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ECONOMIC ANALYSIS DIVISION
NATIONAL CENTER FOR ANALYSIS OF ENERGY SYSTEMS

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## NOTICE



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## ABSTRACT

Value added coefficients have been incorporated into Brookhaven's Energy Input-Output Model so that one can calculate the implicit price at which each sector sells its output to interindustry and final demand purchasers. Certain adjustments to historical 1967 data are required because of the unique structure of the model. Procedures are also described for projecting energy sector coefficients in future years that are consistent with exogenously specified energy prices.

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# I. Introduction

Value added coefficients have been incorporated in Brookhaven's Energy Input-Output Model (I-O). These describe sectoral payments for capital services, labor services, and indirect business taxes per unit of output. With these coefficients and the coefficient of production matrix, one can calculate the implicit price at which each sector sells its output to interindustry and final demand purchasers. This would be a trivial exercise for the Bureau of Economic Analysis (BEA) historical I-O tables in which all transactions are measured in dollars and all implicit prices are indexed at $1. It becomes useful, however, with projected I-O tables for future years where one is interested in examining changes in productivity and relative prices over time.

Because the BNL model differs in structure from BEA I-O tables, some alterations are necessary in the normal procedure for estimating sectoral prices. These techniques are described first, and they are followed by techniques used in projections for future years.

# II. Historical 1967 Prices

## A. Description of BNL Model

The general structure and units of measure in the BNL I-O Model are depicted in Figure 1. A general description of the model is presented in reference 1. BEA data used in specifying the model is contained in reference 2 and energy data in reference 3. A listing of the BNL sectors and the correspondence with BEA sectors is given in Figure 2.

Each column, j, of coefficients in the A matrix describes the interindustry purchases necessary to produce a unit

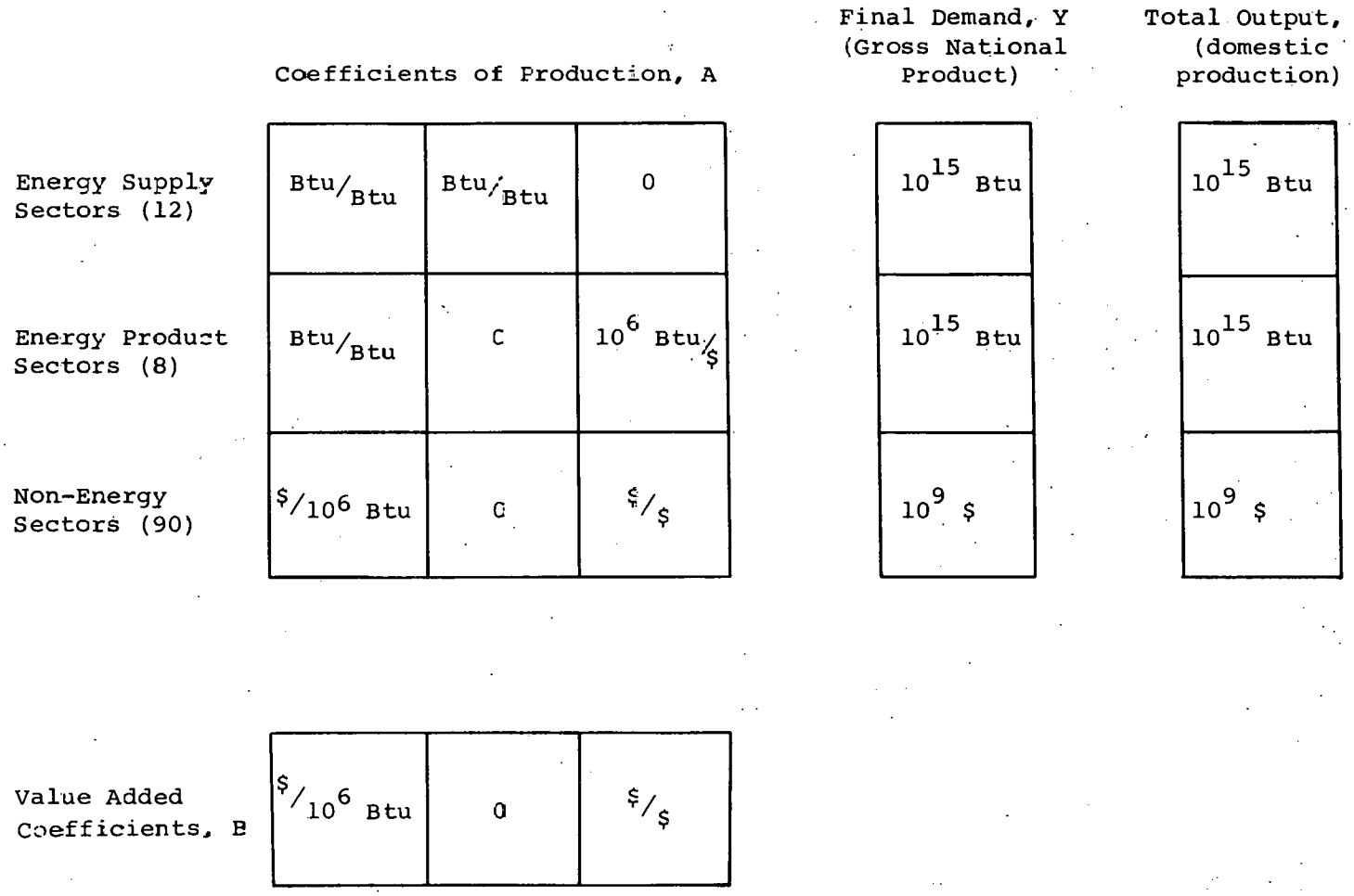


Figure 1. I-O units of measure.

of output of sector j. The corresponding value added coefficients in column j of the B matrix represent primary factor purchases per unit of output of sector j. Three factors of production are employed - labor services, capital services (or property type income), and indirect business taxes. It is assumed that each sector sells its output to every interindustry sector and to each final demand purchaser at a single price, and that each primary factor is also purchased at a single price by every interindustry sector. Under this assumption, one can write a column equation for each sector which says that the value of interindustry purchases per unit output of sector j plus the value of primary factor purchases per unit output of sector j equals the selling price of sector j's output. The set of equations for all sectors can be expressed in matrix notation as,

$$A^T P + B^T W = P \qquad (1)$$

where A = coefficient of production matrix, j x j

P = vector of interindustry prices, j x 1

B = value added coefficient matrix, m x j

W = vector of primary factor prices, m x 1.

Given A, B and W, this can be solved for interindustry prices, P,

$$P = (I - A^T)^{-1} B^T W. \qquad (2)$$

Since all primary factor purchases in the BNL model are expressed in terms of actual 1967 dollar transactions, each of the three factor prices, W, are $1. The only task prior to solving equation (2) is to express the B matrix in terms that are consistent with definitions and conventions used in the BNL model, as described below.

B. Sectoral Classification

Value added purchases in terms of the BEA 85-industry categories are presented in Table 1 of reference 2. They are disaggregated into three components: employee compensation (EC), indirect business taxes (IBT), and property-type income (PTI). Certain BNL model sectors are disaggregates of these sectors, however.* One must therefore use value added data for BEA 367-industry categories for these sectors which is published in reference 4. Because this detailed data is not disaggregated into the three value added components, it has been assumed that the proportional split is the same as that in its aggregate sectoral classification on an 85-industry basis.

C. Structural Difference Between BEA and BNL Models

Sectoral purchases of transferred (competitive) imports are presented as an interindustry row by BEA in their transactions table (sector 80B). The BNL model handles them as negative entries in one column of final demand (GNP). The BNL entries are larger in absolute value than the BEA row entries by the amount of their transportation and trade margins. BNL row transactions** for water transportation (BNL sector 92) and for wholesale and retail trade (BNL sector 99) are therefore less than the corresponding BEA row transactions. The proportion by which trade and transportation margins on imported goods have reduced total output of these two sectors is thus used to scale down the BNL value added purchases for

* These are the new construction, maintenance and repair construction, refined oil products, utilities, transportation, federal government enterprises, and state/local government enterprise sectors, as noted in Figure 2.

** These are obtained by the multiplication $A_{ij} \cdot X_j$.

sectors 92 and 99 from those documented by BEA.

Commodity Credit Corporation column purchases (BEA sector 78.03) have been included in the Federal Government-Other column of final demand in the BNL model. The negative value added number for BEA sector 78.03 is thus not included in the value added purchases of BNL sector 107.

The BNL I-O model does not include two of the BEA sectors - 80A (directly allocated imports) and 83 (scrap, used and second-hand goods). These purchases must be accounted for in the BNL model, however, because equation 2 says that the total value of input purchases per unit output of each sector must add up to the selling price of that sector's output. This problem is corrected in the BNL model by adding an additional value added component (called "other value added") that represents sectoral purchases from BEA sectors 80A and 83.

Column 80A has no entries in the BEA table, so this does not introduce a discrepancy between the two models. Column 83 (scrap) does have entries, however, and the BNL model has added them to the diagonal transactions for each row in which they appear. Although this does not bias total sales or production for each sector (the sum of interindustry and final demand purchases), it does bias upward the value of each sector's purchases. This bias is removed in the BNL model by adding another value added component (called "diagonal scrap") to the B matrix. The value of this component for any sector is equal to the negative of that sector's sales to sector 83 in the BEA I-O table.

D. Normalization of Coefficients

The five components of value added purchases must be normalized, or divided, by 1967 total output for each of the

102 purchasing sectors.* Total outputs (domestic production) in the BNL model differ from the totals presented by BEA. BNL outputs are lower than those in BEA by the amount of competitive imports specified in the BNL import column of final demand. Additionally, outputs of the BNL energy sectors are expressed in physical units (Btu); so the value added coefficients for the energy sectors have units of 1967 $/10^6 Btu. The 1967 BNL model energy sector outputs which are used for normalization are listed in Table 1.

Energy sector I-O prices for 1967 are also listed in Table 1. The coal price, $.18/10^6 Btu, is an average for lignite, bituminous and anthracite coals from Minerals Yearbook (10, pp. 20, 301, 380). Wellhead prices for the crude oil and gas sector (from the same source) are $.16/10^6 Btu for natural gas (10, p. 723) and $.52/10^6 Btu for crude petroleum (10, pp. 20, 810). The average, weighted price for the crude sector is $.35/10^6 Btu. The price for the refined oil products sector, $.97/10^6 Btu, is averaged over Minerals Yearbook prices for gasoline, kerosene, jet fuel, distillate, and residual oils at various U.S. ports (10, pp. 868-71). For the pipeline gas sector, an average price of $.61/10^6 Btu for gas utilities over customers is used from Gas Facts (11, p. 111). Electric sector prices are also based on utility sales and revenues for all customer types, as listed in Historical Statistics of the U.S. This price of $4.57/10^6 Btu is based upon delivered Btu of energy, after transmission and distribution losses.

E. Transactions Between Energy Supply Sectors

Physical energy transactions between the energy sectors in the BNL model will not correspond to dollar transactions in the BEA table for several reasons. First, these

* The eight, dummy, energy product sectors, 13-20, have no value added purchases.

sales will not in general be made at the same price as sales to other sectors in the economy. Secondly, the diagonal entries differ by definition. In the BEA model they represent sales between companies which are all classified within a single I-O sector. In the BNL model they are only an accounting method for Btu conversion losses (say crude gas to pipeline quality gas), distribution losses, and transmission losses. In order to calculate correct sectoral prices in the BNL model it is therefore necessary to convert physical energy purchases by each of the first 12 sectors to the correct dollar purchases specified in the BEA I-O table.

With the implicit I-O energy prices listed in Table 1 one can express the BNL physical energy transactions in terms of dollars and compare them with BEA dollar transactions. The most important intersectoral fuel transactions are compared in Table 2.

The disparity in the crude oil sales to the refined oil and pipeline gas sectors is a result of gas being very cheap relative to oil in 1967. The lower BEA dollar fuel sales to the electric sector primarily reflect the fact that fuel sales to utilities were at lower prices than fuel sales to other sectors.

The BNL model corrects the problem with these five transactions in the following manner. The five A matrix coefficients for these transactions are simply multiplied by the ratios listed in Table 2 prior to calculating I-O prices in equation 2. A subprogram is incorporated to do this, as well as store the original A matrix coefficients so that the "true" physical values can be printed out at the end of the program. This subprogram also zeros the twelve diagonal "loss" coefficients before I-O prices are calculated.

TABLE 1

1967 Energy Sector Outputs and Prices

| Sector | Total Output, $10^{15}$ Btu | I-O Price, \$/$10^6$ Btu |
|---|---|---|
| 1. Coal | 14.804 | .18 |
| 2. Crude Oil and Gas | 40.068 | .35 |
| 6. Refined Oil Products | 23.244 | .97 |
| 7. Pipeline Gas | 18.355 | .61 |
| 9. Fossil Electric | 3.362 | 4.57 |
| 10. LWR Electric | 0.026 | 4.57 |
| 12. Hydroelectric | 0.756 | 4.57 |

TABLE 2

Comparison of Major 1967 Fuel Transactions, $10^9$ \$

| | (1) BNL \$ Transaction | (2) BEA \$ Transaction | Ratio (2) ÷ (1) |
|---|---|---|---|
| $T_{2,6}$ (crude to refined oil) | 8.21 | 11.56 | 1.408 |
| $T_{2,7}$ (crude to pipeline gas) | 6.37 | 2.52 | 0.396 |
| $T_{1,9}$ (coal to electric) | 1.53 | 1.03 | 0.672 |
| $T_{6,9}$ (refined to electric) | .92 | .29 | 0.309 |
| $T_{7,9}$ (gas to electric) | 2.11 | .70 | 0.330 |

TABLE 3

Final Adjustment Coefficients for Energy Sectors

| Purchasing Sector | "Other Value Added" Coefficient |
|---|---|
| 1. Coal | 0.0 |
| 2. Crude Oil and Gas | .00537 |
| 6. Refined Oil Products | -.09146 |
| 7. Pipeline Gas | .11668 |
| 9. Fossil Electric | .34963 |
| 10. LWR Electric | -.62454 |
| 12. Hydroelectric | 1.04075 |

| BNL 110 | Sector | BNL 101 | BEA | Battelle | A. Carter | BLS | DRI 18 |
|---|---|---|---|---|---|---|---|
| 1 | Coal | 1 | 7 | 7 | 7 | 8 | 5 |
| 2 | Crude Oil<br>Crude Gas | 2 | 8 | 8 | 8 | 9 | 6<br>10 |
| 3 | Shale Oil | - | - | - | - | - | 15 |
| 4 | Methane from coal | 3 | - | - | - | - | 17 |
| 5 | Coal liquefaction | - | - | - | - | - | 16 |
| 6 | Refined oil products | 4 | 31.01 | part 31 | part 41 | part 42 | 7 |
| 7 | Pipeline gas | 5 | 68.02 | 68.2 | 93 | 102 | 9 |
| 8 | Coal combined cycle electric | - | - | - | - | - | |
| 9 | Other fossil electric | 6 | 68.01<br>78.02<br>79.02 | | | | 8 |
| 10 | LWR electric | 7 | 68.01<br>78.02<br>79.02 | | 92 | 101 | |
| 11 | HTGR electric | - | - | 68.1 | part 104<br>part 105 | 123<br>part 125 | 11 |
| 12 | Hydroelectric | 8 | 68.01<br>78.02<br>79.02 | | | | 12 |
| | Geothermal | - | - | - | - | - | 13 |
| | Solar electric | - | - | - | - | - | 14 |
| | Solar direct | - | - | - | - | - | 18 |
| 13 | Ore reduction feedstocks | 9 | - | - | - | - | - |
| 14 | Chemical feedstocks | 10 | - | - | - | - | - |
| 15 | Motive power | 11 | - | - | - | - | - |
| 16 | Process heat | 12 | - | - | - | - | - |
| 17 | Water heat | 13 | - | - | - | - | - |
| 18 | Space heat | 14 | - | - | - | - | - |
| 19 | Air conditioning | 15 | - | - | - | - | - |
| 20 | Electric power | 16 | - | - | - | - | - |
| 21 | Livestock and livestock products | 17 | 1 | 1 | 1 | 1 | |
| 22 | Other agricultural products | 18 | 2 | 2 | 2 | 2 | |
| 23 | Forestry and fishery products | 19 | 3 | 3 | 3 | 3 | |
| 24 | Agricultural, forestry and fishery services | 20 | 4 | 4 | 4 | 4 | |
| 25 | Iron and ferroalloys ores mining | 21 | 5 | 5 | 5 | 5 | |
| 26 | Nonferrous metal ores mining | 22 | 6 | 6 | 6 | 6-7 | |
| 27 | Stone and clay mining, quarrying | 23 | 9 | 9 | 9 | 10 | 1 |
| 28 | Chemicals and fertilizer mineral mining | 24 | 10 | 10 | 10 | 11 | |
| 29 | New construction, residential buildings | 25 | 11.01 | 11.1 | 11 | 12 | |
| 30 | New construction, nonresidential buildings | | 11.02 | 11.2 | 12 | 13 | |
| 31 | New construction, public utilities | | 11.03 | 11.3 | 13 | 14 | |
| 32 | New construction, highways | | 11.04 | 11.4 | 14 | 15 | |
| 33 | New construction, all other | | 11.05 | 11.5 | 15 | 16 | |
| 34 | Maintenance and repair construction, residential | 26 | 12.01 | 12.1 | 16 | 17 | |
| 35 | Maintenance and repair construction, all other | | 12.02 | 12.2 | 17 | | |
| 36 | Ordnance and accessories | 27 | 13 | 13 | 18 | 18-19 | |
| 37 | Food and kindred products | 28 | 14 | 14 | 19 | 20 | |
| 38 | Tobacco manufacturers | 29 | 15 | 15 | 20 | 21 | |
| 39 | Broad and narrow fabrics, yarn and thread mills | 30 | 16 | 16 | 21 | 22 | |
| 40 | Misc. textile goods and floor coverings | 31 | 17 | 17 | 22 | 23 | |
| 41 | Apparel | 32 | 18 | 18 | 23 | 24-25 | |
| 42 | Misc. fabricated textile products | 33 | 19 | 19 | 24 | 26 | |
| 43 | Lumber and wood products, except containers | 34 | 20 | 20 | 25 | 27, p. 28 | |
| 44 | Wooden containers | 35 | 21 | 21 | 26 | part 28 | |
| 45 | Household furniture | 36 | 22 | 22 | 27 | 29 | |
| 46 | Other furniture and fixtures | 37 | 23 | 23 | 28 | 30 | |
| 47 | Paper and allied products except containers and boxes | 38 | 24 | 24.1<br>24.2<br>24.3 | 29<br>30<br>31 | 31 | |
| 48 | Paperboard containers and boxes | 39 | 25 | 25 | 32 | 32 | |
| 49 | Printing and publishing | 40 | 26 | 26 | 33 | 33-34 | 2 |
| 50 | Chemicals and selected chemical products | 41 | 27 | 27.1<br>27.2<br>27.3 | 34<br>35<br>36 | 35-36 | |
| 51 | Plastics and synthetic materials | 42 | 28 | 28.1<br>28.2 | 37<br>38 | 37<br>38 | |
| 52 | Drugs, cleaning and toilet preparations | 43 | 29 | 29 | 39 | 39-40 | |
| 53 | Paints and allied products | 44 | 30 | 30 | 40 | 41 | |
| 54 | Paving mixtures and blocks | 45 | 31.02 | part 31 | part 41 | part 42 | |
| 55 | Asphalt felts and coatings | 46 | 31.03 | part 31 | part 41 | part 42 | |
| 56 | Rubber and miscellaneous plastics products | 47 | 32 | 32.1<br>32.2<br>32.3 | 42<br>43<br>44 | 43-44 | |
| 57 | Leather tanning and industrial leather products | 48 | 33 | 33 | 45 | 45 | |
| 58 | Footwear and other leather products | 49 | 34 | 34 | 46 | | |
| 59 | Glass and glass products | 50 | 35 | 35 | 47 | 46 | |
| 60 | Stone and clay products | 51 | 36 | 36 | 48 | 47-48 | |

Figure 2. Sectoral classification of BNL energy input-output model and alignment with other classification systems.

| BNL 110 | Sector | BNL 101 | BEA | Battelle | A. Carter | BLS | DRI 18 |
|---|---|---|---|---|---|---|---|
| 61 | Primary iron and steel manufacturing | 52 | 37 | 37 | 49 | 49-50 | |
| 62 | Primary nonferrous metals manufacturing | 53 | 38 | 38.1, 38.2, 38.3 | 50, 51, 52 | 51-57 | |
| 63 | Metal containers | 54 | 39 | 39 | 53 | 58 | |
| 64 | Heating, plumbing and fabricated structural metal products | 55 | 40 | 40 | 54 | 59-60 | |
| 65 | Screw machine prod., bolts, nuts, etc. & metal stampings | 56 | 41 | 41 | 55 | 61 | |
| 66 | Other fabricated metal products | 57 | 42 | 42 | 56 | 62 | |
| 67 | Engines and turbines | 58 | 43 | 43 | 57 | 63 | |
| 68 | Farm machinery | 59 | 44 | 44 | 58 | 64 | |
| 69 | Construction, mining, oil field machinery, equipment | 60 | 45 | 45 | 59 | 65 | |
| 70 | Materials handling machinery and equipment | 61 | 46 | 46 | 60 | 66 | |
| 71 | Metalworking machinery and equipment | 62 | 47 | 47 | 61 | 67 | |
| 72 | Special industry machinery and equipment | 63 | 48 | 48 | 62 | 68 | |
| 73 | General industrial machinery and equipment | 64 | 49 | 49 | 63 | 69 | |
| 74 | Machine shop products | 65 | 50 | 50 | 64 | 70 | 2 |
| 75 | Office, computing and accounting machines | 66 | 51 | 51 | 65 | 71-72 | |
| 76 | Service industry machines | 67 | 52 | 52 | 66 | 73 | |
| 77 | Elec. trans. & dist. eq. & elec. industry apparatus | 68 | 53 | 53.1, 53.2 | 67, 68 | 74, 75 | |
| 78 | Household appliances | 69 | 54 | 54 | 69 | 76 | |
| 79 | Electric lighting and wiring equipment | 70 | 55 | 55 | 70 | 77 | |
| 80 | Radio, television and communications equipment | 71 | 56 | 56 | 71 | 78-80 | |
| 81 | Electronic components and accessories | 72 | 57 | 57.1, 57.2, 57.3 | 72, 73, 74 | 81 | |
| 82 | Miscellaneous elec. machinery, equipment & supplies | 73 | 58 | 58 | 75 | 82 | |
| 83 | Motor vehicles and equipment | 74 | 59 | 59 | 76 | 83 | |
| 84 | Aircraft and parts | 75 | 60 | 60 | 77 | 84 | |
| 85 | Other transportation equipment | 76 | 61 | 61 | 78 | 85-87 | |
| 86 | Professional, scientific & controlling inst. & supp. | 77 | 62 | 62 | 79 | 88-89 | |
| 87 | Optical, opthalmic, & photographic equip. & supp. | 78 | 63 | 63 | 81 | 90-91 | |
| 88 | Miscellaneous manufacturing | 79 | 64 | 64 | 82 | 92 | |
| 89 | Railroads and related services | 80 | 65.01 | 65.1 | 83 | 93 | |
| 90 | Local, urban and interurban highway pass. trans. | 81 | 65.02, 79.01 | 65.2 | 84 part 105 | 94 part 125 | |
| 91 | Motor freight transportation and warehousing | 82 | 65.03 | 65.3 | 85 | 95 | 3 |
| 92 | Water transportation | 83 | 65.04 | 65.4 | 86 | 96 | |
| 93 | Air transportation | 84 | 65.05 | 65.5 | 87 | 97 | |
| 94 | Pipe line transportation | 85 | 65.06 | 65.6 | 88 | 98 | |
| 95 | Transportation services | 86 | 65.07 | 65.7 | 89 | | |
| 96 | Communications except radio & television broadcasting | 87 | 66 | 66 | 90 | 99 | |
| 97 | Radio and TV broadcasting | 88 | 67 | 67 | 91 | 100 | |
| 98 | Water and sanitary services | 89 | 68.03 | 68.3 | 94 | 103 | |
| 99 | Wholesale and retail trade | 90 | 69 | 69 | 95 | 104-105 | |
| 100 | Finance and insurance | 91 | 70 | 70 | 96 | 106-107 | |
| 101 | Real estate & rental | 92 | 71 | 71 | 97 | 108-109 | |
| 102 | Hotels & lodging; pers. & repair serv., except auto repair | 93 | 72 | 72 | 98 | 110-111 | |
| 103 | Business services | 94 | 73 | 73 | 99 | 112-114 | 4 |
| 104 | Automobile repair & services | 95 | 75 | 75 | 101 | 115 | |
| 105 | Amusements | 96 | 76 | 76 | 102 | 116-117 | |
| 106 | Medical, educ. services & nonprofit inst. | 97 | 77 | 77 | 103 | 118-121 | |
| 107 | Federal government enterprises | 98 | 78.01, 78.04 | - | part 104 | 122, 124 | |
| 108 | State and local government enterprises | 99 | 79.03 | - | part 105 | part 125 | |
| 109 | Business travel, entertainment & gifts | 100 | 81 | - | 107 | 128 | |
| 110 | Office supplies | 101 | 82 | - | 108 | 129 | |
| - | Research & development | - | 74* | - | 100 | - | |
| - | Gross imports | - | 80 | - | 106 | 126-127 | |
| - | Scrap, used and second hand goods | - | 83 | - | 109 | 130 | |
| - | Government industry | - | 84 | - | - | 131 | |
| - | Rest of world industry | - | 85 | - | - | 132 | |
| - | Households | - | 86 | - | - | 133 | |
| - | Inventory valuation adjustment | - | 87 | - | - | 134 | |

*Eliminated as a separate sector by BEA in the 1963 and 1967 studies.

Code: BNL 110 - Brookhaven National Laboratory 110 sector version
BNL 101 - Brookhaven National Laboratory 101 sector version
BEA - Bureau of Economic Analysis, U.S. Dept. of Commerce
Battelle- Battelle Memorial Institute; used in an "Ex Ante" Capital Matrix for the United States, 1970-1795
A.Carter- Professor Ann Carter, Brandeis University
BLS - Bureau of Labor Statistics, U.S. Dept. of Labor
DRI 18 - Data Resources, Inc. 18 sector Interindustry model

Figure 2 (Cont'd.). Sectoral classification of BNL energy input-output model and alignment with other classification systems.

With the above adjustments one does still not obtain the desired energy sector prices because energy sector transactions on the diagonal are now zero in the price calculation program of the BNL model. By trial and error, coefficients have been added to the "other value added" row to obtain the desired energy prices. These coefficients are listed in Table 3.

If one now calculates BNL I-O prices after the above modifications one still does not come out with a price of $1.0 for all non-energy sectors. This is primarily a result of fuel sales to non-energy sectors being in some cases at different prices from the "average" I-O prices. Adjustments to "other value added" purchases have therefore been made in certain non-energy sectors to bring their calculated I-O price to within 5% of the desired price of $1.0. Sectors so adjusted are identified in Table 4 which tabulates the value added coefficients by component for all 110 sectors in the BNL model. Table 5 lists the final set of sectoral prices as calculated from equation 2, total value added purchases, and aggregated value added coefficients.

## III. Projected 1985 Prices

Brookhaven's Energy Input-Output Model, when specified for a future planning year, can be used to estimate relative prices for the output of all 110 sectors in the economy. To do this one must first project the level and structure of Gross National Product (a 110 x 8 matrix), the A matrix coefficients of production (a 110 x 110 matrix) and the value added coefficients (a 5 x 110 matrix). Procedures for doing this and for controlling to a set of exogenously specified energy prices are described below.

## Table 4

### 1967 Value Added Coefficients ($/10^6 Btu, $/$)

| Sector | Labor Services | Business Taxes | Capital Services | Other Value Added | Scrap Adjustment |
|---|---|---|---|---|---|
| 1 | .08355 | .00466 | .03633 | 0.00000 | 0.00000 |
| 2 | .02201 | .01834 | .17455 | .00537 | 0.00000 |
| 3 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 4 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 5 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 6 | .08187 | .13051 | .06419 | -.09146 | -.00050 |
| 7 | .10010 | .04338 | .15454 | .11668 | 0.00000 |
| 8 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 9 | .73205 | .26328 | 2.03867 | .34963 | 0.00000 |
| 10 | .73179 | .26436 | 2.03829 | -.62454 | 0.00000 |
| 11 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 12 | .73209 | .26317 | 2.03869 | 1.04075 | 0.00000 |
| 13 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 14 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 15 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 16 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 17 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 18 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 19 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 20 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 21 | .03981 | .02525 | .20078 | 0.00000 | 0.00000 |
| 22 | .07710 | .03331 | .38559 | 0.00000 | 0.00000 |
| 23 | .08026 | .00788 | .49812 | 0.00000 | 0.00000 |
| 24 | .26943 | .02326 | .27920 | .01366 | 0.00000 |
| 25 | .22649 | .04404 | .18425 | .00647 | 0.00000 |
| 26 | .33554 | .04439 | .10547 | .00556* | 0.00000 |
| 27 | .32817 | .02059 | .24266 | .00103 | 0.00000 |
| 28 | .20019 | .02370 | .41977 | -.04999* | 0.00000 |
| 29 | .28592 | .00605 | .09360 | .00092 | 0.00000 |
| 30 | .31390 | .00605 | .05761 | .00151 | 0.00000 |
| 31 | .32795 | .00604 | .04407 | .00119 | 0.00000 |
| 32 | .34295 | .00604 | .10462 | .00128 | 0.00000 |
| 33 | .39221 | .00605 | .09397 | .00111 | 0.00000 |
| 34 | .38783 | .00415 | .12090 | .00109 | 0.00000 |
| 35 | .55391 | .00414 | .05525 | .00072 | 0.00000 |
| 36 | .38444 | .00685 | .06465 | 0.00000 | -.00262 |
| 37 | .14997 | .05009 | .07290 | .01491 | 0.00000 |
| 38 | .07617 | .27209 | .13932 | .00111 | -.00126 |
| 39 | .21926 | .00557 | .08679 | .00189 | -.00388 |
| 40 | .18768 | .00569 | .09787 | .01477 | 0.00000 |
| 41 | .30249 | .00427 | .06431 | .00042 | -.00041 |
| 42 | .21067 | .00397 | .07707 | 0.00000 | -.00072 |
| 43 | .25796 | .00937 | .13667 | 0.00000 | 0.00000 |
| 44 | .28312 | .00741 | .11470 | 0.00000 | 0.00000 |
| 45 | .32678 | .00722 | .10756 | .00041 | 0.00000 |
| 46 | .33154 | .00717 | .11790 | .00007 | 0.00000 |
| 47 | .25024 | .01110 | .14318 | -.02439* | -.00109 |
| 48 | .27820 | .00796 | .08178 | .00002 | -.00635 |
| 49 | .37232 | .00733 | .11798 | .00013 | -.00336 |
| 50 | .18984 | .00940 | .18133 | .00330* | 0.00000 |
| 51 | .24004 | .00858 | .10552 | -.03999* | 0.00000 |
| 52 | .19778 | .00683 | .18372 | .00168 | 0.00000 |
| 53 | .22048 | .00892 | .09430 | .02104 | 0.00000 |
| 54 | .28192 | .00892 | .10233 | -.14980* | 0.00000 |
| 55 | .30988 | .00894 | .07205 | -.17024* | 0.00000 |
| 56 | .29501 | .04198 | .11790 | .01523 | -.00071 |
| 57 | .23144 | .00595 | .08207 | .00753 | -.00446 |
| 58 | .34995 | .00450 | .07880 | 0.00000 | -.00005 |
| 59 | .38464 | .00898 | .18007 | .00204 | 0.00000 |
| 60 | .31241 | .01155 | .14035 | .00037* | 0.00000 |
| 61 | .30484 | .01189 | .09482 | .02794 | -.00683 |
| 62 | .18459 | .00829 | .11258 | .02000* | -.00032 |
| 63 | .22471 | .00926 | .11548 | 0.00000 | -.00851 |
| 64 | .27609 | .00891 | .08870 | .00280 | -.00317 |
| 65 | .33607 | .00819 | .12094 | 0.00000 | -.01295 |
| 66 | .29791 | .00698 | .14838 | .00135 | -.00329 |
| 67 | .26037 | .00728 | .09807 | .00300 | -.00323 |
| 68 | .27470 | .00725 | .08864 | .00213 | -.00149 |
| 69 | .29385 | .00935 | .12643 | .00175 | -.00388 |
| 70 | .31416 | .00716 | .07687 | 0.00000 | -.00163 |
| 71 | .39415 | .00862 | .12036 | .00164 | -.00096 |
| 72 | .35137 | .00687 | .08488 | .00442 | -.00108 |
| 73 | .33940 | .00806 | .11001 | .00133 | -.00404 |
| 74 | .41553 | .00686 | .13182 | .00183 | -.00150 |
| 75 | .30837 | .00509 | .11040 | 0.00000 | -.00037 |
| 76 | .21855 | .00532 | .04399 | 0.00000 | -.00173 |
| 77 | .34415 | .00754 | .11754 | .00301 | -.00216 |
| 78 | .24729 | .00625 | .10370 | 0.00000 | -.00221 |
| 79 | .29669 | .00668 | .17256 | .00057 | -.00245 |
| 80 | .38160 | .00580 | .08467 | .00001 | -.00135 |
| 81 | .39137 | .00577 | .05985 | .00718 | -.00222 |
| 82 | .32127 | .00793 | .10204 | 0.00000 | -.00423 |
| 83 | .19607 | .04630 | .06840 | .00586 | -.00228 |
| 84 | .39296 | .01059 | .03052 | .00167 | -.00105 |
| 85 | .32682 | .00696 | .04541 | .00053 | -.00240 |
| 86 | .32609 | .00766 | .10320 | .00017 | -.00205 |
| 87 | .31168 | .00505 | .27242 | .00006 | -.00088 |
| 88 | .31272 | .00724 | .11363 | .02083 | -.00220 |
| 89 | .43276 | .03716 | .17075 | .00374 | -.00255 |
| 90 | .42855 | .03611 | .16594 | .00007 | 0.00000 |
| 91 | .41354 | .03551 | .16317 | .00031 | 0.00000 |
| 92 | .30451 | .02616 | .12015 | -.12022* | -.00469 |
| 93 | .39266 | .03372 | .15493 | -.00892* | -.00034 |
| 94 | .45206 | .03886 | .17834 | 0.00000 | 0.00000 |
| 95 | .56321 | .04833 | .22228 | 0.00000 | 0.00000 |
| 96 | .33636 | .12755 | .36581 | .00686 | 0.00000 |
| 97 | .33295 | .01037 | .15298 | .00016 | 0.00000 |
| 98 | .09699 | .05658 | .08209 | 0.00000 | 0.00000 |
| 99 | .42734 | .14011 | .15648 | .00034 | -.00001 |
| 100 | .40911 | .04019 | .11588 | .00172 | -.00011 |
| 101 | .01660 | .16119 | .56463 | .00000 | 0.00000 |
| 102 | .34007 | .01346 | .24307 | .00001 | -.00030 |
| 103 | .28450 | .00733 | .22404 | .00011 | 0.00000 |
| 104 | .25669 | .01390 | .27874 | .00258 | 0.00000 |
| 105 | .29813 | .07632 | .14611 | .00704 | 0.00000 |
| 106 | .48524 | .00505 | .20856 | .00006 | 0.00000 |
| 107 | .78853 | .00869 | -.07564 | .04779 | 0.00000 |
| 108 | .17514 | 0.00000 | .36927 | .00002 | 0.00000 |
| 109 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 110 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |

*Adjusted to reflect difference in actual energy prices paid versus I-O energy prices.

## Table 5

### I-O Prices

| Sector | I-O Price ($/10^6 Btu, $/$) | Total VA Purchases (1967 $) | VA Coefficient ($/10^6 Btu, $/$) |
|---|---|---|---|
| 1 | .180287 | 1.843801 | .124544 |
| 2 | .350076 | 8.825753 | .220269 |
| 3 | 0.000000 | 0.000000 | 0.000000 |
| 4 | 0.000000 | 0.000000 | 0.000000 |
| 5 | 0.000000 | 0.000000 | 0.000000 |
| 6 | .962923 | 4.291093 | .184609 |
| 7 | .609326 | 7.611699 | .414697 |
| 8 | 0.000000 | 0.000000 | 0.000000 |
| 9 | 4.561563 | 11.376446 | 3.383633 |
| 10 | 4.581806 | .062899 | 2.409903 |
| 11 | 0.000000 | 0.000000 | 0.000000 |
| 12 | 4.572238 | 3.079579 | 4.074703 |
| 13 | .776133 | 0.000000 | 0.000000 |
| 14 | .892776 | 0.000000 | 0.000000 |
| 15 | 4.814607 | 0.000000 | 0.000000 |
| 16 | 1.009560 | 0.000000 | 0.000000 |
| 17 | 1.731263 | 0.000000 | 0.000000 |
| 18 | 1.589840 | 0.000000 | 0.000000 |
| 19 | 1.660862 | 0.000000 | 0.000000 |
| 20 | 4.563629 | 0.000000 | 0.000000 |
| 21 | 1.004844 | 8.085800 | .265829 |
| 22 | .993274 | 13.953003 | .496006 |
| 23 | 1.003950 | .818800 | .586263 |
| 24 | 1.000387 | 1.560600 | .585571 |
| 25 | 1.029383 | .513200 | .481249 |
| 26 | 1.042975 | .618201 | .490965 |
| 27 | .994719 | 1.323300 | .592446 |
| 28 | 1.024297 | .551000 | .593670 |
| 29 | 1.012498 | 10.197398 | .386485 |
| 30 | 1.011425 | 10.192208 | .379062 |
| 31 | 1.008653 | 4.161097 | .379256 |
| 32 | .980253 | 3.807900 | .454892 |
| 33 | .994994 | 3.614101 | .493325 |
| 34 | 1.008784 | 3.219800 | .513968 |
| 35 | 1.001337 | 10.518593 | .614020 |
| 36 | 1.007359 | 4.831203 | .453320 |
| 37 | 1.003941 | 25.302664 | .287877 |
| 38 | 1.000659 | 3.858602 | .487437 |
| 39 | 1.019627 | 4.780100 | .309640 |
| 40 | 1.009704 | 1.291001 | .306008 |
| 41 | 1.006884 | 8.349296 | .371070 |
| 42 | 1.010124 | 1.246001 | .290980 |
| 43 | 1.001659 | 4.830408 | .403990 |
| 44 | 1.001980 | .218700 | .405230 |
| 45 | 1.003804 | 2.263699 | .441973 |
| 46 | 1.004848 | 1.273598 | .456688 |
| 47 | 1.002235 | 5.802889 | .379036 |
| 48 | 1.000941 | 2.179898 | .361600 |
| 49 | 1.000997 | 10.919808 | .494399 |
| 50 | 1.028203 | 8.614096 | .383873 |
| 51 | 1.005916 | 2.598501 | .314154 |
| 52 | 1.005178 | 4.852496 | .390013 |
| 53 | 1.003420 | 1.004599 | .344735 |
| 54 | .994125 | .144600 | .243375 |
| 55 | .991424 | .128300 | .220629 |
| 56 | 1.010881 | 6.375105 | .469417 |
| 57 | .990905 | .325400 | .322529 |
| 58 | 1.000595 | 1.830602 | .433197 |
| 59 | 1.026570 | 2.116299 | .575724 |
| 60 | 1.038878 | 5.028501 | .464605 |
| 61 | 1.031702 | 13.022487 | .432662 |
| 62 | 1.019632 | 5.934504 | .317211 |
| 63 | 1.014990 | 1.141400 | .340938 |
| 64 | 1.010853 | 4.593900 | .369126 |
| 65 | 1.010707 | 4.144893 | .452249 |
| 66 | 1.007424 | 5.493308 | .451332 |
| 67 | 1.007369 | 1.370099 | .386302 |
| 68 | 1.008470 | 1.000699 | .371225 |
| 69 | 1.008297 | 2.513402 | .427502 |
| 70 | 1.005181 | .996700 | .396563 |
| 71 | 1.001471 | 4.374299 | .523812 |
| 72 | 1.002137 | 2.403901 | .444464 |
| 73 | 1.004829 | 3.443603 | .454757 |
| 74 | .995504 | 2.183299 | .554541 |
| 75 | 1.003710 | 2.747603 | .423489 |
| 76 | 1.006409 | 1.664199 | .316129 |
| 77 | 1.004865 | 4.550901 | .470070 |
| 78 | 1.008088 | 1.930598 | .355031 |
| 79 | 1.006368 | 1.916700 | .474038 |
| 80 | 1.003217 | 7.789905 | .470733 |
| 81 | 1.006833 | 3.682298 | .461954 |
| 82 | 1.008791 | 1.293100 | .427002 |
| 83 | 1.009004 | 13.551500 | .314343 |
| 84 | 1.002654 | 9.485209 | .434688 |
| 85 | 1.007201 | 2.874596 | .377311 |
| 86 | 1.001209 | 2.613397 | .435063 |
| 87 | 1.004380 | 2.678702 | .588118 |
| 88 | 1.001623 | 3.939499 | .452727 |
| 89 | 1.017705 | 8.152203 | .641868 |
| 90 | 1.005891 | 3.409005 | .622677 |
| 91 | 1.007454 | 11.819790 | .612540 |
| 92 | 1.018912 | 1.548797 | .325907 |
| 93 | 1.018314 | 4.554902 | .572057 |
| 94 | .974148 | .806101 | .664253 |
| 95 | 1.000477 | .848900 | .833808 |
| 96 | 1.000361 | 16.161612 | .833577 |
| 97 | .999483 | 1.580400 | .496654 |
| 98 | 1.010263 | .839700 | .235654 |
| 99 | 1.000489 | 117.368161 | .724270 |
| 100 | 1.002666 | 26.976196 | .566797 |
| 101 | .993392 | 84.072781 | .742426 |
| 102 | 1.015169 | 12.405996 | .596308 |
| 103 | 1.002657 | 29.082093 | .515981 |
| 104 | 1.001584 | 8.138808 | .551911 |
| 105 | .998808 | 5.088097 | .527599 |
| 106 | .998692 | 33.899897 | .698920 |
| 107 | .999924 | 5.497802 | .769373 |
| 108 | 1.007972 | 3.430502 | .544425 |
| 109 | 1.009650 | 0.000000 | 0.000000 |
| 110 | 1.003732 | 0.000000 | 0.000000 |

PRICE INDEX= 1.00264

A. Non-Energy Sector Coefficients

A 1985 A-matrix has been projected by the U.S. Bureau of Labor Statistics.[5] This is specified in 1958 dollars, and they furnish sectoral deflators for the years 1958-1971 so that coefficients can be converted to other year dollars. For non-energy purchases by non-energy sectors, BLS A-matrix coefficients are inflated to 1967 dollars and used directly. For energy product purchases by non-energy sectors, Brookhaven has made its own coefficient projections based on the 1967 estimates made by the Center for Advanced Computation and on trends in energy consumption projected by the Data Resources, Inc., Long Term Interindustry Model.[6]

For the value added coefficients it is assumed that those describing indirect business taxes, property type income, scrap adjustment, and other value added remain constant over time. All productivity changes are captured in the projections of employee compensation coefficients.

The productivity rates used to project the employee compensation coefficients from 1967 to 1985 were derived from estimates made by Almon[7] and Bezdek[8] for this period. They were judgementally adjusted based on information available for 1976. Annual percentage changes in output per constant hour man year for the periods 1967-1976, 1976-1985, and 1985-2000 appear in Table 6. Figure 3 shows annual changes by sector for the 1967 to 1985 period. These productivity rates ($R_{1967-1985}$) were applied to the 1967 employee compensation coefficients ($EC/_X$) in the following manner:

$$(EC/_X)_{1985} = (1 + R_{1967-1985})^{-18} \cdot (EC/_X)_{1967}. \qquad (3)$$

If the model is now run for 1985 using equation 2 and the 1985 data, the prices obtained for the energy sectors 1-12

TABLE 6

Annual Percent Change in Output Per Manyear
for 1967-1976, 1976-1985
and 1985-2000
(Percent/year)

| Sector Number | 1967-1976 | 1976-1985 | 1985-2000 |
|---|---|---|---|
| 1 | -2.93 | 0.95 | 1.49 |
| 2 | 1.39 | 1.49 | 1.59 |
| 3 | 0.00 | 0.00 | 2.79 |
| 4 | 0.00 | 0.00 | 3.59 |
| 5 | 0.00 | 0.00 | 0.00 |
| 6 | 4.08 | 3.10 | 2.89 |
| 7 | 3.12 | 2.26 | 1.99 |
| 8 | 0.00 | 0.00 | 0.00 |
| 9 | 3.99 | 3.79 | 3.59 |
| 10 | 5.55 | 4.35 | 4.19 |
| 11 | 0.00 | 0.00 | 0.00 |
| 12 | 4.33 | 4.05 | 3.89 |
| 13 | 0.00 | 0.00 | 0.00 |
| 14 | 0.00 | 0.00 | 0.00 |
| 15 | 0.00 | 0.00 | 0.00 |
| 16 | 0.00 | 0.00 | 0.00 |
| 17 | 0.00 | 0.00 | 0.00 |
| 18 | 0.00 | 0.00 | 0.00 |
| 19 | 0.00 | 0.00 | 0.00 |
| 20 | 0.00 | 0.00 | 0.00 |
| 21 | 4.80 | 5.28 | 5.30 |
| 22 | 4.97 | 5.40 | 5.30 |
| 23 | 2.54 | 1.24 | 1.24 |
| 24 | -0.78 | 2.59 | 1.39 |
| 25 | 4.53 | 2.16 | 2.09 |
| 26 | -1.16 | 3.90 | 2.09 |
| 27 | 2.68 | 2.00 | 1.89 |
| 28 | 2.69 | 1.97 | 1.89 |
| 29 | 1.53 | 1.87 | 1.04 |
| 30 | 1.53 | 1.86 | 1.04 |
| 31 | 1.53 | 1.87 | 1.04 |
| 32 | 1.53 | 1.87 | 1.04 |
| 33 | 1.53 | 1.87 | 1.04 |
| 34 | 1.53 | 1.87 | 1.04 |
| 35 | 1.53 | 1.87 | 1.04 |
| 36 | 3.39 | 1.59 | 1.59 |
| 37 | 3.85 | 1.74 | 1.69 |
| 38 | 3.59 | 2.81 | 2.69 |
| 39 | 3.37 | 1.97 | 1.79 |
| 40 | 2.75 | 3.03 | 3.14 |
| 41 | 2.70 | 1.88 | 1.79 |
| 42 | 2.54 | 2.20 | 2.09 |
| 43 | 3.39 | 2.39 | 1.89 |
| 44 | 8.45 | 0.10 | 1.99 |
| 45 | 2.09 | 1.89 | 1.64 |
| 46 | 3.52 | 1.96 | 1.74 |
| 47 | 2.81 | 1.95 | 1.84 |
| 48 | 3.17 | 2.12 | 2.04 |
| 49 | 1.98 | 1.90 | 1.86 |
| 50 | 5.14 | 3.84 | 4.59 |
| 51 | 5.75 | 3.44 | 3.49 |
| 52 | 3.86 | 2.63 | 2.54 |
| 53 | 3.57 | 2.01 | 2.19 |

TABLE 6 (cont'd.)

| Sector Number | 1967-1976 | 1976-1985 | 1985-2000 |
|---|---|---|---|
| 54 | -1.68 | 5.38 | 1.09 |
| 55 | -1.68 | 5.39 | 1.09 |
| 56 | 4.42 | 3.24 | 2.19 |
| 57 | -0.98 | 1.98 | 1.99 |
| 58 | 0.14 | 1.84 | 3.89 |
| 59 | 2.68 | 3.80 | 2.79 |
| 60 | 4.01 | 1.88 | 1.49 |
| 61 | 1.75 | 1.58 | 1.41 |
| 62 | 1.42 | 1.80 | 1.75 |
| 63 | 4.63 | 1.57 | 1.59 |
| 64 | 1.56 | 2.02 | 1.97 |
| 65 | 2.76 | 2.22 | 1.79 |
| 66 | 1.38 | 2.22 | 1.71 |
| 67 | 1.68 | 2.70 | 2.79 |
| 68 | 2.96 | 2.12 | 1.99 |
| 69 | 0.33 | 2.53 | 2.19 |
| 70 | 2.84 | 1.50 | 1.24 |
| 71 | 4.99 | 0.05 | 0.99 |
| 72 | 4.78 | 2.41 | 2.29 |
| 73 | 3.29 | 2.49 | 1.90 |
| 74 | 2.77 | 1.42 | 1.79 |
| 75 | 0.88 | 2.70 | 3.19 |
| 76 | 0.38 | 2.61 | 3.44 |
| 77 | 3.08 | 2.70 | 2.44 |
| 78 | 3.27 | 3.71 | 3.89 |
| 79 | 3.29 | 2.29 | 2.36 |
| 80 | 4.85 | 3.34 | 3.09 |
| 81 | 3.28 | 3.90 | 4.40 |
| 82 | 0.44 | 1.94 | 1.99 |
| 83 | 3.11 | 3.26 | 2.99 |
| 84 | 2.16 | 2.72 | 3.00 |
| 85 | -0.81 | 2.82 | 2.09 |
| 86 | 3.41 | 3.57 | 3.69 |
| 87 | 1.59 | 2.19 | 3.39 |
| 88 | 3.33 | 5.16 | 5.29 |
| 89 | 5.23 | 4.25 | 4.09 |
| 90 | 2.61 | 1.38 | 1.30 |
| 91 | 3.34 | 3.96 | 4.09 |
| 92 | 4.27 | 3.31 | 2.79 |
| 93 | 5.59 | 3.40 | 3.34 |
| 94 | 2.06 | 1.52 | 1.21 |
| 95 | 1.95 | 1.22 | 1.19 |
| 96 | 4.13 | 3.85 | 3.69 |
| 97 | 0.94 | 1.44 | 1.84 |
| 98 | 0.23 | 1.92 | 2.60 |
| 99 | 0.76 | 1.42 | 2.14 |
| 100 | 0.81 | 1.07 | 1.34 |
| 101 | 1.32 | 1.65 | 1.89 |
| 102 | 0.66 | 0.96 | 1.09 |
| 103 | 0.26 | 0.72 | 1.19 |
| 104 | 2.60 | 3.58 | 4.71 |
| 105 | 0.00 | 0.00 | 0.00 |
| 106 | 0.72 | 0.86 | 1.14 |
| 107 | -1.00 | 0.24 | -0.26 |
| 108 | -1.81 | 2.03 | 0.29 |
| 109 | 0.00 | 0.00 | 0.00 |
| 110 | 0.00 | 0.00 | 0.00 |

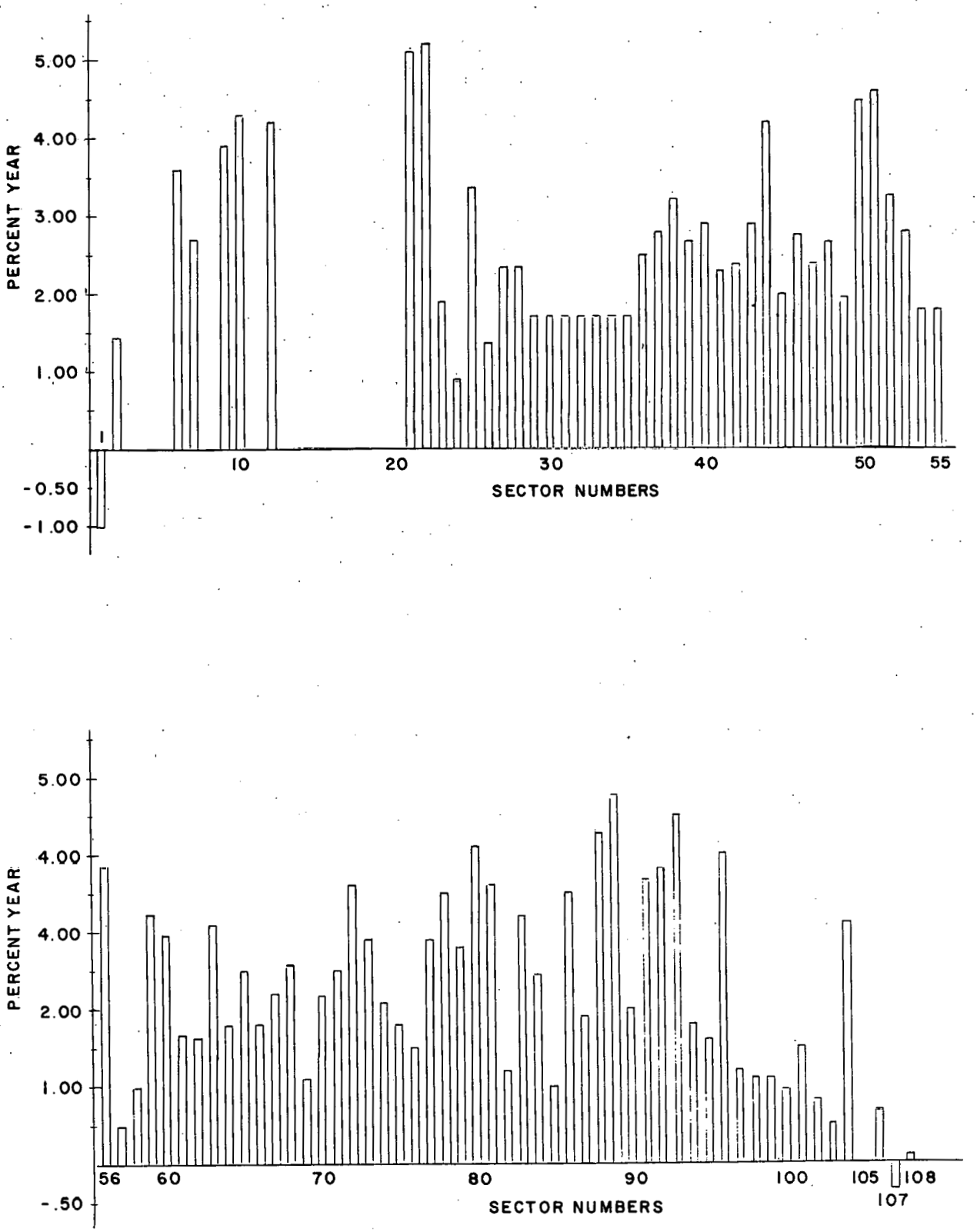


Figure 3. Annual percentage changes in output per manyear, 1967-1985.

may not conform to exogenously specified prices. Several adjustments must be made to obtain the desired 1985 prices for sectors 1-12. These desired prices are discussed next, followed by the parameter changes which were necessary to obtain these prices.

B. Determination of Energy Sector Prices

In order to set up the model in terms of exogenously specified energy prices, one must first determine the desired I-O prices that you want equation 2 to calculate. This involved the following steps: (1) deflating specified energy prices to 1967 dollars* to obtain the "real" 1985 energy price (in 67 $) with respect to the "real" 1985 price of all other goods and services ($1.0 in 1967 $), and (2) adjusting for productivity gains in the production of other goods and services. Because of aggregate productivity gains expected between 1967 and 1985, calculated I-O prices in (67 $) of most non-energy goods and services will be lower in 1985 than in 1967. To maintain correct relative 1985 prices, energy prices must be reduced in proportion to the average reduction in the cost of non-energy goods and services.

For the second step, an aggregate price index** of non-energy goods and services is constructed for 1967 and the planning year, in this case 1985. This is computed with the solution prices to equation 2 and the vector of total sectoral outputs:

$$PI^t = \frac{\sum_j p_j^t \cdot x_j^t}{\sum_j x_j^t}, \text{ for } j = 21 - 100, \text{ in year } t. \quad (4)$$

* The following deflator is used: 1967-1975 = 1.586 (Survey of Current Business GNP deflator).

** C.E. Furguson's index of income change is employed.

For 1967 this price index is 1.0, and for 1985 it is .878 in this example. The 1985 X vector was estimated with a projected GNP (Y vector) according to the standard input-output equation,

$$X = (I-A)^{-1} Y. \qquad (5)$$

(Since non-energy prices for 1985 changed slightly as energy sector prices were adjusted, a 1985 price index was actually recalculated several times as energy prices were brought into alignment.) Now, given deflated energy prices for the corresponding I-O definitions, they are multiplied by $PI^{85}/PI^{67}$ to obtain the relative price that one wants the model to calculate.

Calculation of desired I-O prices are discussed below using BNL estimates for a recent planning exercise as an example, first for conventional technologies and secondly for new technologies.

1. Coal

The 1985 BNL coal price is $\$.64/10^6$ Btu (1967 $) at the minemouth. This price must be multiplied by .878 to find the relative coal price in 1967 dollars, $\$.56/10^6$ Btu, that should be calculated by the I-O price program. Since the price of coal was $\$.18/10^6$ Btu in 1967, a significant decrease in this sector's productivity is presumed.

2. Crude Oil and Gas

Deflated 1985 prices assumed for crude oil and crude gas at the wellhead are, respectively, $\$1.34/10^6$ Btu and $\$1.48/10^6$ Btu in 1967 dollars. The single sectoral price, weighted by their respective 1985 production levels, is $\$1.40/10^6$ Btu. Correcting for productivity change, the desired 1985 I-O price for crude oil and gas is $\$1.23/10^6$ Btu. (Individual prices that correspond to this aggregate I-O

price are $1.18/10^6 Btu of crude oil and $1.30/10^6 Btu of crude gas.)

3. Refined Oil Products

The 1985 refined petroleum products price which is assumed is $1.79 in 1967 dollars. This $.45 markup from crude oil is the same as the 1967 markup, and it is assumed that there is no aggregate change in productivity for the refined oil sector over this period. Correcting for productivity change (by multiplying by .878), the desired 1985 price for refined oil products is $1.57/10^6 Btu.

4. Pipeline Gas

The 1985 assumed price for delivered pipeline gas is $1.93/10^6 Btu. As with oil, it is assumed that there is no aggregate change in productivity for this sector between 1967 and 1985, and the 1967 markup of $.45/10^6 Btu over crude gas is assumed. Adjusting for productivity change in non-energy goods and services, the desired I-O price for pipeline gas is $1.70/10^6 Btu.

5. Coal Combined Cycle Electric, Fossil Electric, Light Water Reactor, High Temperature Gas Cooled Reactor, and Hydroelectric

The 1985 price of delivered electricity for these sectors is obtained from solution of the Brookhaven Energy System Optimization Model, $6.17/10^6 Btu in 1967 dollars. This model (BESOM) which is linked to the I-O model brings in the detailed cost structure of the utility industry, the fuel mix, and the mix between base, intermediate and peak load demands for electric power.(1) Multiplying by the productivity factor of .878 then gives the desired 1985 I-O price of $5.42/10^6 Btu for all electric sectors, with all outputs mea-

sured in Btu of delivered electricity. A single price is used for all electric sectors to avoid bias in calculations of energy product prices.

6. Shale Oil, Coal Gasification and Coal Liquefaction

The prices for these fuels are tied to the desired I-O prices of crude oil and crude gas. The desired crude shale oil price of $\$1.50/10^6$ Btu is 18% above the crude oil price; so the desired I-O price of shale oil is $\$1.39/10^6$ Btu in 1967 dollars. Similarly, the assumed coal liquids price of $\$2.40/10^6$ Btu is 79% above the crude oil price; so the desired I-O price of coal liquids is $\$2.11/10^6$ Btu. Finally, the assumed coal gas price of $\$2.36/10^6$ Btu is 59% above the crude gas price; so the desired I-O price of coal gas is $\$2.07/10^6$ Btu.

The method for calculating all twelve desired I-O energy prices is summarized in Table 7.

C. Alignment of Coefficients to Desired 1985 Prices

As in 1967, the major transactions between the energy supply sectors must be adjusted to take into account the fact that these sales will not in general be made at the same price as sales to other sectors of the economy. In 1967, we were able to compare the BNL transactions values with the BEA values in order to make this adjustment. In 1985, however, it is not known what the values of these transactions should be and the values in Table 8 were judgementally chosen. These eight adjustment factors must be inserted into the price calculation program so that the corresponding A matrix coefficients are multiplied by these factors prior to calculating I-O prices.

In addition, coefficients for coal to coal liquids and coal to coal combined cycle electric generation were cal-

TABLE 7

Calculation of Desired I-O Energy Prices

| Sector | Measurement Unit | Specified Price, 67$/$10^6$ Btu | | | | Desired I-O Price, 67$/$10^6$ Btu |
|---|---|---|---|---|---|---|
| coal | raw coal | $P_c$ | x | PI* | = | $P_c^{IO}$ |
| crude oil | crude | $P_{co}$ | x | PI | = | $P_{co}^{IO}$ |
| crude gas | crude | $P_{cg}$ | x | PI | = | $P_{cg}^{IO}$ |
| shale oil | syncrude | $P_{so}$ | x $P_{co}^{IO} \div P_{co}$ | | = | $P_{so}^{IO}$ |
| coal gas | procsd. gas | $P_m$ | x $P_{cg}^{IO} \div P_{cg}$ | | = | $P_m^{IO}$ |
| coal liquids | syncrude | $P_{cl}$ | x $P_{co} \div P_{co}$ | | = | $P_{cl}^{IO}$ |
| refined oil | refined | $P_{ro}$ | x | PI | = | $P_{ro}^{IO}$ |
| pipeline gas | delivered gas | $P_{pg}$ | x | PI | = | $P_{pg}^{IO}$ |
| coal combd. cycle | dlvd. elec. | | | | | |
| fossil electric | dlvd. elec. | | | | | |
| LWR electric | dlvd. elec. | $P_e$** | x | PI | = | $P_e^{IO}$ |
| HTGR electric | dlvd. elec. | | | | | |
| hydroelectric | dlvd. elec. | | | | | |

* Price index for non-energy goods and services; approx. .878 for 1985/1967.
** Average price of electricity from BESOM solution.

TABLE 8

1985 Adjustment Factors for Major Fuel Transactions

| | | |
|---|---|---|
| $T_{2,6}$ | (crude to refined oil) | .77 |
| $T_{2,7}$ | (crude to pipeline gas) | .61 |
| $T_{1,9}$ | (coal to electric) | .67 |
| $T_{6,9}$ | (refined to electric) | .75 |
| $T_{7,9}$ | (pipeline gas to electric) | .75 |
| $T_{3,6}$ | (shale to refined) | .77 |
| $T_{4,7}$ | (coal gas to pipeline gas) | .61 |
| $T_{5,6}$ | (coal liquids to refined) | .77 |

culated from BESOM and inserted in the A matrix so that prices could be estimated correctly for these technologies, even though their output levels were zero in the 1985 example.

In order to obtain the desired prices discussed above, the Property-Type Income (PTI) coefficients for the energy supply sectors are adjusted until the desired prices are obtained. The 1967 PTI coefficients and the 1985 PTI coefficients are compared in Table 9. All other value added coefficients for the energy sectors are unchanged from their 1967 values.

Table 10 shows the value added coefficients for all 110 sectors of the BNL model and Table 11 shows the final set of sectoral prices as calculated from equation 2 for 1985.

If one wishes to set up the model for a different set of 1985 energy prices, it is necessary to first ask what factors are causing the difference in energy prices from the base case. The reasons then provide a basis for changing A matrix and value added coefficients in the alignment process. A shift toward greater stripmining, for example, would be reflected through certain A matrix changes in the coal column and changes in the property type income and employee compensation coefficients. Further, changes in government tax rates can be reflected in the indirect business tax coefficients.

TABLE 9

Comparison of 1967 and 1985 Property Type Income Coefficients ($/10$^6$ BTU)

| | | |
|---|---|---|
| coal | .036 | .217 |
| crude oil and gas | .175 | 1.038 |
| shale oil | -- | 1.045 |
| coal gas | -- | 1.134 |
| coal liquids | -- | .937 |
| refined oil | .064 | .064 |
| pipeline gas | .155 | .155 |
| coal combd. cycle elec. | -- | 3.108 |
| fossil electric | 2.039 | 2.635 |
| LWR electric | 2.039 | 2.150 |
| HTGR electric | -- | 3.100 |
| hydroelectric | 2.039 | 1.714 |

Table 10

1985 Value Added Coefficients
(1967 $/$10^6$ Btu, $/$)

| Sector | Labor Services | Business Taxes | Capital Services | Other VA | Scrap Adjustment |
|---|---|---|---|---|---|
| 1 | .15017 | .00466 | .21700 | -.00847 | .03000 |
| 2 | .01702 | .01834 | 1.03800 | -.25256 | .19000 |
| 3 | .06700 | .13051 | 1.04500 | .00679 | .14000 |
| 4 | .09446 | .04338 | 1.13400 | 0.00000 | 0.00000 |
| 5 | .10894 | .13051 | .93700 | 0.00000 | 0.00000 |
| 6 | .04340 | .13051 | .06419 | -.13638 | -.09050 |
| 7 | .06209 | .04338 | .15454 | .20518 | 0.00000 |
| 8 | .36328 | .26361 | 3.10800 | 0.00000 | 1.12000 |
| 9 | .36837 | .26328 | 2.63500 | -1.03764 | .71000 |
| 10 | .34364 | .26436 | 2.15000 | .43686 | .21000 |
| 11 | .36545 | .26361 | 3.10000 | 0.00000 | 0.00000 |
| 12 | .34976 | .26317 | 1.71400 | 2.85366 | -.21000 |
| 13 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 14 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 15 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 16 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 17 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 18 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 19 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 20 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 21 | .01629 | .02525 | .20078 | 0.00000 | 0.00000 |
| 22 | .03102 | .03331 | .38559 | 0.00000 | 0.00000 |
| 23 | .05731 | .00788 | .49817 | 0.00000 | 0.00000 |
| 24 | .22975 | .02326 | .27920 | .01366 | 0.00000 |
| 25 | .12540 | .04404 | .18425 | .00647 | 0.00000 |
| 26 | .26409 | .04439 | .10547 | .00566 | 0.00000 |
| 27 | .21644 | .02059 | .24266 | .00103 | 0.00000 |
| 28 | .13203 | .02370 | .41977 | -.04999 | 0.00000 |
| 29 | .21112 | .00605 | .09360 | .00092 | 0.00000 |
| 30 | .23178 | .00605 | .05761 | .00151 | 0.00000 |
| 31 | .24215 | .00604 | .04407 | .00119 | 0.00000 |
| 32 | .25323 | .00604 | .10462 | .00128 | 0.00000 |
| 33 | .28960 | .00605 | .09397 | .00111 | 0.00000 |
| 34 | .28637 | .00415 | .12090 | .00109 | 0.00000 |
| 35 | .40900 | .00414 | .05525 | .00072 | 0.00000 |
| 36 | .24696 | .00685 | .06465 | 0.00000 | -.00262 |
| 37 | .09140 | .05009 | .07290 | .01491 | 0.00000 |
| 38 | .04322 | .27209 | .13932 | .00111 | -.00126 |
| 39 | .13647 | .00557 | .08679 | .00189 | -.00388 |
| 40 | .11240 | .00569 | .09787 | .01477 | 0.00000 |
| 41 | .20127 | .00427 | .06431 | .00042 | -.00041 |
| 42 | .13822 | .00397 | .07707 | 0.00000 | -.00072 |
| 43 | .15449 | .00937 | .13667 | 0.00000 | 0.00000 |
| 44 | .13527 | .00741 | .11470 | 0.00000 | 0.00000 |
| 45 | .22923 | .00722 | .10756 | .00041 | 0.00000 |
| 46 | .20386 | .00717 | .11790 | .00007 | 0.00000 |
| 47 | .16389 | .01110 | .14318 | -.02439 | -.00109 |
| 48 | .17407 | .00796 | .08178 | .00002 | -.00635 |
| 49 | .26350 | .00733 | .11798 | .00013 | -.00336 |
| 50 | .08613 | .00940 | .18133 | .00330 | 0.00000 |
| 51 | .10704 | .00858 | .10552 | -.03999 | 0.00000 |
| 52 | .11143 | .00683 | .18372 | .00168 | 0.00000 |
| 53 | .13438 | .00892 | .09430 | .02104 | 0.00000 |
| 54 | .20488 | .00892 | .10233 | -.14980 | 0.00000 |
| 55 | .22520 | .00894 | .07205 | -.17024 | 0.00000 |
| 56 | .15000 | .04198 | .11790 | .01523 | -.00071 |
| 57 | .21197 | .00595 | .08207 | .00753 | -.00446 |
| 58 | .29312 | .00450 | .07880 | 0.00000 | -.00005 |
| 59 | .21670 | .00898 | .18007 | .00204 | 0.00000 |
| 60 | .18547 | .01155 | .14035 | .00037 | 0.00000 |
| 61 | .22629 | .01189 | .09482 | .02794 | -.00683 |
| 62 | .13849 | .00829 | .11258 | .02008 | -.00832 |
| 63 | .12996 | .00926 | .11548 | 0.00000 | -.00851 |
| 64 | .20064 | .00691 | .08670 | .00260 | -.00317 |
| 65 | .21589 | .00819 | .12094 | 0.00000 | -.01295 |
| 66 | .21612 | .00698 | .14030 | .00135 | -.00329 |
| 67 | .18174 | .00722 | .09007 | .00388 | -.00323 |
| 68 | .17492 | .00725 | .08864 | .00213 | -.00149 |
| 69 | .24178 | .00915 | .14814 | .05115 | -.00588 |
| 70 | .21350 | .00716 | .07687 | 0.00000 | -.00163 |
| 71 | .25320 | .00862 | .12036 | .00164 | -.00096 |
| 72 | .18626 | .00687 | .08488 | .00442 | -.00108 |
| 73 | .20326 | .00806 | .11001 | .00133 | -.00404 |
| 74 | .28640 | .00686 | .13182 | .00183 | -.00150 |
| 75 | .22410 | .00509 | .11040 | 0.00000 | -.00037 |
| 76 | .16749 | .00532 | .09399 | 0.00000 | -.00173 |
| 77 | .20611 | .00754 | .11754 | .00301 | -.00216 |
| 78 | .13338 | .00625 | .10370 | 0.00000 | -.00221 |
| 79 | .18082 | .00668 | .17256 | .00057 | -.00245 |
| 80 | .18549 | .00580 | .08467 | .00001 | -.00135 |
| 81 | .20747 | .00577 | .05985 | .00718 | -.00222 |
| 82 | .25968 | .00793 | .10204 | 0.00000 | -.00423 |
| 83 | .11143 | .04630 | .06840 | .00586 | -.00228 |
| 84 | .25466 | .01059 | .03057 | .00167 | -.00105 |
| 85 | .27375 | .00696 | .04541 | .00053 | -.00240 |
| 86 | .17589 | .00766 | .10320 | .00017 | -.00205 |
| 87 | .22240 | .00505 | .27242 | .00804 | -.00088 |
| 88 | .14812 | .00724 | .11363 | .02083 | -.00220 |
| 89 | .18806 | .03716 | .17075 | .00374 | -.00255 |
| 90 | .29501 | .03611 | .16594 | .00007 | 0.00000 |
| 91 | .21694 | .03551 | .16317 | .00031 | 0.00000 |
| 92 | .15591 | .02616 | .17015 | -.12022 | -.00469 |
| 93 | .17814 | .03372 | .15493 | -.00892 | -.00034 |
| 94 | .32852 | .03886 | .17834 | 0.00000 | 0.00000 |
| 95 | .42404 | .04833 | .22228 | 0.00000 | 0.00000 |
| 96 | .16635 | .12755 | .36581 | .00686 | 0.00000 |
| 97 | .26913 | .01037 | .15298 | .00016 | 0.00000 |
| 98 | .07981 | .05658 | .08209 | 0.00000 | 0.00000 |
| 99 | .35163 | .14011 | .15648 | .00034 | -.00001 |
| 100 | .34575 | .04019 | .11588 | .00172 | -.00011 |
| 101 | .01272 | .16119 | .56463 | .00000 | 0.00000 |
| 102 | .29414 | .01346 | .24307 | .00001 | -.00030 |
| 103 | .26057 | .00733 | .22404 | .00011 | 0.00000 |
| 104 | .14843 | .01390 | .27874 | .00258 | 0.00000 |
| 105 | .29816 | .07632 | .14611 | .00704 | 0.00000 |
| 106 | .42121 | .00505 | .20856 | .00006 | 0.00000 |
| 107 | .84455 | .00869 | -.07564 | .04779 | 0.00000 |
| 108 | .17235 | 0.00000 | .36927 | .00002 | 0.00000 |
| 109 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| 110 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |

## Table 11

## 1985 I-O Prices

| Sector | I-O Price ($/10^6 Btu, $/$) | VA Purchases (1967 $) | VA Coefficients ($/10^6 Btu, $/$) |
|---|---|---|---|
| 1 | .556666 | 8.527281 | .393359 |
| 2 | 1.221125 | 42.326566 | 1.010808 |
| 3 | 1.389920 | .417540 | 1.389295 |
| 4 | 2.074875 | .265813 | 1.271835 |
| 5 | 2.110378 | 0.000000 | 0.000000 |
| 6 | 1.590923 | .400611 | .011214 |
| 7 | 1.713821 | 8.288754 | .465186 |
| 8 | 6.204063 | 0.000000 | 0.000000 |
| 9 | 5.427907 | 20.254657 | 2.939014 |
| 10 | 5.419400 | 9.254337 | 3.404857 |
| 11 | 3.777156 | 0.000000 | 0.000000 |
| 12 | 5.417436 | 7.119909 | 4.970595 |
| 13 | 2.331113 | 0.000000 | 0.000000 |
| 14 | 1.578291 | 0.000000 | 0.000000 |
| 15 | 6.120090 | 0.000000 | 0.000000 |
| 16 | 3.438240 | 0.000000 | 0.000000 |
| 17 | 3.948706 | 0.000000 | 0.000000 |
| 18 | 3.498929 | 0.000000 | 0.000000 |
| 19 | 1.505854 | 0.000000 | 0.000000 |
| 20 | 5.584859 | 0.000000 | 0.000000 |
| 21 | .914037 | 12.291726 | .242313 |
| 22 | .914130 | 20.437671 | .449921 |
| 23 | .946810 | 1.899460 | .563307 |
| 24 | .920355 | 2.281691 | .545877 |
| 25 | .933511 | 1.051892 | .360156 |
| 26 | .969434 | 1.277916 | .419611 |
| 27 | .886477 | 1.903473 | .480721 |
| 28 | 1.034226 | .889223 | .525519 |
| 29 | .864306 | 13.425838 | .311684 |
| 30 | .858529 | 19.088026 | .296942 |
| 31 | .858915 | 9.131177 | .293459 |
| 32 | .840754 | 2.316304 | .365172 |
| 33 | .841681 | 3.325569 | .390718 |
| 34 | .855399 | 4.836381 | .412505 |
| 35 | .817226 | 14.912234 | .469109 |
| 36 | .780157 | 2.253185 | .315841 |
| 37 | .873298 | 32.676724 | .229308 |
| 38 | .924974 | 4.481250 | .454479 |
| 39 | .854952 | 6.099558 | .226850 |
| 40 | .844049 | 1.842465 | .230728 |
| 41 | .803620 | 9.786916 | .269851 |
| 42 | .827944 | 1.636411 | .218526 |
| 43 | .829623 | 7.203975 | .300523 |
| 44 | .762677 | .235436 | .257372 |
| 45 | .825704 | 2.865716 | .344428 |
| 46 | .803095 | 1.578547 | .328987 |
| 47 | .905873 | 9.091883 | .292686 |
| 48 | .834272 | 2.842266 | .257472 |
| 49 | .838769 | 15.257573 | .385574 |
| 50 | .984745 | 13.079827 | .280156 |
| 51 | .874457 | 3.005396 | .181154 |
| 52 | .859616 | 9.123587 | .303658 |
| 53 | .864414 | 1.377828 | .258632 |
| 54 | 1.187365 | .146999 | .166328 |
| 55 | 1.104601 | .150726 | .135950 |
| 56 | .807947 | 8.726616 | .324410 |
| 57 | .912231 | .378458 | .303060 |
| 58 | .873745 | 1.758786 | .376370 |
| 59 | .855311 | 2.683872 | .407785 |
| 60 | .920684 | 6.934955 | .337747 |
| 61 | .941540 | 20.026623 | .354109 |
| 62 | .957327 | 10.865559 | .271112 |
| 63 | .854420 | 1.419578 | .246182 |
| 64 | .869608 | 7.726779 | .293677 |
| 65 | .833956 | 5.305999 | .332066 |
| 66 | .871954 | 8.592424 | .369536 |
| 67 | .836616 | 2.374897 | .279670 |
| 68 | .826643 | 1.475864 | .271448 |
| 69 | .886405 | 3.692585 | .375440 |
| 70 | .821911 | 1.670048 | .295900 |
| 71 | .797058 | 4.596747 | .382860 |
| 72 | .758225 | 2.815554 | .281352 |
| 73 | .798699 | 4.217924 | .318623 |
| 74 | .818607 | 2.653384 | .425407 |
| 75 | .820922 | 5.089030 | .339218 |
| 76 | .853908 | 2.846899 | .265070 |
| 77 | .794790 | 5.714161 | .332031 |
| 78 | .809908 | 2.821759 | .241128 |
| 79 | .826394 | 3.057132 | .358173 |
| 80 | .697498 | 6.879829 | .274627 |
| 81 | .730725 | 3.883559 | .278045 |
| 82 | .879273 | 1.952606 | .365419 |
| 83 | .816331 | 19.682601 | .229704 |
| 84 | .763052 | 5.676816 | .296387 |
| 85 | .872976 | 5.723497 | .324240 |
| 86 | .762481 | 2.752403 | .284863 |
| 87 | .867684 | 4.168745 | .499032 |
| 88 | .761797 | 5.046531 | .287625 |
| 89 | .733435 | 9.523890 | .397170 |
| 90 | .841659 | 3.972853 | .497141 |
| 91 | .728946 | 13.811430 | .415941 |
| 92 | .819483 | 1.459215 | .177306 |
| 93 | .793221 | 5.718230 | .357529 |
| 94 | .849113 | .861888 | .545714 |
| 95 | .844427 | 1.794800 | .694644 |
| 96 | .813606 | 27.292223 | .666572 |
| 97 | .907181 | 2.568763 | .432632 |
| 98 | .964672 | 1.193263 | .218470 |
| 99 | 907242 | 195.343915 | .648555 |
| 100 | .901485 | 45.262413 | .503431 |
| 101 | .963368 | 158.759641 | .738547 |
| 102 | .941203 | 19.318484 | .550379 |
| 103 | .918468 | 50.245762 | .492049 |
| 104 | .837360 | 10.909700 | .443671 |
| 105 | .973530 | 7.876714 | .527631 |
| 106 | .916613 | 64.176126 | .634886 |
| 107 | 1.024175 | 11.906039 | .825390 |
| 108 | .968342 | 5.959573 | .541630 |
| 109 | .855805 | 0.000000 | 0.000000 |
| 110 | .845763 | 0.000000 | 0.000000 |

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