Appendix

Appendix on Data and Methods

Input-Output Analysis

Much of the analysis that appears in chapters 4, 5, 7, and 10 is based on input-output calculations. The following discussion will briefly review input-output methods, focusing on techniques employed in this study that may be unfamiliar. For a comprehensive treatment of the theory behind input-output analysis see the recent text by Miller and Blair.[1] A description of the mechanics involved in constructing input-output tables and the underlying mathematical derivation are contained in a report published by the Department of Commerce.[2]

The analysis actually employed in the input-output calculations presented in this report used 85 business sectors. Detail is available on 537 business types for the "benchmark" years in which the quinquennial census of industries is conducted.[3] Unfortunately the last "benchmark" for which data are available is 1977. The Department of Commerce has updated the 85-sector data to 1981 using annual survey data that are much less comprehensive than the census data.[4]

The "Use" Table

The heart of input-output data is the "use" table. The columns of this table show the value of each commodity *used* in a given year by producers in each type of industry.[5] Matrix element U(i,j) shows the value of commodity i **used by** industry j for i and j = i to 85. Data are also provided on the total value of industry and commodity output and the value-added by each industry.

The 1977 table shows, for example, that the motor vehicles and equipment manufacturing industry (j=59) produced output whose total value was $117.7 billion. This output was created by purchasing $84 billion in commodities from other businesses, and adding $33.7 billion in value in industry 59 itself. The columns of the use table indicate the amounts of each type of commodity purchased by the industry. For example, in 1977 the motor vehicle industry purchased $2.3 billion worth of miscellaneous fabricated textile products (i= 19), and $5.0 billion of rubber and miscellaneous plastic products (i = 32).

The use of different commodities by the various industries can be expressed as a series of linear equations using the following variable names: call the total value of the output of industry j, X(j), and the value-added by industry j, VA(j).[6] The fact that the value of industry output is equal to the value of commodities purchased as inputs plus the value-added by the industry can be written as follows:

$$X(j) = \sum_{i=1}^{85} U(i,j) + VA(j) \qquad (1)$$

The total output for a particular commodity in the economy is equal to the sum of the deliveries of a commodity to all industries in the economy plus any deliveries to final demand. Hence, if Y(i) is defined to be the sales for commodity i, and Q(i) the total output of commodity i in the economy, we can write this accounting equation in the following form:

$$Q(i) = \sum_{j=1} U(i,j) + Y(i) \qquad (2)$$

The sum extends only from j = 1 to 79 since at the 85-sector level, only the first 79 industries use intermediate inputs from domestic industries. The remaining 6 industries are: Noncomparable imports [j =80], Scrap, Used, and secondhand goods [j=81], Government Industry [j=82], Rest of the world industry [j =83], Household industry [j =84], and Inventory valuation adjustment [j =85]. All elements of U(i,j) are zero for i =82 to 85 and for j =80 to 85.

Final Demand (Y(i)) is divided into five components[7]

$$Y(i) = C(i)+ GPFI(i)+INV(i)+ EXP(i)-IMP(i) \qquad (3)$$

where

C(i) = commodity i purchased as final demand by consumers and the government
GPF1(i) = commodity i purchased as gross private fixed investment
INV(i) = inventory change in commodity i
EXP(i) = exports of commodity i
IMP(i) = imports of commodity i

1 Ronald E. Miller and Peter D. Blair, *Input-Output Analysis* (Englewood Cliffs, NJ: Prentice-Hall), 1985. For further reading, see Wassily Leontief, *Input-Output Economics* (New York, NY: Oxford Press, 1966); and Alpha C. Chaing, *Fundamental Methods of Mathematical Economics* (New York, NY: McGraw-Hill, 1974).

2 Philip M. Ritz, "Definitions and Conventions of the 1972 Input-Output Study," Department of Commerce, Bureau of Economic Analysis, Staff Paper, BEA-SP 80-034, July 1980.

3 See for example, U.S. Department of Commerce, Bureau of Economic Analysis, The Detailed *input-Output Structure of the U.S. Economy, 1977, 1984.*

4 Mark A. Planting, "Input-Output Accounts of the U S. Economy, 1981 ," *Survey of Current Business,* January 1987. The 1980 revision was the latest available for most of the calculations presented in the text.

5 The use table is shown as table 1 in the "Input-Output Structure of the U.S. Economy, 1977," U.S. Department of Commerce, Bureau of Economic Analysis, Survey *of Current Business, vol. 64, No. 5,* May 1984, p. 52

6 The following calculations will use a notation that differs from standard input/output notation. The object of the present discussion is to provide a clear, and quick description of the analysis for the lay reader The variable names were chosen as mnemonics in order to obviate memorizing numerous unfamiliar variables that will only be used once, Standard notation will be indicated in the notes. For example, most works use W to represent value-added.

7 In conventional notation: C = commodity purchased as final demand by consumers, G = commodity purchased as final demand by the government, J = commodity purchased as gross private fixed investment, N = inventory change in commodity, E = exports of commodity, M = imports of commodity.

For simplicity, the effects of inventory change are not included in the following discussion and the variable INV is not used.[8]

The "Make" *Table*

Calculations are complicated by the fact that some commodities are made by more than one industry. In 1977, for example, only $50.7 billion of the $63.2 billion worth of Chemicals and selected chemical products (commodity #27) were made by the Chemicals and selected products industries (industry #27) the remainder being produced by other industries. Petroleum refining and related industries produced $6.9 billion worth of commodity #27.

In input-output analysis, the table used to account for secondary production in an economy is called a "make" table written in matrix form as M(i,j).[9] The columns of the make show the commodities j produced by industry i. The diagonal elements of the table show the primary products of industries, while the off-diagonal elements are the secondary products. The make matrix includes all commodity output (including deliveries to final demand), and all industry output. These accounting relationships can be written as follows:

$$Q(j) = \sum_{i=1}^{85} M(i,j)$$

The make table is created by collecting data on individual establishments within an industry category. The output of each establishment is assigned to a single commodity class. In practice, of course, many establishments make more than one product (sometimes referred to as secondary production). The output of each establishment is assigned to the commodity type representing the largest fraction of its output. Most establishments producing more than one commodity produce items that all fall into only one of 85 possible commodity classifications. As firms expand the scope of their production, however, this may be an increasingly tenuous assumption (see ch. 5).

Correcting for Scrap

By convention, each industry is permitted to make "scrap" in addition to other commodities. Call the amount of scrap produced by industry S(i). The total output of an industry can then be written as the sum of commodities 1 to 79 it produces plus scrap. The equation is as follows:

$$X(i) = \sum_{j=1}^{79} M(i,j) + S(i) \qquad (4)$$

The available data can be used to calculate the fraction of all industrial output produced as scrap [S(i) /X(i)] and the fraction of commodity i produced by industry j IM(i,j)/Q(j)].[10] As a result, equation (4) can be rewritten as follows:

$$X(i) = 1/(1-S'(i)] * \sum_{j=1} [M(i,j)/Q(j)] * Q(j) \qquad (5)$$

Where S'(i) = S(i)/X(i).

Shifting to vector notation, let X be a 79-element vector representing industry output, Q be a 79-element vector representing commodity output, Y be a 79-element vector representing the first 79 elements of final demand.[11] The 79x79 matrices U' and M' are defined as follows in their normalized form:[12]

$$U'(i,j) = U(i,j)/X(j) \qquad (6)$$

$$M'(i,j) = [1/(1-S'(i))] * [M(i,j)/Q(j)] \qquad (7)$$

Notice that these equations make two major assumptions that lie at the core of input-output calculations and make it mathematically possible to describe the behavior of a highly linked economy:

1. *Industry inputs change in direct proportion to industry output.*
11. *The fraction of a commodity produced by each industry (including the fraction of output counted as scrap) remains fixed.*

Equation (4) can be rewritten in the new notation to provide a convenient bridge between industry output and commodity output:

$$\mathbf{X} = \mathbf{M'} * \mathbf{Q} \qquad (8)$$

The normalized matrices U' and M' can be used to rewrite equation (2) as follows:

$$Q = U'*X + Y$$

$$Q = \mathbf{U'*M'*Q} + \mathbf{Y}$$

or

$$Q = A*Q + Y \qquad (9)$$

Where $\mathbf{A} = \mathbf{U'} * \mathbf{M'}$ is Leontief's original "transactions" matrix whose jth column shows the value of a commodity needed to make a dollar's worth of commodity output. The **A** matrix was shown in summary form in table 4-2.

Constructing the Basic Equation

Equation (9), the key equation of input-output analysis, is equivalent to 79 coupled linear equations. It's solution allows an estimate of the total output of a commodity (or industry) created by any pattern of final

'For most purposes, changes in inventories can be treated exactly as changes in C.

9 The "make" table is shown in table 2 in the article cited in footnote 1.

10 The scrap produced by each industry is shown in columns **#81 of the Make table—Table 2** in the Department of Commerce publication cited in footnote 1.

11 In this discussion vectors and matrices are represented in BOLD type. Matrix multiplication is indicated using the character • also used to indicate scalar multiplication (i.e. the product of two vectors G and **H** could be written as the sum over i of Cl(i) *H(i) or as **G* H.)**

12In **Conventional** notation **U'** is **called B (the matrix of "technical coefficients") and M' is called D (the matrix of "commodity output proportions")** demand. Making the key assumptions of linearity described earlier, a solution to (9) can be written as follows:

$$Q = @A)^{-1} . Y \qquad (l0)$$

Industry output can be calculated using equation (8) to convert commodity output to industry output:

$$X = M' *(l-A)^{-1} * Y \qquad (11)$$

Including Capital Goods in the Transactions Table

The matrix **U** used in the construction of equation (6) does not include any purchases of capital equipment. Capital equipment purchases are included as a part of final demand (see equation (3)). Ultimately, of course, the purchase of capital goods depends on the size and growth rates of different types of industries. A fully dynamic model can include these effects. It is possible, however, to make a third simplifying assumption and include annual capital purchases of each industry as a part of an expanded transactions table. The assumption is:

III. lndustry purchases *of gross private fixed investment are in direct proportion to industry output.*

This assumption can be put to use given the gross private fixed investment in commodity type i purchased by industry j. Call this matrix CAPITAL(i,j). Data for CAPITAL(i,j) are available for the input-output benchmark years.[14] Call this benchmark matrix $CAPITAL_b(i,j)$. The data, available for the benchmark years, can be updated given information about gross private fixed investment by commodity (GPFl(i)) in any given year. One component of GPFI, residential structures, is not incorporated into the transactions table because it is not an input into a businesses production process. This updating procedure makes the assumption that the share of a particular capital good used by the various industries has not changed from the benchmark year used and it makes no effort to distinguish between capital purchased for replacement and capital used for expansion.

The matrix $CAPITAL_b(i,j)$ can then be used to create a new transactions matrix **A”** that includes intermediate inputs and gross private fixed investments. The matrix **A“** can be defined as follows:

$$A''(i,j) = A(i,j)$$

$$+ [CAPITAL_b(i,j)/X(j)]*[GPFI(i)/(\sum_{k=1} CAPITAL_b(i,k))]$$

It should be noted that capital coefficients tend to be much less stable than the technical coefficients. Equation (9) can then be rewritten as follows:

$$Q = (I-A'')^{-1} * (C + EXP - IMP) \qquad (12)$$

Where domestic final demand, inventory changes, exports, and imports have been written as 79-element vectors.

Adjusting for the Effects of Trade

The use table appearing in equation(1) shows the commodities needed as inputs to an industry’s production process without regard to whether they were produced by a domestic industry or purchased from abroad. Similarly, no distinction is made between the consumer or government purchases of foreign and domestic products. Unfortunately no data is available to distinguish between foreign and domestic products in either the use table or in consumer and government purchases, It is possible to explore situations where imports have penetrated different proportions of U.S. markets by making a fourth simplifying assumption:

IV. The fraction of a given commodity supplied by imports is the same for each industry. The fraction also represents the imported proportion of all consumer and government purchases.

Let the fraction of a commodity i supplied by domestic producers (eg. the fraction imported) be called R(i). These ratios can be computed from equation (9) imports of commodity i used as intermediate demand and imports of commodity i purchased by consumers and by the government must combine to total total imports IMP(i). Using the notation of equation (9),

$$IMP(i) = \sum_{j=1} A''(i,j)*Q(j)*R(i) + C(i)*R(i) \qquad (13)$$

rearranging:

$$R(i) = IMP(i)/[\sum_{j=1} A''(i,j)*Q(j) + C(i)] \qquad (14)$$

This ratio can now be used to remove imports from equation (11).[15] The resulting equations effectively treat all imports as noncomparable imports which are not included in transactions. The domestic part of the transactions matrix can be written as A''_d, and the domestic part of final consumer and government consumption as C_d defined as follows:

13 See Wassily Leontief and Faye Duchin, *The Impacts of Automation on Employment /9&’–2000,* Institute for Economic Analysis, under contract to the National Science Foundation. Contract #PRA-8012844, April 1984, for an example of a dynamic model.

14 Gerald Silverstein, “New Structures and Equipment by Using Industry, 1977,” *Survey of Current Business,* November 1985; and Peter B Coughlin, “New Structures and Equipment by Using Industry, 1972, ” *Survey of Current* Business, July **1980.**

15 For other analyses that use this trade adjustment method see Kan Young, Ann Lawson, and Jennifer Duncan, “Trade Ripples Across U.S. Industries, ” Working Paper, U S. Department of Commerce, Office of Business's Analysis, January 1986, and Charles F. Stone and Isabel Sawhill, “Labor Market Implication of the Growing internationalization **of the U.S. Economy,” paper** for the National Commission for Employment Policy, Contract #J-9-M-5-0040, February 1986

$$A''_d(i,j) = (1-R(i)) * A''(i,j) \qquad (15)$$
$$C_d(i) = (1-R(i)) * C(i) \qquad (16)$$

Using equations (14) through (16) in (1) an equation can be written that includes only domestic inputs and the part of consumer and government demand met from domestic producers:

$$Q = (I-A''_d)^{-1} * (C_d + EXP) \qquad (17)$$
$$X = M' * (I-A''_d)^{-1} * (C_d + EXP)$$

Equation (8) has again been **used** to convert commodities Q to industry output X.

Equation (17) can now be used to explore the effects of different patterns of trade. For example the calculations presented in chapter 7 were computed using the following techniques:

- An economy with no imports can be constructed by holding EXP(i) constant and setting R(i)=0 for all i.
- An economy with no exports can be constructed by holding R(i) constant and setting EXP(i)=0 for all i.
- An economy with no trade can be constructed by setting R(i)= EXP(i)=0 for all i.

Notice that the total amount of domestic production is different in each case.

When an attempt is made to show what would happen if, for example, 1984 trading patterns applied in 1972, ratios similar to R(i) can be **computed** for both imports and exports and used to construct an equation similar to (14) except that only consumer and government purchases remain as final demand. This was done in the calculations of chapter 5. The impact of changes in final demand on industry output X could be computed by altering C, changes in producer recipes could be considered by changing **A"**, and changes in trade by changing R(i) (and an equivalent set of ratios for exports).

One final complication must be introduced. Using standard BEA conventions, tariffs levied against imports are counted as a part of the imports of wholesale and retail trade (i =69) and transportation and warehousing (i =65), resulting in a postive import figure for those two commodities. Imports are normally reported as a negative component of final demand. In most cases the ratios R(i) for these two commodities are not set to O when a "no import" cases are considered, eliminating any effect caused by changing levels of duties on value-added or jobs.

The ratios calculated for the case when the transactions matrix is adjusted for both imports and exports, are shown in table A-1 for the years 1972, 1977, 1980, and 1984.

Adjusting for Inflation

As the discussion of chapters 4 and 5 point out, an analysis of structural change which is not sensetive to price effects requires a way to convert equations like (17) into

Table A-1.-Import and Export Penetration of Domestic Consumption (R(i))

I-O industry number	1972	1977	1980	1984
1	0.99638	0.99668	0.99732	0.99711
2	1,13763	1.22197	1,36148	1.35224
3	0.68196	0.82617	0,85170	0.61239
4	1.00411	1.00238	1.00357	1.00264
5	0.71468	0.72308	0,97932	0.93621
6	0.85251	0.85694	0.81841	0.80827
7	1.10012	1.13734	1,17189	1.17266
8	0.85830	0.55526	0.64179	0.73057
9	0.97033	0.97905	1.00394	1.01465
10	0.96660	0.99811	0,99023	0.88700
11	1.00008	1.00000	1.00002	1.00000
12	1.00016	1.00035	1.00032	1.00035
13	1.03645	1.19322	1.12094	1.08519
14	0.98373	0.99458	0,99783	0.99123
15	1.09075	1.12184	1.13420	1.05530
16	0.97380	1.00279	1.02382	0.94681
17	0.93414	0.99347	1.03886	0.94244
18	0.92693	0.88988	0.87163	0.76981
19	0.99465	1.00835	1,01180	0.95152
20	0.94652	0.95999	0.99217	0.94942
21	0.99782	0.94497	0.95938	0.98778
22	0.97538	0.97392	0.97693	0.96688
23	0.97440	0.97317	0.95769	0.89611
24	0,95912	0.95990	0,97810	0.95551
25	1.00341	1.01286	1,00956	1.00468
26	1.00815	1.01085	1.01345	1.02135
27	1.03750	1.03102	1.05875	1.07061
28	1.04874	1.05883	1.12547	1.08509
29	1,02309	1.01285	1.00386	1,02106
30	1,01916	1.02558	1.02828	1.01920
31	0.93417	0.91723	0.93132	0.91806
32	0.97348	0.97559	0.98605	0.96655
33	0.92430	0.99445	1.03125	0.93547
34	0.81517	0.72191	0.68944	0.49741
35	0.97748	1.00395	1.01164	0.95776
36	0.97576	0.97548	0.97220	0.95647
37	0.92915	0.91808	0,93415	0.88598
38	0.92932	0.92639	0.97582	0.85358
39	1,00210	1.00277	1.00909	0.99759
40	1.01587	1.03349	1.03204	1.01474
41	1.02922	1.02255	1.02332	1.01848
42	0.98350	0.98984	0.98410	0.95595
43	1.08907	1.16325	1.13442	1.04763
44	1.00256	1.01627	0,99853	0.99282
45	1.30584	1.26968	1.39385	1.21651
46	1.02528	1.04767	1.05790	0.97490
47	1.03972	1.00981	0.98710	0.95082
48	1,04678	1.14341	1.09642	0.92172
49	1.04430	1.07955	1.05441	0.98087
50	1.01635	1.00774	1.01349	1.04215
51	1.12892	1.13879	1.20961	1.03667
52	1.05915	1.09862	1.12053	1.05859
53	1.02810	1.03293	1.09864	1.04475
54	0.95881	0.97119	0.99456	0.93552
55	1.01201	1,02757	0.96785	0.98016
56	0.91533	0.89801	0.93408	0.81497
57	1.05319	1.01658	1.01127	0.88130
58	0.99511	1.01121	1.00079	0.98615
59	0.93747	0.94131	0.87614	0.80553
60	1.17626	1.34053	1.27526	1.15410
61	0.92683	0.98572	0.97620	0.96223

Table A.1.—Import and Export Penetration of Domestic Consumption (R(i))–(Continued)

I-0 industry number	1972	1977	1980	1984
62	1.04763	1,04451	1.02127	1.01192
63	1.00619	0.98295	1.00607	0.93225
64 ...,.,,,	0.91194	0.88240	0.86642	0.73565
65 .., ,...,	1.05597	1.07930	1.08638	1.08062
66	1.01285	1.01899	1.02057	1.02866
67 . . .	1.00000	1.00000	1.00000	1.00000
68 .. ...,,,	0.99565	0.98453	0.97851	0.98173
69	1.03358	1.04830	1,06149	1.05060
70 ,,, ,,,..	1.00116	1.00083	1.00149	1.00157
71 ...,.,,	1.01177	1.01345	1.01468	1.01489
72 .. .,,...	1.00013	1,00062	1.00061	1.00096
73 ,,, ,,,,,	1.00949	1.02132	1.01796	1.02743
74 ,, ...,	1.00000	1.00092	1.00083	1.00157
75 .. .,..,.	1.00000	0.99979	0.99981	0.99972
76	1.03465	1.01681	1.02182	1.02022
77 .. ....,,	1.00027	1.00046	1.00034	1.00049
78 ,, .,....	1.01485	1.01375	1.00385	1.01553
79 .. .,...,	1.00000	1.00010	1.00014	1.00016
80	0.00000	0.00002	0.00000	–0.78546
81	0.87134	2.35374	–3.12859	0.89780
82	1.00000	1.00000	1.00000	1.00000
83	–1.85569	–3.11294	–4.06765	–1.80829
84 . .	1.00000	1.00000	1.00000	1.00000
85	1.00000	1.00000	1.00000	1.00000

constant dollars.[16] Most of the data used in this analysis are expressed in 1980 dollars because of the extensive use of the 1980 input-output table as an endpoint. The calculation of constant dollar industry output or value-added can be done by defining C80(i) to be the consumer and government demand for product i expressed in constant 1980 dollars, and U80(i,j) to be the use matrix in constant dollars. They can be computed as follows:

$$C80(i) = P(i)*C80(i)$$
$$U80(iJ = u(iJ)*\ P(i)$$

Using the definition in equation(6)

$$U80'(i,j) = u80(ij)/x80(j) = U'(i,j)*P(i)/P(j) \quad (18)$$

Assuming that the deflator for an industry's scrap is the same as the deflator for the entire industry the matrix M' is unaffected by the deflation process since it involves ratios of identical commodities. As a result, a 1980 based A matrix can be calculated as follows:

$$A80(i,j) = A80'*M'$$
$$A80(i,j) = A(i,j)*P(i)/P(j) \quad (19)$$

Equation (18) can also be used to compute a deflated value-added using equation (1)[17].

$$VA(j) = X(j) - \sum_{i=1}^{85} U(i,j)$$

$$VA80(j) = X(j)*P(j) - \sum_{i=1}^{85} U(i,j)*P(i) \quad (20)$$

Equation (20) provides a way to construct a deflated value for value-added given deflators for the products of each industry. Because it involves deflating both the gross output, X(j), and the intermediate inputs, U(i,j), it is called "double-defaltion." The process is considered a "preferred method" when all relevant data is available.[18] As the discussion of chapter 5 points out, however, it is often necessary to use other methods to compute deflators for value-added. Arguments about the ratio of deflated manufacturing value-added to the sum of all value-added in the economy (the GNP) hinge on disputes about the validity of these alternative methods.

While the logic of the deflation process just described may be clear, two problems must be overcome to put it to practical use. The first problem results from the fact that deflators for the 85-level input-output industries are not published as a consistent time series. The Bureau of Labor Statistics compiles such a series, but the deflators are for 156 industries and are based on gross output (the value of shipments).[19] Using them in equations **18-20** requires an aggregation for some to the 85 BEA input-output industries using current dollar value of their gross output.[20]

A second problem results from using domestic price deflators to adjust input-output tables when many intermediate inputs are imported. The Producer Price Index that forms the basis for industry deflators is based on

[16] For additional examples of deflating input-output matrices, see Wassily Leontief and Faye Duchin, *The Impacts of Automation on Employment 1963—2000*, op. cit., p. 3.18; and Anne P. Carter, Structural Change *in the American Economy* (Boston, MA: Harvard University Press, 1970), p. 21

[17] Equation (20) makes the implicit assumption that deflators for industry and deflators for commodities are identical. For simplicity, this assumption is frequently used in practice. The error introduced by using industry deflators for commodities can be estimated by using the make matrix to convert commodity deflators to industry deflators. If the industry deflator is called P' The deflator for industries 1-79 are computed as follows:

$$P'(j) = \sum^{79} M(j,k)*P(k) / \sum_{k-1}^{79} M(j,k)$$

The procedure reveals that errors of were close to 3 percent in only 4 of 85 industries—most prove to be very small. Attempting to use the make matrix to compute commodity deflators from industry deflators and vice versa introduces an additional uncertainty because the make matrix is only updated infrequently. As a result, estimation of P' contains errors whose size is difficult to estimate except when benchmark years are compared.

[18] Milo F. Peterson, "Gross Product by Industry, 1986, " *Survey* of *Current Business*, April 1987, pp. 25-27.

[19] See Valerie A. Personick, *Methodology for Time Series Data on Industry, Output, Price and Employment*, unpublished Bulletin, Bureau of Labor Statistics, Office of Economic Growth and Employment Projections, fall 1987; and "Time Series Data Base for Input-Output Industries, " unpublished, Bureau of Labor Statistics, Office of Economic Growth and Employment Projections, June 1985.

[20] See "BLS Economic Growth Model System Used for Projections to 1990, " Bulletin 2112, April 1983, app. F,

changes in domestic prices.[21] Using domestic deflators obviously leads to an error under conditions of disequilibrium when the price of foreign goods may be changing at different rates than the price of domestic goods. The error can be reduced by removing imported products from the transactions table using methods described in equations 13-16.

Converting Industry Output to an Estimate of Employment

Equation (13) allows an estimate of output given assumptions about demand (Y), producer recipes (A), and trade (R(i), and EXP(i)). The estimates of output X can be converted to estimates of employment for each industry and occupation through use of a matrix which shows the number of jobs in occupation category k available in industry i. Call this matrix L(k,i). The number of jobs in occupation category k are represented by OCC(k) and computed from L as follows:

$$OCC = L*X \qquad (21)$$

The occupation by industry matrix L is available for the year 1984 from the Bureau of Labor Statistics.** It provides data on approximately 679 occupations and 331 industries. Self employed persons are not included in the basic data. Data is available, however, on the total number of self employed persons by occupation.[23] When it is necessary to include self-employed persons, elements of the matrix L are increased under the assumption that the percentage of people in an occupation that are self employed does not depend on the industry in which they work. That is, if 10 percent of all machine operators are self employed, 10 percent of all machine workers in the metal container industry are self employed. If the total number of self employed persons in an occupation SEL(k) are known, a labor matrix including self employment can be constructed as follows:

$$L'(k,i) = L(k,i) * [1 + SEL(k)/ \sum_{i=1}^{i=85} L(k,i)]$$

Collapsing the 331 BLS industries to BEA's 85 allows the construction of a crude measure of labor productivity by simply dividing total industry output by total industry employment.[24]

$$PROD(i) = X(i)/ \sum_{k=1}^{k=679} L'(k,i)$$

A matrix L" that keeps staffing patterns the same with in industry but increases productivity (equivalent to an assumption that the productivity of all occupations in the industry increase by the same percentage) can be computed as follows:

$$L''(k,i) = L'(k,i)* [OLD\ PROD\ (i)]/[NEW\ PROD\ (i)]$$

Converting to 10 Indusries and 16 Occupations

Since 79 categories of commodities and industries could not be conveniently displayed in the text, the results of the 79-industry calculations were summarized using ten business sectors. Their relationship to the standard input-output industry categories is shown in table A-2.

Since 679 occupation categories are clearly also unmanageable, the occupation data was compressed to show 45 occupation categories for most calculations. These 45 occupation categories can in turn be reduced to 16 or 11 categories. The 16 category aggregation is used whenever possible since it provides somewhat better detail on occupations of interest to this study. The 11 category set is used when it is necessary to be consistent with some historical BLS series. Table A-3 provides a map showing how the three categories are related.

Constructing Demand Scenarios

The analysis described in the text is built from a series of models. Scenarios are created in the following steps:

1. Estimating U.S. population by age and sex.
2. Estimating numbers of households by type and by income.
3. Estimating spending patterns by households of different types and incomes.
4. Estimating the demand for the output of the business categories for which input-output data is available.
5. Estimating the output of different businesses that result from domestic demand.
6. Estimating how trade affects the output of businesses by business category.
7. Estimating the employment created in different business categories given estimates of yearly output and industry productivity}'.
8. Estimating jobs by occupations.

Each of these steps provides techniques for understanding trends during the past few decades, which can be used as the basis for constructing estimates about the future that were described in the input-output section appear-

21 See Andrew G Clem and William D. Thomas, "New Weight Structure being Used in Producer Price Index," *Monthly Labor Review*, August 1987, and Elizabeth Gibbons and Gerald F Halpin, "Import Price Delines in 1986 Reflected Reduced 011 Prices, " *Monthly Labor Review,* April 1987

22 "1984 Industry by Occupation Matrix," Bureau of Labor Statistics, Office of Economic Growth and Employment Projections, unpublished, June 1985

23 "'Total Employment by Occupation, 1984 and 1995 Projected," Bureau of Labor Statistics, Office of Economic Growth and Employment Projections, unpublished, June 1985

24 Use of US Department of Labor, Bureau of Labor Statistisc, "BLS Input-Output Industry Sectors, " unpublished, and U S Department of Commerce, Bureau of Economic Analysis, "Appendix B Industry Classification of the 1977 input-output Tables," Survey of Current Business, vol 64, No. 5, May 1984, p. 80.

Table A-2.—Grouping the 79 Input-Output Industries Into 10 Summary Sectors

Natural Resource Intensive Production
1. Livestock and livestock products
2. Other agricultural products
3. Forestry and fishery products
4. Agricultural, forestry, and fishery services
5. Iron and ferroalloy ores mining
6. Nonferrous metal ores mining, except copper
7. Coal mining
8. Crude petroleum and natural gas
9. Stone and clay mining and quarrying
10. Chemical and fertilizer mineral mining

Construction
11. New Construction
12. Maintenance and repair construction

Low Wage Manufacturing[a]
16. Broad and narrow fabrics, yarn, and thread mills
17. Miscellaneous textile goods and floor coverings
18. Apparel
19. Miscellaneous fabricated textile products
20. Lumber and wood products, except containers
21. Wood containers
22. Household furniture
23. Other furniture and fixtures
32. Rubber and miscellaneous plastic products
33. Leather tanning and finishing
34. Footwear and other leather products
64. Miscellaneous manufacturing

Medium Wage Manufacturing
14. Food and kindred Products
26. Printing and publishing
36. Stone and clay products
40. Heating, plumbing, and structural metal products
41. Screw machine products and stampings
42. Other fabricated metal products
44. Farm and garden machinery
47. Metal working machinery and equipment
49. General industrial machinery and equipment
50. Miscellaneous machinery, except electrical
51. Office, computing, and accounting machines
52. Service industry machines
53. Electrical industrial equipment and apparatus
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
62. Scientific and controlling instruments
63. Optical, ophthalmic, and photographic equipment

High Wage Manufacturing
13. Ordinance and accessories
15. Tobacco manufacturers
24. Paper and allied products, except containers
25. Paperboard containers and boxes
27. Chemicals and selected chemical products
28. Plastic materials and synthetic materials
29. Drugs, cleaning, and toilet preparations
30. Paints and allied products
31. Petroleum refining and related industries
35. Glass and glass products
37. Primary iron and steel manufacturing
38. Primary nonferrous metals manufacturing
39. Metal containers
43. Engines and turbines
45. Construction and mining machinery
46. Materials handling machinery and equipment
48. Special industry machinery and equipment
59. Motor vehicles and equipment
60. Aircraft and parts
61. Other transportation equipment

Transportation and Trade
65. Transportation and warehousing
68. Electric, gas, water, and sanitary services
69. Wholesale and retail trade
74. Eating and drinking places

Transactional Activities
66. Communications, except radio and television
67. Radio and TV broadcasting
70, Finance and insurance
71. Real estate and rental
73. Business services

Personal Services
72. Hotels: personal and repair services (exe. auto)
75. Automobile repair and services
76. Amusements
84. Household Industry

Social Services
77. Health, education, & social services
78. Federal government enterprises
79. State and local government enterprises
82. Government industry n.e.c., excluding defense

Defense
82. Government industry, defense only

[a]1984 Wages and Salaries per Full-Time Equivalent Employee by Industry (NIPA Table 6.4B and 6.7B) were ranked and divided into 3 groups of 7 Industries each These industries were matched to BEA Input-Output Categories via an unpublished mapping system provided by the BEA.

ing earlier in this appendix. The section that follows will provide details on the first three steps.

A closed model would ensure consistency in the way that the production recipes affect prices that in turn influence consumption. Income available to different occupations would be used to compute income distribution, which would also influence consumption.[25] The scenarios examined in this work are forced into consistency in that both demand and value-added are forced to conform to the same total GNP in the year 2005. A closed model capable of exploring structural changes of the magnitude examined in this analysis, and capable of maintaining consistency over 20-year periods, would require precise data in many areas where existing data are not available. Indeed many of the most critical pieces of information (e.g. the cross elasticities between information and transportation demand) are unknowable. The assumptions needed to make such a model work in the absence of

25 See Duchin and Leontief, op cit , footnote 13

52-635 0 - 88 - 16

Table A-3.—Grouping 45 Occupation Classifications in a 16-Occupation Set and an 1 l-Occupation Set

Executive, Administrative, and Managerial
Managers and Management Support
Managerial and administrative occupations
Management support occupations

Professional Specialty
Technical Professionals
Engineers
Architects and surveyors
Natural, computer, and mathematical scientists

Education and Health Professionals
Teachers, librarians, and counselors
Health diagnosing and treating occupations

Other Professionals
Social scientists
Social, recreational, and religious workers
Lawyers and judges
Writers, artists, entertainers, and athletes
All other professional, paraprofessional, and technicians workers

Technicians and Related Support
Technicians
Health technicians and technologists
Engineering and science technicians and technologists
Technicians, except health and engineering and science

Sales
Sales *Workers*
Marketing and sales occupations

Administrative Support, including clerical
Other Customer Contact
Adjusters and investigators
Information clerks

Information Distribution
Communications equipment operators
Mail and message distribution workers
Duplicating, mail, and other office machine operators
Material records, scheduling, dispatching, and distribution
Data Entry, Manipulation, and Processing
Computer operators and peripheral equipment operators
Financial records processing occupations
Records processing occupations, except financial
Secretaries, stenographers, and typists
Other clerical and administrative support workers

Private Household and Other Servlce
Food and Beverage Preparers
Food and beverage preparers and service occupations
Other Service Workers
Cleaning and building service occupations, except private household
Health service and related occupations
Personal service occupations
Private household workers
Protective service occupations
All other service occupations

Precision Production, Craft, and Repair
Precision Production, Craft, and Repair
Blue collar worker supervisors
Construction trades
Extractive and related workers, including blasters
Mechanics, installers, and repairers
Precision production occupations
Plant and system occupations

Machine Operators, Assemblers, and Inspectors
Machine Operators, Assemblers, and Inspectors
Machine setters, set-up operators, operators, and tenders
Hand working occupations, including assemblers and fabricators

Transportation and Material Moving
Transportation and Material Moving
Transportation and material moving machine and vehicle operators

Handlers, Equipment Cleaners, Helpers, and Laborers
Handlers, Equipment Cleaners, Helpers, and Laborers
Helpers, laborers, and material movers

Farming, Forestry, and Fishing
Farming, Forestry, and Fishing
Agriculture, forestry, fishing, and related occupations

KEY: **The 1 l-occupation aggregation shown in bold are commonly used in Bureau of Labor Statistics time series.**
The 16-occupation aggregation shown in italics are used in most of the summary statistics presented in this document.
The 45-occupation groups 1-45 are subheadings of the 679-occupation categories available from the Bureau of Labor Statistics data.

credible statistics are large, and often difficult to interpret. The methods described below are designed to make the best possible use of existing data, while allowing speculative assumptions to be kept clearly in view.

Demographics

Estimates of the future U.S. population by age and sex were made using a demographic model developed by the U.S. Social Security Administration (SSA)[26] and adapted for use on a personal computer.[27] The assumptions used in the calculations follow those used by SSA—with the exceptions noted:

- *Three mortality rate alternatives.* These translate into an assumed increase in U.S. life expectancy (from birth) of between 2 and 7 years over the next 20 years.
- ‘*Three fertility rate alternatives.* The lowest is 1.6 births per woman and the highest 2.3, with a midpoint of 2.0. Fertility rates fell sharply from 3.4 in

26 U.S. Department of Health and Human Services, Social security Administration, “social Security Area Population Projections, 1984,” Actuarial Study No. 92, Washington, DC, May 1984.

27 U.S. Congress, Office of Technology Assessment, “Modified Social Security Population Projection Program,” working paper prepared for the Economic Transition Project, November 1985.

the baby boom period of the early 1960s to well below 1.8 during the mid 1970s, but have since risen slightly and are now above 1.8.

There has been some debate about whether, over the long term, the U.S. fertility rate will remain below the "replacement rate"—which allows the long term natural rate of increase of the U.S. population to remain positive—of 2.1. A long term rate of 1.9 or less will mean that, even accounting for immigration, the rate of natural increase will become negative toward the end of the 21st century .[28]

- *Immigration projections.* Although net legal immigration has stood at an annual average rate of just over 500,000 persons during the past decade, the effects of immigration reform may cause this figure to increase. In so far as amnesty provisions now apply to all illegal aliens who arrived in the United States prior to 1982, the number of legal immigrants may rise significantly, while the illegal immigrant population declines.

  Illegal immigration, however, is more difficult to predict. Over the next 20 years, this factor will depend heavily on economic conditions in developing countries (particularly in Central and South America). Indeed, immigration pressures resulting from economic failure in developing nations could have as great an impact on the U.S. economy as the disruption in trade that such failures cause. In this study, it is assumed that illegal immigration will, after an initial decline through the early 1990s, creep back to currently estimated levels. This would place annual net legal and illegal immigration in 2005 at close to 1 million.[29]

  By way of comparison, the U.S. Census Bureau's "high" series for net immigration, which also assumes a significant level of illegal immigration, matches the current overall level cited here of roughly 750,000 (though OTA estimates an increase by 2005). The Census "middle" series assumes only a small rate of illegal immigration.[30] The comparatively high rates of illegal immigration assumed here result in population estimates for the year 2005 that are slightly higher than those projected by SSA; roughly, the middle estimate used here is roughly similar to the SSA high estimate.

These assumptions can be converted to population estimates for the year 2005 using standard demographic techniques. Results of the projections show an annual average increase in total population of between 0.76 and 1.06 percent, with a median estimate–the one most frequently used in the projections that follow—of 0.93 percent. This annual growth rate would place the U.S. population at 292 million by 2005—some 23 percent higher than the 1983 population of 238 million. By way of comparison, the annual average increase in population between 1960 and 1983 was 1.1 percent, while the U.S. Census Bureau's estimates for 2005 show an overall population increase from 1983 of 25.9 percent for the "high" series and 17.7 percent for the "middle" series (annual rates of increase of 1.05 and 0.74, respectively). The incorporation of illegal immigration into the estimates used in this analysis accounts for the difference between the OTA median estimate and the Census "middle" series.[31]

Households

Estimates of population by age and sex can be used to estimate the number of households of different types. The estimates assumed that people of any age and sex are as likely to be in any of 17 household types in 2005 as they were in 1984. This implicitly assumes that divorce and marriage rates remain unchanged. The 17 household types are listed in table A-4. The probabilities were computed for each age and sex using the 1984 Current Population Series (CPS).[32]

All U.S. households were ranked by income per family member using CPS data. This ranked list was divided into seven equal groups—each group representing different income-per-family-member cohorts. It was then possible to compute the percent of all households of a given type that were in each of the seven income cohorts. Unless otherwise noted, it was assumed that the income distribution of each household type remained unchanged. Household income for each household type and income cohort could therefore be estimated given information about total personal income available.

Spending by Household Groups

The initial projection of patterns of consumer expenditures to 2005—the Trend scenarios-rests on the assumption that these expenditures will be based on existing relationships between expenditure by household type and income, and historically based price trends. The existing relationship between expenditures, household types and household income is defined by the patterns of expendi-

[28] For some interesting perspectives on the issue, see Ben J. Wattenberg, *The Birth Dearth* (New York, NY: Pharos Books, 1987), chapter 3.

[29] F. D. Bean et al., "projections of Net Legal and Illegal Immigration to the United States," contract paper prepared for the Office of Technology Assessment by the Population Research Center, University of Texas, Austin Texas, August 1984.

[30] U.S. Bureau of the Census, Current Population Reports, Series P-25, No. 952, *Projections of the Population by Age, Sex, and Race: 1983 to 2080* (Washington, DC: U.S. Government Printing Office, 1984).

[31] For a review of the Census Projections, see U.S. Bureau of the Census, *Projections of the Population by Age, Sex, and Race: 1983 to 2080,* op. cit.

[32] U.S. Department of Commerce, Bureau of the Census, digital files. See "Household Formation Program," working paper prepared for the Office of Technology Assessment, Washington, DC, May 1986.

Table A-4.—The 17 Household Types Used To Construct Demand Scenarios

1. Single consumer unit, age 15 to 34
2. Single consumer unit, age 35 to 64
3. Single consumer unit, age 65 and Over
4. Two or more unrelated adults living together, age 15 to 84 (no children) (excluding household type #13)
5. Married couples living without any children, age 15 to 65
6. Single parent with children under 18, age 15 to 65 (excluding household type #14)
7. Married couples with own child, oldest child under 6, householder age 15 to 65 (excluding household type #15)
8. Married couples with own child, oldest child 6 to 17, householder age 15 to 65 (excluding household types #16 & #17)
9. Family or couple headed by a person at least age 65
10. Married couples with own child, oldest child over 17, householder age 15 to 65 (excluding household type #12)
11. All other units
12. Married couples with own child, oldest child over 17, householder under 65, with only one child
13. Two unrelated adults living together, age 15 to 64 (no children)
14. Single parent with children under 18, age 15 to 65, with only one child under 18
15. Married couples with only one child under 6, householder age 15 to 65
16. Married couples with only one child age 6 to 17, householder age 15 to 65
17. Married couples with *only* two children, oldest child's age is between 6 and 17, householder age 15 to 65

ture of the U.S. Bureau of Labor Statistics' "Consumer Expenditure Survey" (CES) for 1982/83. The underlying logic of the model is that as household incomes and types of households change, the spending patterns of households change to resemble the established expenditure patterns of income cohort and type into which they have moved.[33] Alternative consumption scenarios were constructed from the base established in the Trend scenarios following methods outlined in chapter 3.

The effect of demographics and household income on consumption patterns was estimated using statistics available from the CES. Regression coefficients were computed using an equation linking expenditure in each household type to household income for each of 31 commodities. The categories were chosen to be as closely compatible as possible with the categories used in the National Income and Product Accounts Personal Consumption Expenditure (PCE) accounts (see table A-5). Expenditures on these 31 items accounted for 75 percent of total PCE in 1983.

Expenditures on the remaining 9 items—health, education, gasoline, electricity, natural gas, other household fuels, stationery, religion and welfare, and foreign travel—are estimated independently (see ch. 3).

This was necessary because expenditure data in the CES, on which the model is based, is incomplete or because there was reason to believe that a price and income coefficients provide an unsatisfactory guide to the future even in the trend cases. For example, the CES covers only out of pocket medical expenses, which account typically for about one quarter of total medical care expenditures. Education from the CES presents another problem since demographic changes, in particular the slow growth of the school age population, will have a greater impact on household educational expenditure than household income or type of household. For energy items, the impact of improved efficiencies is not reflected in existing patterns of household expenditure. The remaining three items—stationery, religion and welfare, and foreign travel—were not separately identified in the CES data.

The influence of income on consumption in 31 categories was computed separately for 17 household types (see table A-4). The equation used was as follows:

$$EX(h,j,I) = a(h,j) + b(h,j)*I + c(h,j)*I^2 \qquad (22)$$

Where EX(h,j,I) is the annual expenditure of household type h for commodity type j when the household income is L The coefficients a(h,j), b(h,j), and c(h,j) were computed by the Bureau of Labor Statistics. A quadratic form was used so that saturation effects and declines in purchases of "inferior goods" with income could be detected.

Expenditures are multiplied by a price adjustment factor based on an assumed future price changes and a set of price elasticities taken from an examination of the Consumer Expenditure Series data (see table A-6).[34] If the adjustment factor is over 1, for example, total expenditure on a given item will be higher than it otherwise would be if prices had not been taken into account. Some adjustments were made to ensure that the set of price changes and elasticities formed a consistent set. A consistent set leave total spending by a household unchanged (e.g. total spending before the price change is equal to total spending after the price change with spending on each commodity adjusted using the elasticities for each commodity).

In the course of developing the model a number of price adjustments were used. A first series (series A of table A-6) was based on an assumed continuation of 1963-83 trends in relative prices.[35] However, series A resulted in a set of 2005 expenditures that were questionable because they sometimes resulted in projections that often departed significantly from historical trends. A major departure from a trends does not necessarily mean that the result is unrealistic. It does require a search for a plausible ex-

33 "Consumer Demand Projection Program," working paper prepared by L. Renner for the Office of Technology Assessment, April 1986.

34 Paul Devine, "Forecasting Personal Consumption Expenditures from Cross-section and Time-series Data," Ph.D dissertation, University of Maryland, 1983.

35 U.S. Department of Commerce, Bureau of Economic Analysis, National Income and Product Accounts, historical diskettes, table 7.10.

Table A-5.–Consumption Items Estimated Using Income and Price Equations and Items Estimated Using Other Methods (1983 spending in each category in billions)

Independently estimated[a]		Estimated using price and income[b]	
Stationery	5.8	Food at home	265.0
Religion and welfare	47.6	Food away from home	104.7
Foreign travel	18.9	Alcohol	52.3
Education	35.1	Tobacco	28.0
Health	267.8	Owner-occupied housing	233.9
Gasoline	90.1	Tenant-occupied housing	96.8
Natural gas	28.9	Maintenance services	8.1
Electricity	51.3	Maintenance commodities	23.6
Household fuels	17.5	Tenants insurance	16.4
Total	533.0	House furnishings	60.2
		House appliances	30.9
% of PCE	24.8	Water and sewer	13.3
		New vehicles	87.0
		Used vehicles	21.6
		Vehicle maintenance	70.7
		Other private transport	1.2
		Air fare	14.3
		Other public transport	9.4
		Personal care commodities	20.4
		Personal care services	14.0
		Men’s and boys’ clothing	38.6
		Women’s and girls’ clothing	76.4
		Other apparel	24,5
		Footwear	20.3
		Apparel services	7.6
		Telephone	37.9
		Personal business	132.5
		Entertainment services	58.2
		Entertainment commodities	62.4
		TV and sound	31.4

[a]See ch.3 for a discussion of the techniques used for the independent estimates.
[b]Calculated using the quadratic equations linking expenditures for 17 household types to household income and using price elasticities described in table A-5. The 31 categories in this list to totaled 75.2% of all consumer expenditure in 1984.

planation and a judgment about which “trend’’to use as the basis for constructing scenarios.

A second price series (series Bin table A-6) was developed as a result of a detailed review of consumption trends. In most cases, series B retains the same price elasticities but changes assumptions about future prices. The adjustments are discussed in chapter 3. The most notable case is items of clothing. In the past, prices of clothing fell sharply by about 34 percent between 1963 and 1983. An assumed continuation of this trend in future as in price series A results in a large increase in the share of total expenditure devoted to clothing, representing major departure from historical trends. The question then becomes whether to use the ’’trends" established by price elasticities or trends emerging from other variables. Expenditures unclothing and Personal Care, have represented about 9 percent of PCE over the last 20 years. The results of the expenditure model including series A price adjustment would have increased expenditures on clothing to over 12 percent of total PCE. In order tearrive at a Trend scenario more in keeping with the historical development of expenditures, it was therefore assumed that prices would remain constant in real terms.

Consumption Scenarios

In the Trend scenarios, personal consumption expenditures are projected for two different scenarios for annual economic growth rates: 1.5 percent and 3 percent. Since it is assumed that PCE will retain a constant share of GNP, the total level of expenditure on personal consumption in 2005 is therefore established in advance. The purpose of the Trend projection for PCE then is to estimate the distribution of expenditure on different items within that pre-determined total.

Equation (22) can be used to estimate spending in each household type given information about household incomes. The projections of expenditure derived from the model are combined with the independently estimated items to provide projected expenditures on all items of PCE for 2005 under the 1.5 percent and 3 percent growth assumptions. These expenditures are shown in table A-

Table A-6.—Price Assumptions

	Series A			Series B		
	Price elasticity	Price ratio	Price adjustment factor	Price elasticity	Price ratio	Price adjustment factor
Food at home	-0.390	1.012	0.9953	-0.39	1.012	0.995
Food away from home	-0.530	1.224	0.8984	-0.98	1.224	0.82
Alcoholic beverages	-0.160	0.848	1.0267	0.2	0.59	0.9
Tenant-occupied housing	2.269	1.019	1.0436	2.269	1.019	1.044
Lodging	-0.760	0.643	1.3988	-0.76	0.8	1.185
Tenants insurance &other rental costs	-0.400	1.243	0.9166	-0.4	1.243	0.917
Maintenance & repair services	-0.430	1.412	0.8621	-0.43	1.412	0.862
Maintenance&repair commodities	-1.040	1.188	0.8359	-1.04	1.188	0.836
Telephone	-1,080	0.533	1.9730	-1.12	0.8	1.284
Water &sewer..	-0.430	0.633	1.2172	-0.43	0.633	1.217
House furnishings.	-1.270	0.803	1.3213	-1	0.803	1.245
Household appliances	-0.830	0,753	1.2654	-0.83	0.753	1.265
Housekeeping services	-0.430	1.412	0.8621	-0.43	1.412	0.862
Men's & boys' apparel	-1,420	0,709	1.6296	-1.42	1	1
Women's & girls' apparel	-1.160	0.580	1.8811	-1.16	1	1
Other apparel..	-0.740	0.709	1.2897	-0.74	1	1
Footwear	-0.760	0.643	1.3988	-0.76	1	1
Apparel services	0.410	1,218	1.0842	0.41	1	1
New vehicles	0.130	0.654	0.9462	0.13	0.654	0.946
Used vehicles	-0,410	1.802	0.7854	-0.41	1.802	0.785
Vehicle maintenance & repair	-0.020	0,820	1.0039	-0.02	0.82	1.004
Private transportation services	-0.500	1,510	0.8137	-0.5	1.51	0.814
Airfare	-1.850	0.536	3.1698	-1.85	1	1
Other public transport	-1.140	1.397	0.6830	-1.14	1.399	0.682
Entertainment services	-0.730	0.892	1.0870	-0.73	1.073	0.95
Tobacco products	-0.370	1.179	0.9408	-0.37	1.179	0.941
Personal care commodities	-0.090	0.905	1.0090	-0.09	0,905	1.009
Personal care services	0,570	1.265	1,1433	0.57	1.265	1.143
Entertainment commodities	-1.940	0.652	2.2927	-0.76	0.8	1.185
TV & sound equipment	-1.020	0.293	3.4978	-1	0.7	1.43
Personal business	-0.350	1,302	0.9117	-0.35	1.302	0.912
Owner-occupied housing	2.269	1.019	1.0436	2.269	1.019	1.044

7. Government spending was estimated using techniques already outlined in chapters 2 and 3.

Converting Consumption in the Consumer Expenditure Series (C=) Categories to Consumption in lnput-Output (I-O) Categories and Consumption by Amenity Group

Consumption in each of the categories shown must be converted into consumer and government demand in the categories used for the input-output analysis discussed in the first part of this appendix. Two steps were required: first, the consumption by CES categories was converted into the categories used in the National Income and Product Accounts (NIPA) Table 2.4 using data provided by the Bureau of Labor Statistics. Since the CES and the NIPA consumption data come from different sources, there is not an exact correspondence between the two even in cases where there is no ambiguity about definitions.[36] To avoid this problem, the scenarios were computed using 1983 data from NIPA increased by the ratio between the CES estimatefor 2005 and the CES base in 1983.

Consumption in NIPA table 2.4 was converted into demand in the input-output categories using the ''margins" tables provided with input-output benchmarks (seethe discussion in ch. 4)[37] Government consumption was converted to I-O categories using similar tables provided by the U.S. Department of Commerce.

Government spending scenarios were constructed in the categories shown in NIPA tables 3.9, 3.15, and 3.16 of the National Income and Product Accounts. Consumption in the categories of NIPA tables 2.4, 3.9, 3.15, and

36 See Raymond Gieseman, "The Consumer Expenditure Survey: Quality Control by Comparative Analysis," *Monthly Labor Review,* March 1987, pp. 8-14, for a comparison of the CES data series with the National income and Product Accounts PCE data.

37 U.S. Department of Commerce *Survey of Current Business*, Op. Cit., footnote 2.

3.16 were converted into consumption by amenity type using assumptions detailed in table A-8.

The trend scenarios were used as the basis for constructing the alternative scenarios described in chapter 3. Most of the details are explained in that chapter. Box A-1 provides details on the algorithms used to estimate education costs.

Table A-7.—Personal Consumption Expenditures— 1983 and the Scenarios (billions of 1983 dollars)

Amenity	1983 ($)	% Share of total	Trend 3% ($)	% Share of total	Trend 1.5% ($)	% Share of total	ALT 3% ($)	% Share of total	ALT 1.5% ($)	% Share of total
1) FOOD										
Food at home	298.4	13.4	433.0	10.1	402,0	13.0	387	9.1	321	10.4
Food away from home : : : :	123.6	5.6	235.0	5,5	146.8	4,7	259	6.1	164	5.3
Tobacco, ...	28.0	1.3	31.2	0.7	35.5	1.1	22	0.5	25	0.8
Total	450.0	20.2	699.2	16.3	584.3	18.8	668	15.7	510	16.5
2) HOUSING										
Shelter ...	330.7	14.8	586.8	13.7	465,2	15.0	565	13,3	429	13.9
Household operation	139.2	6.2	306.9	7.2	221.0	7.1	302	7.1	201	6.5
Utilities .,	111.0	5.0	163.9	3.8	137.7	4.4	95	2.2	80	2.6
Total	580.9	26.1	1,057.6	24.7	823.9	26.6	962	22.7	710	23.0
3) TRANSPORTATION										
Vehicles . .,	108.6	4.9	191,8	4.5	140.2	4.5	192	4.5	162	5.2
Vehicle maintenance	71.9	3.2	134.4	3.1	97.5	3.1	135	3.2	114	3.7
Gasoline and oil	90.1	4.0	81.2	1,9	75.2	2.4	41	1,0	36	1,2
Air fare ... ., : : : :	15.3	0.7	41.8	1.0	22.3	0.7	52	1.2	27	0.9
Other transport	9.4	0.4	12,7	0.3	10.3	0.3	10	0.2	7	0.2
Total	295.3	13.2	461.9	10.8	345.5	11.1	430	10.1	346	11.2
4) HEALTH										
Total	267.8	12.0	650.0	15.2	420.3	13.6	500	11.8	418	13.5
5) CLOTHING AND PERSONAL CARE										
Personal care	34.4	1.5	72,2	1.7	51.5	1.7	72	1,7	52	1,7
Clothing . . . :, . : ::::...	167.4	7.5	378.9	8.8	238.7	7.7	446	10.5	281	9.1
Total	201.8	9.1	451.1	10.5	290.2	9.4	518	12.2	333	10.8
6) EDUCATION										
Total	35.1	1.6	43.3	1.0	41.4	1.3	56	1,3	48	1.6
7) PERSONAL BUSINESS and COMMUNICATION										
Telephone .,, ,.. ,,, .,, .,, .,,,,,.,,	37.9	1.7	78.7	1.8	66.2	2.1	111	2.6	92	3.0
Stationery . .,.,,,...	5.8	0.3	11.1	0.3	8.0	0.3	11	0.3	8	0.3
Personal business , , , , , . . , , , , , , . . , , , , , , , ,	132.5	5.9	282.9	6.6	171.3	5.5	333	7.8	201	6.5
Total	176.2	7.9	372.7	8.7	245.5	7.9	455	10.7	301	9.7
8) RECREATION & LEISURE										
Entertainment services . . .	58.2	2.6	154.3	3.6	81.1	2.6	183	4.3	97	3.1
Entertainment commodities, ...	62.4	2,8	149.8	3.5	104.9	3.4	165	3.9	115	3.7
TV and sound ., ., ..., .,	31.4	1.4	87.6	2.0	61,0	2.0	106	2.5	78	2.5
Lodging. . . .	13.3	0.6	41,8	1.0	23.3	0.8	84	2.0	51	1,7
Religion and welfare	47.6	2.1	91.2	2.1	65.0	2.1	119	2.8	86	2.8
Foreign travel.. ,,, ,, .,.,, ,,, ,, ,,	8.9	0.4	23.1	0.5	14.4	0.5				
Total	221.8	10.0	547.8	12.8	349.7	11.3	657	15.5	427	13.8
Total of above.	2.228.9	100.0	4.283,8	100.0	3.100.5	100.0	4,246	100.0	3,093	100.0

SOURCE 1983 data from NIPA. Scenarios from OTA.

Table A-8.—Consumption by Amenity Group Derived From Consumption by the Personai and Government Expenditure Categories of the Nationai income and Product Accounts (NIPA)

Personal Consumption Expenditures
(line numbers from NIPA Table 2.4)

Food:
3 food purchased for off-premise consumption
4 purchased meals & beverages
5 food furnished employees
6 food produced & consumed on farm
7 tobacco products

Housing:
24 owner-occupied nonfarm dwellings-space rent
25 tenant-occupied nonfarm dwellings-rent
26 rental value farm dwellings
29 furniture
30 kitchen & other appliances
31 china, glassware, tableware, and utensils
32 other durable house furnishings
33 semidurable house furnishings
34 cleaning & polishing preparations
37 electricity
38 gas
39 water & other sanitary services
40 fuel oil & coal
42 domestic services
43 other

Transportation:
65 new **autos**
66 net purchase of used autos
67 other motor vehicles
68 tires, tubes, etc.
69 repair, greasing, etc.
70 gas & oil
71 bridge, tunnel, ferry, toll roads
72 insurance premiums
74 transit systems
75 taxicabs
76 railway (commuter)
78 railway (except commuter)
79 bus
80 airlines
81 other

Health:
45 drug preparations and sundries
46 ophthalmic products
47 physicians
48 dentists
49 other professional services
50 privately controlled hospitals
51 health insurance

Clothing and Personal Care:
12 **shoes & footwear**
14 **women's & children's clothing**
15 **men's & boys' clothing**
16 **standard military clothing**
17 **cleaning, storage and repair of clothing**
18 **jewelry & watches**
19 **other**
21 **toilet articles & preparations**
22 **barbershops, beauty salons, and health clubs**

Education:
99 higher education
100 elementary & secondary schools
101 other

Personal Communication and Business:
41 telephone & telegraph
35 stationery & writing supplies
56 brokerage charges
57 bank service charges
58 services furnished without payment by financial intermediaries
59 **expenses of handling life insurance**
60 legal services
61 funeral & burial expenses
62 other

Recreation and Leisure:
27 other
83 books & maps
84 magazines, newspapers, and sheet music
85 nondurable toys and sport supplies
86 wheel goods, sports equipment, boats, and pleasure aircraft
87 radio & TV receivers
88 radio & TV repair
89 flowers, seeds, & potted plants
91 motion picture theaters
92 legitimate theaters
93 spectator sports
94 clubs and fraternal organizations
95 commercial participant amusements
96 parimutuel net receipts
97 other
102 religious & welfare activities
104 foreign travel
105 expenditures abroad by U.S. residents
106 less expenditures in U.S. by foreigners
107 less foreign travel remittance in kind

Government Consumption
(line number and table number from the National Income and Product Accounts March 1986 version)

Food:
32–Table 3.16 agriculture
61–Table 3.15 agriculture

Housing:
26—Table 3.16 sewerage @ 47%[a]
27–Table 3.16 sanitation @ 47%
30 & 31–Table 3-16 energy @ 44%
53 & 54–Table 3-15 housing & urban renewal
55–Table 3.15 water and sewerage @47%
57–Table 3.15 energy @ 44%
25–Table 3.16 water @ 47%
24–Table 3.16 housing and community development
26—Table 5.4 new residential structures (except mobile homes)
32—Table 5.4 **mobile homes**
40—Table 5.4 **broker's commissions**

Transportation:

35—Table 3.16 highways @ 62%
36 & 37—Table 3.16 water and air transport @ 41%
38—Table 3.16 transit and railroad @ 50%
67—Table 3.15 transportation @ 31%

Health:

15—Table 3.16 health services
16—Table 3.16 hospitals
20—Table 3.16 medical care support
24–Table 3.15 health & hospitals
41 —Table 3.15 medical care
50—Table 3.15 hospitals & medical care

Education:

10—Table 3.16 elementary & secondary education
11 —Table 3.16 higher education
12—Table 3.16 libraries and other education
13—Table 3.16 other
40—Table 3.16 labor training and services
20—Table 3.15 education
48—Table 3.15 education
78—Table 3.15 labor training and services

Recreation and Leisure:

28—Table 3.16 recreational and cultural activities
56—Table 3.15 recreational and cultural activities

Government, n.e.c.

21 —Table 3.16 welfare & social services
44—Table 3.15 welfare & social services
45—Table 3.15 other
26—Table 3.16 sewerage @ 53%
27—Table 3.16 sanitation @ 53%
55—Table 3.15 water and sewerage @ 53%
6—Table 3.16 police
7—Table 3.16 fire
17—Table 3.15 police
18—Table 3.15 fire
19—Table 3.15 correction
8–Table 3.16 correction
35—Table 3.16 highways @ 38%
36 & 37–Table 3.16 water and air transport @ 59%
38–Table 3.16 transit and railroad @ 50%
67–Table 3.15 transportation @ 69%
41—Table 3.16 commercial activities
30 & 31 –Table 3.16 energy @ 56%
57–Table 3.15 energy @ 58%
39–Table 3.16 economic development, regulation, **and services**
33–Table 3.16 **natural resources**
66—Table 3.15 **natural resources**
2–Table 3.16 **administrative activities**
2—Table 3.15 **administrative activities**
7—Table 3.15 international affairs
74—Table 3.15 economic development
18—Table 3.16 government employees retirement
26–Table 3.15 government employees retirement
19—Table 3,16 worker's compensation insurance
31—Table 3.15 disability
37–Table 3.15 unemployment insurance
73—Table 3.15 postal service

Defense and Space:

22—Table 3.16 veteran's benefits and service
10—Table 3.15 space
51 —Table 3.15 other
1—Table 3.9 national defense purchases

[a]Percentage represent the portion of this expenditure category allocated to the particular amenity with the remaining percentage being attributed to Government, n.e.c. This division was primarily based on the ratio of a commodity's total intermediate use to the sum of its intermediate use Plus personal consumer expenditures on the item. This ratio gives a rough indication of personal use as opposed to business or common use of an item; the latter was allocated to the omnibus Government category while the former was assigned to the specific amenity. This division was based on data reported in U.S. Department of Commerce, Bureau of Economic Analysis, "The Detailed Input-Output Structure of the U.S. Economy, 1977," 1984.

Box A-l.—Calculating Education Costs in Different Scenarios

The purpose of this calculation is to compute the time allocations of students and teachers under different assumptions about the use of computer equipment and the cost consequences of the scenarios. For simplicity it is assumed that a program of instruction is divided into three parts: (i) a period during which students are using computers under comparatively loose supervision, (ii) a period during which teachers are lecturing students, (iii) tutorial sessions where a teacher spends time with one or a small number of students. [n addition to staff costs for teachers working in each task, education costs include the capital costs of buildings, computer and other equipment, and other overhead costs.

The scenarios are constructed from assumptions on the following topics:

NC = The number of students per teacher in situations where only a room monitor is required.
NM = The number of students per teachers in lectures or similar situations.
NT = The number of students per teachers in tutorials.
R = The overall student teacher ratio in the school system.
FSC = The fraction of time students spend on a computer or other instructional hardware.

A calculation of costs also requires an estimate of overhead personnel required per student, the annualized average cost of computers per student (a function of number of students per screen as well as the cost per screen), and the salaries of each type of teacher.

The variables that must be calculated to estimate time allocations and costs are as follows:

FST = Fraction of student time spent in tutorials
FSM = Fraction of student time spent in lectures
FTC = Fraction of teacher time spent in computer monitoring
FTT = Fraction of teacher time spent in tutorials
FTM = Fraction of teacher time spent in lectures

These unknowns can be computed from the assumptions using the following equations:

a. The fractions showing student time use sum to 1 (FSC+FST+FSM = 1)
b. The fractions showing teacher time use sum to 1 (FTC+FTT+FTM= 1)
c. The student teacher ratio in tutorials is NT (FTT=R*FST/NT)
d. The student teacher ratio in tutorials is NC (FTC=R*FSC/NC)
e. The student teacher ratio in tutorials is NM (FTM = R* FSM/NM)

Equations a. and b. can be rewritten as follows:

f. FSM= 1-FSC-FST
g. FTT= l-FTC-FTM

Using equations d. and e. in equation 7 yields

h. (R/NT)*FST = l-(R/NC) *FSC-(R/NM)*FSM

Using equations h. and f., two of the variables can be calculated directly:

FSM = l-FSC-(NT/R)* l-(R/NC)*FSC-(R/NM) *FSM)
FSM* (l-NT/NM) = l-(NT/R} FSC*(l-NT/NC)
FSM = ((l-NT/R)+ FSC*(NT/NC-l))/(1-NT/NN) by symetry
FST = ((l-NM/R) +FSC*(NM/NC-l))/(1-NM/NT)

Since FSM and FST have been calculated, equations c., d., and e. can be used to calculate FTM, FTC, and FTT.

The number of computers required per student can be calculated from FSC and the number of students using a computer at any given time. These variables can be used to calculate the cost of scenarios described in chapter 3.