected. Because the algorithm is very slow, it was only used when Kuroda's method produced problems, and then only on the part of the disaggregation where the problems arose. For example, when sector 13 was disaggregated for 1958 using Kuroda's method, negative numbers appeared in the make table. The make disaggregation was redone using annealing, but the use table was not changed. Table C.3 shows the methods used to disaggregate the special sectors for both 1947 and 1958.

Table C.3: Method of Disaggregation

Sector	Description	1947	1958	Method
13	Ordnance	•	•	Kuroda
			•	Anneal (make)
68	Utilities	•	•	Kuroda
69	Trade	•	•	Kuroda
		•		Anneal (make)
71	Real Estate	•	•	Kuroda
78	Federal Gov. Ent.	•	•	Kuroda
			•	Anneal (make)
79	State and Local Gov. Ent.	•	•	Kuroda
		•	•	Anneal (make)

After disaggregating the special sectors, some additional changes were necessary to standardize the first two benchmark tables. First, three sectors which were eliminated by the BEA in 1963 or 1972 had to be removed. The sectors involved were: 74, Research and Development, 81, Business Travel and Entertainment, and 82, Office Supplies. All three were eliminated using the reallocation method described below in section C.3.2.

The remaining step was to redefine secondary production of electricity, real estate, and wholesale trade to conform to the conventions of the 1972 (and 1977) benchmark table. As used by the BEA, the term "redefinition" means to move production from one industry to another using the destination industry's technology as a model. Thus, redefining a given amount of electric generation from primary metals to electric utilities requires moving inputs from metals to utilities in proportion to their use by utilities. Thus, it is not possible merely to scale down the source industry and scale up the destination. Instead, the following procedure must be used.

Let matrix M be the make table, with element M_{sd} being an amount of secondary production of commodity d by industry s which is to be redefined. For example, it could be electricity produced by the primary metals industry. Next, let the use table column for the destination industry be vector U^D, and that for the source industry be U^S. In the case of electricity, U_D would be the column for electric utilities, while U^S would be the column for industry s, whose secondary production was being redefined. The first step in transferring M_{sd} was then to multiply it by the vector of shares of input into the destination industry. This produced vector T, of which element j is defined as shown in the equation below:

$$T_j = M_i \cdot \frac{U_{j_d}}{\sum_{k=1}^{N^C} U_k^d} \tag{1.2}$$

Thus T was a vector of inputs that totaled the amount to be transferred, and was based on the technology of the destination industry. Before it could be subtracted from the source industry, however, it was necessary to insure that the following relationship held for each of its elements:

$$U_j^S - T_j \geq 0 \tag{1.3}$$

Violation of this constraint would leave negative values for some inputs purchased by the source industry. To impose the condition, any element T_j for which the inequality was not satisfied was set equal to U_j^S, and the remaining elements of T were scaled up to preserve its total. The constraint was then tested again, and the revision process repeated until no element of T was in violation. Then the new source and destination use table vectors could be computed:

$$(U^S)^{new} = U^S - T \tag{1.4}$$

$$(U^D)^{new} = U^D + T \tag{1.5}$$

Finally, the value of M_{sd} was added to the diagonal make matrix element for the destination industry, M_{dd}, and element M_{sd} itself was set to zero. Redefinition of that element of secondary production would then be complete.

C.2.1.3. Special Adjustments for 1963 and 1967

Data for 1963 and 1967 were available at a sufficient level of industry detail that it was unnecessary to do any disaggregation. However, there were a few other idiosyncracies that had to be eliminated, all of which were similar to changes that had to be made in the earlier data. First, the treatment of exports and competing imports had to be corrected, as described above for 1947 and 1958. Second, it was necessary to reallocate two sectors which were eliminated in 1972: sector 81, Business Travel and Entertainment, and sector 82, Office Supplies. The way this was accomplished is described in the following section. Finally, secondary production of three commodities had to be redefined. As before, these were electricity, real estate, and wholesale trade. The method of redefinition was the same as used for 1947 and 1958.

C.2.2. Reallocation

Once the tables had been standardized, a number of unusual sectors had to be eliminated. For the most part, these were dummy industries created by the BEA to handle various features of the data. All of the industries eliminated in this step were removed using a process that will be called "reallocation". How it worked can best be understood through an example. One of BEA's dummy categories is 81, Scrap, Used and Secondhand Goods. Scrap is produced as a secondary product by almost every industry, and it is used as an input by many of them. No industry produces it as a primary product.

To eliminate scrap by reallocation, the following procedure was used. First, a dummy primary industry was constructed. Suppose the make column for scrap is vector M, where element M_i is the value of scrap produced by industry i. If the total value of industry i's output is O_i, then the share of scrap in its output is σ_i:

$$\sigma_i = \frac{M_i}{O_i} \tag{1.6}$$

This allowed the industry's input vector from the use table to be split up by assuming that the production of scrap used the same technology as production of the industry's primary good. In particular, if the industry's use column was U^S, the portion devoted to producing scrap was $\sigma_i U^S$. This vector was added to the use column for scrap, while the column for industry s was reduced to $(1 - \sigma_i)U^S$. The operation was completed by adding the value of M_i to the scrap element of M (on the make matrix diagonal), and setting M_i to zero. Repeating the process for all industries that produced secondary scrap created a primary scrap industry and eliminated all secondary production of it.

Scrap was then eliminated entirely by using the primary scrap sector in the following way. Suppose the use table row and column for scrap are R^S and U^S, respectively. Then, element U_i^S is the amount of commodity i used in producing scrap, and R_j^S is the amount of scrap consumed by industry j. Let α_j be the share of total scrap output used by industry j:

$$\alpha_j = \frac{R_j^S}{\sum_{k=1}^{N^I} R_k^S} \tag{1.7}$$

Multiplying the scrap column by α_j produced a vector of inputs which could be added to the use column of industry j and subtracted from the scrap column:

$$(U^j)^{new} = U^j + \alpha_j U^S \tag{1.8}$$

$$(U_S)^{new} = U^S - \alpha_j U^S \tag{1.9}$$

This moved to industry j the inputs used to make the scrap it bought. The process was completed by setting R_j^s to zero, and making a corresponding reduction in the make table entry for the scrap row and scrap column. Repeating these steps for all industries that bought scrap reduced all the elements of the scrap row and column in both the make and use tables to zero, at which point the industry had been eliminated. All of the industries listed in table C.4 were eliminated by reallocation in every benchmark data set. In addition, there were a few industries (mentioned above) that were reallocated only in particular years.

Table C.4: Reallocated Sectors

Sector	Description
81	Scrap, used and secondhand goods
82	Government industry
83	Rest of the world industry
84	Household industry
85	Inventory valuation adjustment
98	Owner occupied housing

C.2.3. Aggregation

Once the tables had been standardized at the 90 sector level, the next step was to aggregate them to the model's 35 sectors. The relationship between these and the 80 sector Bureau of Economic Analysis definitions is shown in the following table. Because it was only necessary to combine values, this was a straightforward matter of matrix multiplication, using an appropriate bridge array. Let O be the original input-output table with n sectors, and B be an $n \times m$ bridge table with rows that sum to one. Then the new aggregated table N $(m \times m)$ can be found using the expression:

$$N = B^T \cdot O \cdot B \tag{1.10}$$

Typically, each row of B would be zero, except for a single value of one in the column corresponding to the output sector of which the industry was to be a part. The only exception to this rule was for industry 13.04 (fire control), which split evenly between electrical machinery (23) and instruments (26). The corresponding row of the bridge matrix was zero everywhere except columns 23 and 26, which each contained the value 1/2. Since sector 13.04 does not exist after 1967, this adjustment applied only to the earlier data. Finally, this procedure was used to aggregate both the make and use tables. The result was a set of six consistent benchmark input-output tables defined in accordance with the 1972 (and hence 1977) conventions used by the Bureau of Economic Analysis.

C.2.4. Interpolation

After standardizing the benchmark tables, it was necessary to construct approximate tables for the nonbenchmark years in the sample. The first step was to convert the standardized tables, both make and use matricies, to shares of industry output. Next, matricies of shares for intervening years were interpolated from the benchmark values. (For years after 1977, the shares used

Relationship Between IGEM and I-O Industry Numbers

IGEM	IO	Description
1		Agriculture, forestry and fisheries
	01	*Livestock and livestock products*
	02	*Other agricultural products*
	03	*Forestry and fishery products*
	04	*Agricultural, forestry and fishery services*
2		Metal mining
	05	*Iron and ferroalloy mining*
	06	*Nonferrous metal mining*
3		Coal mining
	07	*Coal mining*
4		Crude petroleum and natural gas
	08	*Crude petroleum and natural gas*
5		Nonmetallic mineral mining
	09	*Stone and clay mining*
	10	*Chemical and fertilizer mining*
6		Construction
	11	*New construction*
	12	*Maintenance and repair construction*
7		Food and kindred products
	14	*Food and kindred products*
8		Tobacco manufactures
	15	*Tobacco manufactures*
9		Textile mill products
	16	*Broad and narrow fabrics, yarn and tread mills*
	17	*Miscellaneous textiles and floor coverings*
10		Apparel and other textile products
	18	*Apparel*
	19	*Miscellaneous fabricated textile products*
11		Lumber and wood products
	20	*Lumber and wood products, except containers*
	21	*Wood containers*
12		Furniture and fixtures
	22	*Household furniture*
	23	*Other furniture and fixtures*
13		Paper and allied products
	24	*Paper and allied products, except containers*
	25	*Paperboard containers and boxes*
14		Printing and publishing
	26	*Printing and publishing*

IGEM	IO	Description
15		Chemicals and allied products
	27	*Chemicals and selected chemical products*
	29	*Drugs, cleaning and toilet preparations*
	30	*Paints and allied products*
16		Petroleum refining
	31	*Petroleum refining and related industries*
17		Rubber and plastic products
	28	*Plastics and synthetic materials*
	32	*Rubber and miscellaneous plastic products*
18		Leather and leather products
	33	*Leather tanning and finishing*
	34	*Footwear and other leather products*
19		Stone, clay and glass products
	35	*Glass and glass products*
	36	*Stone and clay products*
20		Primary metals
	37	*Primary iron and steel*
	38	*Primary nonferrous metals*
21		Fabricated metal products
	39	*Metal containers*
	40	*Heating, plumbing and fabricated structural metal*
	41	*Screw machine products and stampings*
	42	*Other fabricated metal products*
22		Machinery, except electrical
	43	*Engines and turbines*
	44	*Farm and garden machinery*
	45	*Construction and mining equipment*
	46	*Materials handling machinery*
	47	*Metalworking machinery*
	48	*Special industry machinery*
	49	*General industrial machinery*
	50	*Miscellaneous machinery, except electrical*
	51	*Office, computing and accounting machines*
	52	*Service industry machines*
23		Electrical machinery
	53	*Electrical industrial equipment*
	54	*Household appliances*
	55	*Electric lighting and wiring equipment*
	56	*Radio, tv and communication equipment*
	57	*Electronic components and accessories*
	58	*Miscellaneous electrical machinery and supplies*
24		Motor vehicles
	59	*Motor vehicles and equipment*

IGEM	IO	Description
25		Other transportation equipment
	13	*Ordnance and accessories*
	60	*Aircraft and parts*
	61	*Other transportation equipment*
26		Instruments
	62	*Scientific and controlling instruments*
	63	*Optical, ophthalmic and photographic equipment*
27		Miscellaneous manufacturing
	64	*Miscellaneous manufacturing*
28		Transportation and warehousing
	65	*Transportation and warehousing*
29		Communication
	66	*Communications, except radio and TV*
	67	*Radio and television broadcasting*
30		Electric utilities
	68.01	*Electric utilities*
	78.02	*Federal electric utilities*
	79.02	*State and local electric utilities*
31		Gas utilities
	68.02	*Gas production and distribution utilities*
32		Trade
	69	*Wholesale and retail trade*
	74	*Eating and drinking places*
33		Finance, insurance and real estate
	70	*Finance and insurance*
	71	*Real estate and rental*
34		Other services
	68.03	*Water supply and sewerage systems*
	72	*Hotels, personal and repair services*
	73	*Business services*
	75	*Automobile repair and services*
	76	*Amusements*
	77	*Health, education, social services, nonprofit org.*
35		Government enterprises
	78.01	*U.S. postal service*
	78.03	*Commodity credit corporation*
	78.04	*Other federal government enterprises*
	79.01	*Local government passenger transit*
	79.03	*Other state and local government enterprises*

were those of 1977 itself.) Finally, the tables were transformed back into current dollar values by using the annual industry output figures discussed in section C.2. This produced a consistent set of input-output tables for the 39 year period from 1947 to 1985.

C.3. Gross Output by Commodity

Using the newly created time series of make matricies, it was possible to map the data on industry output into commodity outputs. Obtaining the value of each commodity produced was simply a matter of adding up the entries in the appropriate column of the make table. Commodity prices were constructed by Divisia aggregation of industry prices, where the weights used were obtained from the make table. Specifically, the weights used in constructing the price of commodity *i* were the values in column *i* of the make table divided by the column's sum. These weights are thus value shares in the composition of commodity output. Intuitively, this process was like using the make matrix to define production functions that converted industry outputs into commodities.

C.4. Final Demands

Since data on final demands is available annually (not just in benchmark input-output years) in the National Income and Product Accounts (NIPA), these were used as the basis for construction of the final demand columns in the dataset. However, the data requires a fair amount of manipulation before it is suitable for use with input-output data. This section describes how the input-output final demand vectors for personal consumption, gross private domestic investment, government purchases of goods and services and imports and exports were constructed from the NIPA data.

The basic source of data is the National Income and Product Accounts tape available annually from the Bureau of Economic Analysis. The particular tape used here contained data through

1986. Data on the tape is organized exactly like the tables of NIPA data published in the *Survey of Current Business*, so in the discussion below specific items will be identified by their table and line numbers. For example, total personal consumption expenditure was obtained from table 1.1, line 2.

The raw NIPA data required two types of adjustment before it could be used with the input-output tables. First, it had to be mapped to the commodity definitions used in the 1977 benchmark input-output study. This was required because the NIPA data are valued at purchasers' prices, while the input-output data are in producers' prices, and because the definitions of NIPA and input-output commodities are not identical. Usually this was accomplished by using NIPA/IO bridge tables published with the 1977 benchmark, although in some cases it was necessary to construct special bridges.

Bridge tables were used to convert vectors on one basis to another as follows. Let the original vector of length n be O, and the desired vector be N, of length m. The basis of the bridge was typically a $n \times m$ array M, where element m_{ij} was the value of original commodity i in target commodity j. Dividing each row of M by its sum produced an array B of row shares. This allowed the desired vector to be computed by straightforward matrix multiplication:

$$N = O \cdot B \tag{1.11}$$

After the data had been mapped into input-output categories, it then had to be adjusted to account for the differences between the conventions used in this study and those used by the Bureau of Economic Analysis. For example, owner occupied housing was treated by the model as part of final demand, while the BEA includes it in real estate. The following sections describe the details of constructing consumption, investment and government spending.

C.4.1. Consumption

The fundamental source of the consumption column of final demand is the annual vector of expenditures in NIPA table 2.4. The first stage in processing, after extracting the data from the NIPA dataset, is to convert it to conform to the standards in force when the 1977 benchmark was produced. Specifically, the values of lines 106 and 107 are made negative. Next, the entries for owner occupied housing (line 24) and the rental value of farm dwellings (line 26) were deleted for reasons discussed in detail below. Finally, the data was mapped into input-output commodities using the bridge table published with the 1977 benchmark table.

It was necessary to delete the housing numbers because the demand for owner occupied housing (both farm and nonfarm dwellings) is modelled here as a demand for capital services by consumers, rather than as purchases from the real estate industry. However, the NIPA owner occupied housing commodity maps directly into an input-output industry that demands intermediate goods as well as value added (71.01, also called owner occupied housing). Thus, intermediate goods for these sectors had to be added back in to the consumption column. To accomplish this, the total value of intermediate inputs to each sector was obtained from NIPA table 8.9, lines 85 and 93 respectively. The totals were then split into demands for commodities according to the shares of commodities in the composition of owner occupied housing in the 1977 benchmark table.

After revising the treatment of housing, the consumption vector was aggregated to the 35 sector level. Next, the scrap entry was reallocated to other goods using the 1977 shares of other goods in the composition of scrap. At this point, the total of the column equaled the total of the original NIPA column, less gross housing product (the sum of lines 86 and 94 in NIPA table 8.9). Next, the consumption of noncompeting imports was taken from Ho (1988). Then the consumption of capital services was inserted (see section C.6.2). This entry included the value of owner occupied housing plus imputed service flows from consumer durables. Finally, the entry for labor was replaced by the corresponding value from Ho (1988).

C.4.2. Investment

The final demand column for gross private domestic investment was the sum of separately constructed columns for producers' durable equipment, structures, and inventories. Each of these categories is described below.

C.4.2.1. Producers' Durable Equipment

The basic source of equipment demand was NIPA table 5.6. After it was extracted from the dataset, it was converted to millions of dollars and transformed to conform to the standards prevailing when the 1977 benchmark table was produced. This entailed reordering the lines and putting photocopy equipment into instruments, where it was previously (with photographic equipment). The resulting data was then bridged to input-output commodities using the producers' durable equipment bridge published with the 1977 benchmark, and aggregated to 35 sectors.

The final vector included both nonresidential and residential equipment, so its total equaled the NIPA value of private purchases of producers' durable equipment in line 1 of table 5.6, but was not equal to the value appearing for producers' durable equipment under gross private domestic investment (table 1.1, line 10) because that excludes residential equipment (which is instead combined with Residential structures). The total of PDE and Structures will equal the total for fixed investment, however.

C.4.2.2. Structures

Construction of the structures portion of investment was relatively straightforward. The basic source of data was NIPA table 5.4, which was extracted from the NIPA dataset and converted to millions. In terms of IO commodities, most of structures investment is demand for construction. However, several small adjustments were required to account for mobile homes, and the efforts of real estate brokers. Specifically, line 4 (new nonresidential structures) and line 26 (new residential structures) were mapped to construction; lines 23 and 40 (both brokers' commissions) were mapped to real estate; and lines 24 and 41 (both net purchases of used structures), to scrap. One more adjustment was necessary to account for mobile homes: the value in line 32 (mobile homes) was deducted from residential housing (and hence construction) and allocated to the following sectors in the indicated percentages: other transportation equipment (68.8%), transportation (.02%) and trade (31.0%). The shares were derived from data in the Annual Survey of Manufactures.

C.4.2.3. Inventories

The basic data for inventories was the value for Change in Business Inventories appearing in NIPA table 5.8, line 1. Since the final dataset requires not just the total, but an entire column of commodity inventories, it was necessary to split up the NIPA figure. Furthermore, it was not possible to use a single bridge table (such as one derived from the 1977 benchmark) to accomplish this because the sectoral pattern of inventory investment changes from year to year. Fortunately, data on inventory stocks held by industries was available from Jorgenson and Park (1988), and it could be adapted to the task of splitting up total NIPA inventory investment. First, however, it had to be converted to a commodity basis, since the change in inventories of particular goods was what was needed for the final demand vector.

For most industries, this conversion was made by assuming that the industry's inventories were composed entirely of finished units of that sector's primary product.[1] For example, inventories held by the fabricated metal industry were assumed to be finished fabricated metals, not a collection of primary metals and other inputs to production. Two sectors, wholesale and retail trade, had to be treated differently because the Jorgenson−Park data do not conform to the input-output treatment of trade. That is, the inventories have not been revised to reflect the input-output convention that sectors sell directly to final demand and trade is only a margin industry. In practice, this meant that most of the inventories were held by the trade sector, and were clearly not finished "trade" goods, so it was necessary to split up trade inventories into individual goods. How this was done is the subject of the next two sections. Finally, the dataset contained no inventories for Government Enterprises, so the inventory of Government Enterprise output was assumed to be zero.

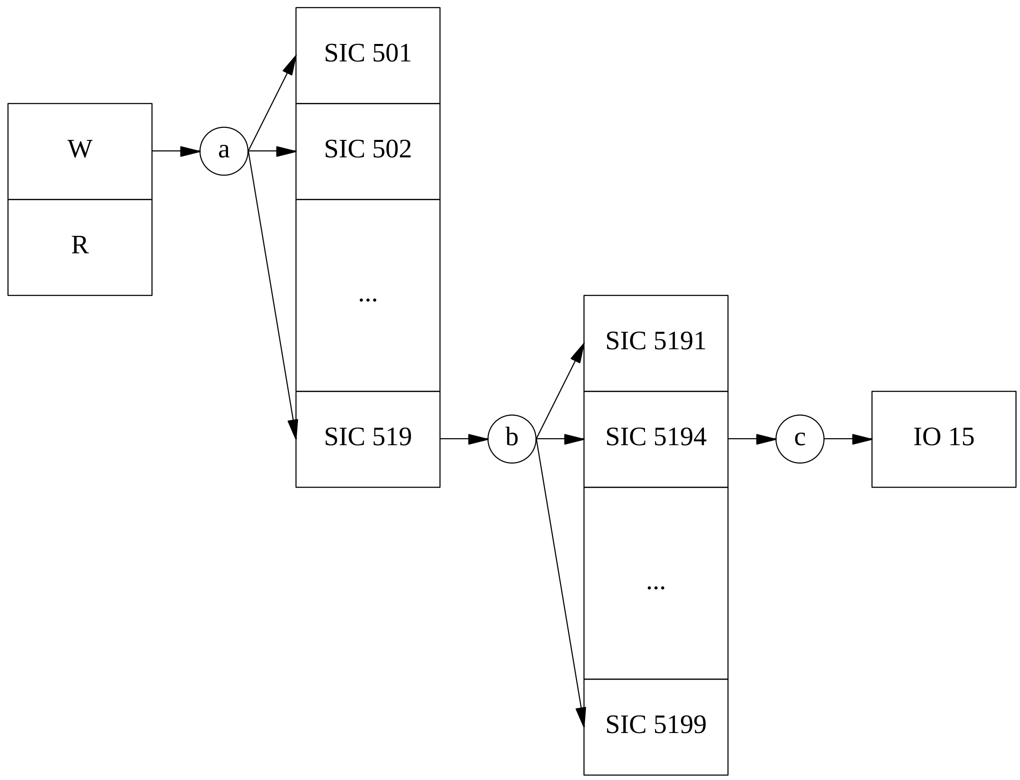
1. A more assiduous treatment would divide the inventories into raw materials, work in progress and finished goods, and then split up raw materials according to the industry's pattern of inputs. The data required for this was not available, however.

C.4.2.3.1. Decomposing Wholesale Trade

Wholesale inventories were split up in a three stage process, as shown in the figure below. Two basic sources were used: the 1977 *Census of Wholesale Trade*, and the December issues of the 1947 to 1986 monthly reports on wholesale trade (published in the Current Business Reports series under various titles). The monthly reports list the value of inventories held by wholesalers at the 3-digit SIC level, including dealers of Motor Vehicles, Furniture, Metals and Minerals, Electrical Goods, Hardware, Machinery, Paper, and Groceries. These sectors account for about 67% of wholesale inventories, so that fraction of total wholesale inventories (from the Jorgenson−Park dataset) was split among them in proportion to their share of the inventories reported in the monthly reports.[2] The remaining 33% is held by wholesalers of Lumber, Sporting Goods, Miscellaneous Durables, Drugs, Apparel, Farm Products, Chemicals, Petroleum, and Miscellaneous Nondurables. Unfortunately, data was not available for the entire period for the latter group, so to allocate inventories to those sectors, the following procedure was used. First, the available shares described above were totaled and subtracted from one. Then, the resulting residual share was then broken up into its components in proportion to each component's share in total inventories in 1977.

2. Inventory stock data was available from 1971 to 1986, but a comparable series would not be obtained for earlier years. However, the annual percentage change in inventories was available, so it was used to compute stock data working backwards from 1971.

Figure C.3: Typical Decomposition of Trade Inventories



Node	Method of Decomposition
a	Allocate in proportion to target sector inventories
b	Allocate in proportion to target sector sales
c	Map into closest input-output commodity

This produced data on the share of wholesale trade sectors (SIC 501 to SIC 519) in the value of wholesale inventories. Since these inventories do not map perfectly into producing sectors, additional processing was required to obtain commodity inventories. First, Table 4-1 of the *1977 Census of Wholesale Trade* was used to obtain a breakdown of each sector's sales by 4-digit SIC code. For example, Motor Vehicle and Automotive Equipment dealers, SIC 501, was split into three parts: SIC 5012, Automobiles and Other Motor Vehicles; SIC 5013, Automotive Parts and Supplies; and SIC 5014, Tires and Tubes. Unfortunately, inventory data do not exist at this level of detail, so inventories had to be split in proportion to sales. Extending the example above, SIC 5012 accounts for 95% of the sales of SIC 501, so it was assumed to hold 95% of the inventories. Finally, each resulting stock was mapped into the input-output commodity with the most similar definition. The breakdown of 3-digit wholesalers into 4-digit sectors was assumed to be constant over time, so the 1977 Census data was used for all years.

C.4.2.3.2. Decomposing Retail Trade

Retail trade was treated in much the same way as wholesale was. Two basic sources were used to construct the retail trade inventory reallocation shares: the *1977 Census of Retail Trade*, and the December issues of the 1951 to 1986 monthly reports on retail trade (published in the Current Business Reports series under various titles). Useful data before 1951 were not available. From the monthly reports, it was possible to construct series giving the value of inventory stocks in the following retail trade sectors: Building Materials, General Merchandise, Groceries, Automobile Dealers, Apparel, and Furniture. Stock data was obtained from 1967 to 1986, but was not available for earlier years. However, the annual percentage change in inventories was available, so it was used to compute stock data working backwards from 1967. In addition, the total value of retail inventories was available. From this, the share of each of these sectors in retail inventories was computed for 1951 to 1986.

Total retail inventories include two additional sectors for which data was not available: Eating and Drinking Places, and Miscellaneous Retail. To determine the annual shares of these sectors in inventories, the following procedure was used. First, the shares described above were totaled and subtracted from one. The resulting residual share was then broken up between Eating and Drinking and Miscellaneous in proportion to those sectors' shares in total inventories in 1977.

These two steps produced data on the share of retail trade sectors (SIC 52 to SIC 59) in the value of retail inventories. Since these inventories do not map easily into input-output goods, an additional step was required to obtain commodity inventories. In this case, the 1977 *Census of Retail Trade* was used to obtain a breakdown of each sector's sales into "merchandise lines". Assuming that inventories were proportional to sales, the retail trade sector inventory shares were allocated to merchandise lines. Each merchandise line was then mapped into the input-output commodity with the most similar definition.

C.4.2.3.3. Computing Inventory Changes

After calculating the annual reallocation shares for wholesale and retail trade, these inventories were redistributed. This was accomplished by dividing the total value of each trade inventory into parts according to the shares described above. Then, each part was added to the value of inventories in the corresponding industry. For example, if motor vehicle dealers held 10% of retail trade inventories, that value of inventories was moved from retail trade to motor vehicles.

After the trade sectors were reallocated, each sector's inventory was converted to a quantity by dividing it by the corresponding price from the data bank described in Park (1988). The annual value of changes in inventories was then calculated by multiplying the price by the difference between one year's quantity and the quantity the year before. A little accounting shows why this formula was used. Let the change in the book value of inventories be denoted CBV, the inventory valuation adjustment by IVA, and the true change in business inventories by CBI. If the price and quantity of inventories at time t are P_t and Q_t, respectively, then the following are true:

$$CBV = P_t Q_t - P_{t-1} Q_{t-1} \tag{1.12}$$

$$IVA = -(P_t Q_{t-1} - P_{t-1} Q_{t-1}) \tag{1.13}$$

$$CBI = CBV - IVA = P_t Q_t - P_t Q_{t-1} \tag{1.14}$$

This approach presented a problem for 1947, for which no earlier quantities were available. Values for that year were computed by using the 1947 prices, and assuming that the change in quantities from 1946 to 1947 was the same as from 1947 to 1948. Finally, the results were converted to millions of dollars and normalized to the NIPA total for changes in inventories from table 5.8, line 1.

C.4.3. Government

Total government spending on goods and services was the sum of federal and state and local components. These were calculated separately as described below.

C.4.3.1. Federal Government

The initial source of data on federal government expenditures for goods and services was NIPA table 3.2, lines 16 (national defense) and 17 (nondefense). To split these totals up into demands for commodities, the corresponding columns were extracted from the 1977 benchmark and used as a bridge. For example, the shares of commodities in the 1977 national defense column were used to split up the total for defense spending in all years. The results were then aggregated to the 35 sector level. This procedure allows shifts in the composition of federal spending between defense and nondefense, but holds constant the commodity composition of the two categories.

C.4.3.2. State and Local Government

To create the state and local government data, parts of two NIPA tables had to be used. For 1952 and subsequent years, the basic source of data was NIPA table 3.16, which provides detailed information on the composition of state and local spending. The various components were aggregated into four broad categories: education, health and hospitals, public safety, and other. Table 3.16 is not available for years before 1952, so for that period total state and local spending (from table 3.3, line 14) was divided into the four categories using the 1952 shares obtained from table 3.16.

These categories were chosen because the 1977 benchmark table provides commodity use columns (at the 450 sector level) for these types of spending. This allowed spending on each category to be split into expenditure on commodities in a manner analogous to that used for defense spending above. The resulting four columns were added together and aggregated to 35 sectors to produce the final State and Local component of government final demand. Parallel to the federal government case, this process allows spending to shift among the four broad categories, but the commodity composition of each is fixed.

C.4.3.3. Total Government Demand

After the state and local data was constructed, federal and state and local demands were added together, and the demand for scrap reallocated (see the construction of consumption). This produced the column of government demand (which totaled exactly the NIPA value for government final demand). Finally, the entries for noncompeting imports and labor were replaced by the corresponding values from Ho (1988). This improved the series somewhat by allowing the share of these expenditures to vary more freely from year to year.

C.4.4. Exports and Imports

Values for exports and imports by commodity were obtained from Ho (1988), and were used without modification. Ho also provided price indicies for imported commodities, which were used to form the final commodity supply prices described in section C.8. Several entries in these columns deserve special attention. First, the export and import entries in the rest-of-the-world-row contain the values of earnings on capital abroad and domestic capital owned by foreigners, respectively. Second, the import column entry in the noncompeting imports row is the negative of the sum of noncompeting imports. Finally, the import column entry in the trade sector row is the (positive) value of customs duties paid.

C.5. Value Added

The value added part of the input-output table consists of four rows: noncompeting imports, capital, labor and net taxes, each of which will be discussed below. Following that is a description of the process used to convert some of the data from the national accounts conventions to a basis compatible with the benchmark input-output tables.

C.5.1. Noncompeting Imports

Noncompeting imports are goods for which there is no domestic substitute. Each entry in the row is the total value of such goods used by a particular industry or final demand sector. The construction of these figures is described in Ho (1988). Since they were produced on an input-output basis, they could be inserted directly into the input-output table. Ho also provided price deflators for noncompeting imports, which are discussed further in section C.8.

C.5.2. Capital and Net Taxes

The prices and values of capital services used and net taxes paid by each sector were taken from Park (1988). The original source of data was the fourteen components of income tape from the Bureau of Economic Analysis[3], but the capital services defined here include several extra imputations not found in the NIPA data. First, additional capital income is imputed to the Other Transportation Equipment sector in certain years in which the NIPA data show a net loss. This is necessary to ensure that the sector's price of capital is always nonnegative. Second, extra capital income is imputed to Government Enterprises to account for the capital used by nonprofit organizations like the Postal Service. Some of this imputation is then transferred to Electric Utilities, since government utilities have been moved to there from Government Enterprises. Third, the capital input to the final demand category Consumption includes the imputed value of owner occupied housing plus an extra imputation for consumer durables. This is in contrast to the national accounts convention of treating housing as a purchase from the real estate sector, and ignoring the services of consumer durables. Table C.6 shows the extra imputations to each of the sectors discussed.

3. This tape is produced by the National Income and Wealth Division and provides value added by industry broken down into fourteen parts.

Table C.6: Extra Capital Imputations

(Millions of Current Dollars)

Year	Sector Number 25	30	35	C
1947	185	337	830	13147
1948	0	356	1362	20577
1949	0	366	1187	22436
1950	0	361	1611	25322
1951	0	392	1555	27927
1952	0	425	1180	29698
1953	0	459	1100	32168
1954	0	508	1118	30274
1955	0	586	2028	34310
1956	0	636	2525	31907
1957	0	605	1967	34441
1958	0	558	1979	32307
1959	0	625	1872	38919
1960	0	655	1973	37156
1961	0	692	2376	38019
1962	0	774	2673	41245
1963	0	871	2575	45870
1964	0	996	3190	51562
1965	0	1085	3729	59889
1966	0	1163	4224	62360
1967	0	1114	3331	66078
1968	0	1138	2801	65913
1969	0	1263	3315	68551
1970	0	1177	3552	73486
1971	0	1365	4363	77355
1972	0	1646	5087	90717
1973	0	1567	8030	96294
1974	0	1803	8325	92386
1975	0	2308	9193	111581
1976	0	2451	8062	131944
1977	1125	2679	11407	155620
1978	1583	3730	12574	174933
1979	2269	3859	13704	184015
1980	3179	4247	13295	192134
1981	6166	4601	13171	227481
1982	3144	5158	10445	279896
1983	0	6100	12883	304471
1984	0	7234	10456	369606
1985	0	7876	7008	392693

The net taxes row also comes from the fourteen components of income data, and includes sales taxes paid by businesses less the value of any subsidies. In other words, net taxes are indirect business taxes less property taxes (which are included as part of capital income) less subsidies. In addition, the extra imputations discussed above were deducted from the net tax entries for the affected sectors. This was necessary to bring the total value of industry output back to the appropriate basis for use with the industry output series described earlier.

Finally, since the capital and tax series were created from national accounts data, it was necessary to transform them to be compatible with the conventions used in the benchmark input-output studies. Roughly speaking, this involved moving certain secondary products out of the industry of production and into the industry for which they were primary products. This process is discussed in detail in section C.6.5.

C.5.3. Labor

The raw value of labor input to each sector was taken from Ho (1988a). Since these figures were also on a national accounts basis, they had to be converted to conform to the input-output conventions, as described in the following section.

C.5.4. Rest of the World

One additional value added row was present to account for factor payments exchanged with the rest of the world. Values were present in this row for three columns only. In the consumption column, a negative entry was used to account for spending on travel abroad. In the exports and imports columns, entries were used to account for payments on capital received and paid by the United States. All three of these figures were obtained from Ho (1988a).

C.5.5. Converting to Input-Output Conventions

Figures for capital and labor input and net taxes were generated from national accounts data by Ho (1988a) and Park (1988). Before the data could be used, however, it was necessary to convert it to conform to the standards used by the Bureau of Economic Analysis in constructing the benchmark input-output tables, since these differ slightly from the conventions used for the national accounts. In particular, the definitions of some NIPA industries are different from their IO counterparts. To convert the NIPA data to an IO basis, it was necessary to move certain secondary products out of the industry that produced them and into the industry for which they were primary. For example, electric power generated as a secondary product by the primary metals industry is moved to electric utilities. In the terminology of the Bureau of Economic Analysis, this is known as redefinition. The redefinitions described here made the value added data consistent with the conventions used in the 1972 and 1977 benchmark input-output tables.

In principle, it would be best to redefine each component of value added separately: for example, moving ten percent of the capital input and twenty percent of the labor. However, the information required to do that was not available, and it was only possible to obtain the value of redefined output. Because of this, all value added redefinitions were done in proportion to the movement in output. As a concrete example, consider the redefinition of secondary construction out of petroleum refining. About five percent of the output of the petroleum refining is construction, so five percent of its labor, capital and net tax inputs were moved.

Following the Bureau of Economic Analysis, the five redefinitions below were performed. The primary data source used to determine the proportion of output (and hence value added) to be moved is indicated. The actual mechanics of each redefinition will be described in detail following the list.

(1) *Construction.* Construction performed within an industry, such as new power plants built by electric utilities, was redefined to the construction industry. The primary data source was Table C in Ritz (1980), "Definitions and Conventions of the 1972 Input-Output Study." Some the government's final demand for labor (it has no observable final demand for capital) was also moved to construction to account for structures built by government employees. Total government final demand was unchanged since government purchases from construction were increased by the value of labor moved.

(2) *Electric Generation.* Electric power generated as a secondary product by industries other than electric utilities was redefined to utilities. Redefinition was based on the data in the transfers table of the 1967 benchmark input-output study. These figures were available then but not for later years because electric generation was redefined beginning in 1972.

(3) *Wholesaling.* Wholesale activities of manufactures were redefined to the trade sector. This data came from the source described for electric utilities, and for the same reason.

(4) *Real Estate.* Rentals produced as secondary products were redefined to the real estate sector. Again, the source of data was the 1967 benchmark study.

(5) *Miscellaneous.* A number of other redefinitions were required to conform to the input-output conventions. Manufacturing done by nonmanufacturing sectors was moved to the appropriate manufacturing industry; wholesale and retail trade done by service industries was moved to trade; and services produced by trade sectors were moved back to the service industry. This data came from Fawcett (1977).

The first four redefinitions all required transferring output from a number of industries to a single destination. This was accomplished by constructing a bridge table to map the NIPA industry outputs for each year into IO values. If there are n NIPA and m IO sectors, the bridge would be an $n \times m$ array B, where element B_{ij} is the share of the output of NIPA industry i which is to be allocated to IO industry j. If the row vector of NIPA outputs is N, the IO outputs would be $N \cdot B$. Anticipating the fifth redefinition, let the bridge for these first four be called B_1.

The last redefinition was treated differently because the movement of value was not into a single industry. More precisely, output was extracted from one set of sectors (source group) and redistributed to the industries in another set (destination group). To handle this, the output to be removed from each source group industry was transferred to a single dummy sector. Then, the output of the dummy was reallocated to the destination industries. In practice, this required building two bridge tables: one to move output to the dummy, and one to allocate the dummy back to real sectors. Multiplying the two bridges together produced a single bridge (B_2) that would accomplish the task.

Finally, the overall NIPA-IO value added bridge was constructed by multiplying the two bridges together: $B = B_1 \cdot B_2$. Ideally it would have been desirable to construct a separate bridge table for each year. Unfortunately, there was not enough data available (even to construct separate bridges for the benchmark IO years), so it was necessary to use a single bridge for the entire period.

Once constructed, the bridge was used in the following way. First, each row was multiplied by the original value added figure for that industry. Then, summing the columns of the resulting array gave the revised current dollar value added figures. To construct corresponding price indicies, the columns were then converted to shares and used as weights for Divisia aggregation of the original prices. This meant, for example, that the revised price of labor to the construction industry was a Divisia aggregate of the prices of labor to all the sectors producing construction, with weights chosen to be the share of each sector in total construction output. Thus, converting the value added data to an IO basis resulted in changes to both the values and prices of each element of the series.

C.6. Consistency Adjustments

Since the value added and final demand figures were available annually, the data set was improved by using them instead of the corresponding data in the interindustry tables. Because the data came from different sources, however, it was not fully consistent with the input-output data, even after making the corrections discussed above. Specifically, when value added was replaced, the sum of industry inputs no longer matched the industry output data, and after replacing the final demands, total commodity output failed to match the corresponding series. To reconcile the data, Kuroda's matrix adjustment method was employed.[4]

Kuroda's method was applied as follows. In each year, the revised use table (with new value added and final demand data inserted) was used as the initial matrix. The row targets were the commodity output figures described in section C.4, while the column targets were given by the industry output data. The data was adjusted to conform to the targets, and then checked to verify that no elements had changed sign. If no sign changes occurred, which was the case for most years, data construction for that year was complete.

In 1948, however, a sign change did occur, and it was brought about in the following way. Output of the petroleum extraction sector in that year was 50% high than in either 1947 or 1949. Petroleum extraction sells about 85% of its output to petroleum refining, so high output meant a large increase in the sales of crude oil to refining. The output of the refining sector, however, did not increase markedly in that year. This forced the adjustment algorithm to alter all the other inputs substantially, in order to attain the industry output target with such a large purchase of crude oil. The capital input to refining was actually driven negative. Since the original value added series showed positive capital input in 1948, the negative figure was unsatisfactory.

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4. Kuroda's method is described in Appendix E.

There were at least two possible sources of the problem. First, the industry output figure for petroleum extraction could have been incorrect. If so, the source of the error would have been the Bureau of Labor Statistics, since its data was used without alteration. More likely, however, was that the inventory data for crude petroleum in 1948 showed too little increase. Of all the data in the tables, inventories were the least reliable because of the difficulty of allocating the total change in inventories among commodities. This suggested supplementing inventories to absorb the extra output of crude oil. Scaling up the 1947 intermediate input of oil to refining to match the increase in refining output from 1947 to 1948 produced an estimate of what the input of crude should have been. Comparing this to the value implied by the increase in the output of crude showed a difference of about $1.8 billion. The pre-adjustment inventories of crude were increased by this amount, and the data were adjusted again. Since the target total for inventories was not changed, this resulted in a shift of inventories toward oil and away from other commodities. However, it also controlled the original problem, so no negative numbers were introduced.

C.7. Constructing Constant Dollar Tables

To convert the completed current dollar tables to a constant dollar basis, each row of the use table had to be deflated using an appropriate price index. For the rows corresponding to intermediate goods, the index used was an aggregate of the domestic and imported prices of the good called the "supply" price. The domestic price was constructed as described in section C.4, while the import price was taken from Ho (1988). The supply price was formed from the two by Divisia aggregation with the shares of domestic and imported goods in total supply of the commodity used as weights. Finally, the value added rows were deflated using the price indicies described in section C.6.

C.8. Summary

This appendix presents the method used to construct the 39 year time series of consistent input-output tables. Gross output by industry was taken from Bureau of Labor Statistics data, and was on an annual basis. The interindustry use and make table data were derived from the six benchmark tables produced by the Bureau of Economic Analysis. Commodity outputs were derived from industry output using the make tables constructed above. Final demands and value added, both on an annual basis, originated with the National Income and Products Accounts data. Final demands were taken from a data set similar to that published in the *Survey of Current Business*, and the value added came from the 14 components of income series. All of these pieces were combined and adjusted to be internally consistent using Kuroda’s method. Finally, price indicies were constructed to allow the current dollar tables to be converted to constant dollars.