General Equilibrium Analysis of U.S. Taxation Policy

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In this paper we report work in progress on the construction of a medium size general equilibrium model of the U.S. economy and taxation system. The model incorporates the full range of taxes currently employed in the United States. We identify 19 producer good industries, 16 consumer goods, and 12 consumer types classified by income range. In general, taxes affect the economic behavior of both producers and consumers. The model (outlined in chart 1) is being constructed in an interactive, user-oriented form in order to allow consideration of many alternative changes in tax policy. The model incorporates not only conventional consumer and producer behavior, but also savings and investment activity, foreign trade activity, and government purchase policies. The model is parameterized with 1973 data. The general capability of our approach is illustrated with a specific set of calculations performed by the model. We calculate the economic effects of remov-

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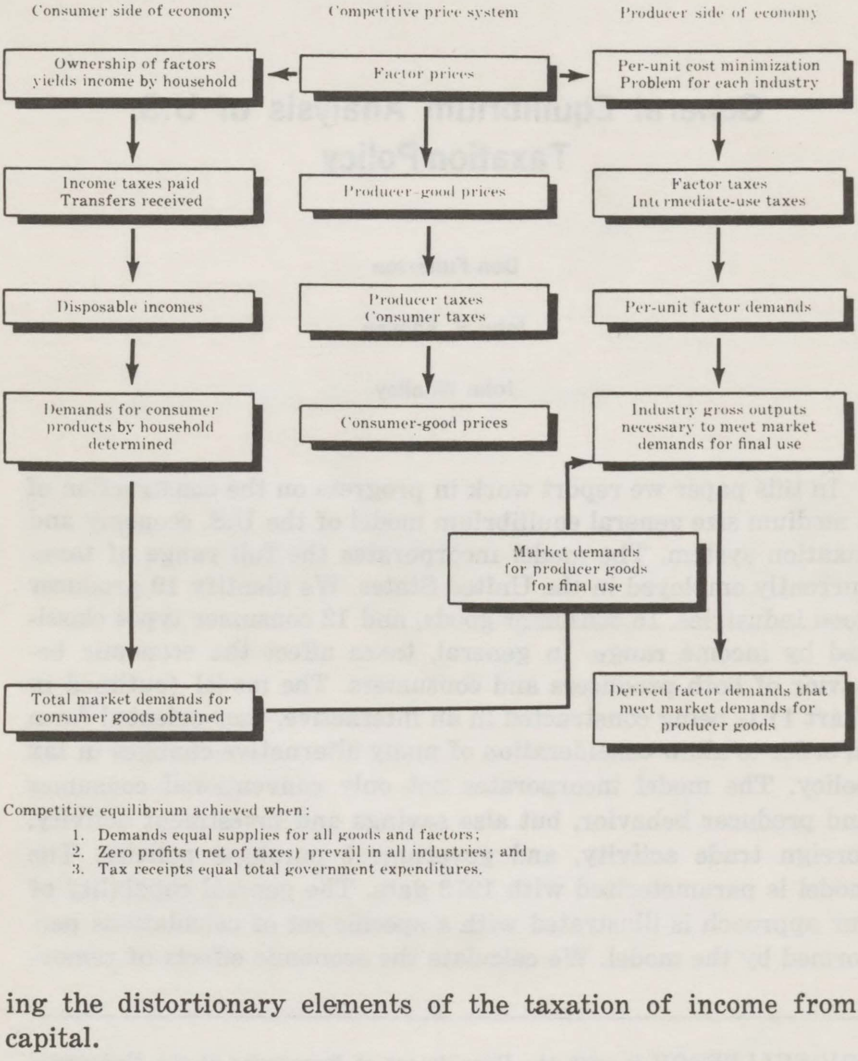
CHART 1.—*Diagram of the model structure*



ing the distortionary elements of the taxation of income from capital.

One major contribution of the present work is the assembling of a recent and consistent microeconomic data set that shows the interactive effects of all taxation policies. Such a data set, essential for a complete general equilibrium analysis of U.S. taxation policy, has never been constructed. This data set provides information not only on use of factors by industry (and taxes paid for these factors), but also on intermediate usage of products, outputs of both producer and consumer goods, purchases of consumer goods by household types, incomes by source and by household type, income taxes paid, and several other items, including business investment and foreign trade. Inconsistencies between these data sets and general equilibrium conditions are resolved using systematic adjustment procedures described in the paper.

Despite the richness of the present structure in comparison with other available analyses, there are a number of ways in which further improvements could be made. The present model is motivated by a concern to produce within a reasonable period of time a manageable functioning model that provides realistic, if highly aggregated, analyses of tax change effects. It should be regarded as a pilot model that provides a base for future refinements. For instance, if detailed analysis of the effects of a complex reform of the personal income tax were to be undertaken, more richness of consumer groupings, emphasizing family and age characteristics, would be required. The approach draws on and extends that used by Whalley (1973) and Whalley and Piggott (1976) in their work on the United Kingdom tax system.

An outline of our model is given in chart 1. In the next two sections we describe more fully the structure of the model and discuss our approach towards its parameterization. In the following sections we outline our data and we present our adjustments to make them mutually consistent. We go on to describe computational aspects of the solution of the model and we discuss uses of the approach and possible extensions. Finally, to illustrate the capability of the model, we analyze the tax change referred to above.

The Structure of the Model

Production Side

On the production side of the model 19 industries are identified. Each industry produces a single output (or producer good) from a combination of primary factor inputs (capital and labor services) and the outputs of other industries. These industries are shown in table 1 along with the consumer goods considered. Industry input decisions are assumed to be made on the basis of cost minimization, and these decisions are affected by the U.S. tax sys-

TABLE 1.—*Classification of industries and consumer goods*

Industries	Consumer goods
1. Agriculture, forestry, and fisheries	1. Food
2. Mining	2. Alcoholic beverages
3. Crude petroleum and gas	3. Tobacco
4. Contract construction	4. Utilities
5. Food and tobacco	5. Housing
6. Textiles, apparel, leather products	6. Furnishings
7. Paper and printing	7. Appliances
8. Petroleum refining	8. Clothing and jewelry
9. Chemicals and rubber	9. Transportation
10. Lumber, furniture, stone	10. Motor vehicles
11. Metals, machinery, miscellaneous manufacturing	11. Services
12. Transportation equipment	12. Financial services
13. Motor vehicles	13. Reading, recreation, misc.
14. Transportation, communications, and utilities	14. Nondurable-nonfood household items
15. Trade	15. Gasoline and other fuels
16. Finance and insurance	16. Savings
17. Real estate	
18. Services	
19. Government enterprises	

tem since the relative producer prices of inputs are altered for each industry.

The decision to select these 19 industries was based on a number of considerations. An attempt was made to separate industries for which there are important differences in taxation, but the availability of data somewhat constrained this level of detail. The model has been kept within an overall dimensionality so that solutions can be executed within a reasonable amount of time and so that the basic data set can be manipulated. Considerably more detail can be considered, but at this stage our concern is to develop a manageable model that improves upon those currently available for partial or general equilibrium analysis of United States taxation issues.

The use of primary factors by each industry is described by a separate constant elasticity of substitution (CES) or Cobb-Douglas production function. The model embodies a capability for preselection of functional form in addition to selection of parameter values. Later in this paper we outline our procedures for selecting parameter values of these functions.

The intermediate use of products by industries is described by a conventional fixed-coefficient input/output (I/O) matrix. The matrix is derived from published 1970 input/output data for the United States; some of the difficulties with the utilization of this data are discussed later.

A number of taxation instruments are treated as production taxes and directly affect the cost structures of industries in the model. The corporation income tax, the corporate franchise tax, and the property tax are in combination treated as ad valorem taxes on capital services by industry. Social security tax, unemployment insurance, and workmen's compensation are treated as ad valorem taxes on labor services by industry. There is some discussion in the literature as to the appropriateness of treating each of these taxes in this way. For instance, the treatment of social security taxation as a set of benefit related contributions and the treatment of the corporate income tax as either a lump sum tax or a tax on the use of particular financial instruments by firms rather than as a tax on capital services have prompted considerable discussion in recent years. Our model abstracts from these problems, but we are aware of the controversies.

In addition to the taxes on the primary factor inputs, we consider taxes on the intermediate usage of producer goods by industry and on the outputs of producer goods. Taxes paid on intermediate inputs include the registration fees paid on motor vehicles for business use. Producer output taxes include the federal manufacturers excise tax on tires, which is paid by purchasers for intermediate or final use. Table 2 contains the detailed treatment of all these taxes along with an outline of the treatment of the entire U.S. tax system.

Consumption Side

Within the personal sector, we have identified 12 consumer groups defined by their family gross of tax income as reported in the 1973 Consumer Expenditure Survey Data published by the U.S. Department of Labor. The number of groups has been restricted in order to keep the model to a manageable size, but more consumer groupings could be considered by the approach. In addition to income, such characteristics as family size, age or marital status of household heads, and regional location could be examined.

Consumer demands are assumed to be generated by a process of utility maximization subject to a budget constraint. Any one of the conventional functional forms, such as Cobb-Douglas, CES, or

TABLE 2.—*United States taxes and their treatment in the model*

Tax	Treatment in model	Problem areas
Corporate taxes (including state and local) and corporate franchise taxes	Ad valorem tax on use of capital services by industry	Some argue for treatment as a lump sum tax; model treatment ignores role of financial instruments
Property taxes	Ad valorem tax on use of capital services by industry	Differential rates across jurisdictions ignored
Social Security taxes, unemployment insurance, and workmen's compensation	Ad valorem tax on use of labor services by industry	Benefit-related nature of contributions; arbitrary distinction between public and private insurance programs
Motor vehicles tax	Ad valorem tax on use of motor vehicles by producers and consumers	In practice, a yearly registration fee and not a purchase tax; averaging over jurisdictions
Retail sales taxes	Ad valorem taxes on purchase of consumer goods	Averaging of rates over states
Excise taxes	Ad valorem taxes on output of producers goods	Taxes often expressed as charge per unit physical measure such as volume
Other indirect business taxes and nontax payments to government	Ad valorem tax on output of producer goods	Payments depend on output levels by industry to only limited extent; averaging of rates over states
Personal income taxes (including state and local)	Set of average and marginal income tax rates differing over consumer groups	Detailed deductions and exemptions not specifically considered in model

linear expenditure system (LES), can be used for this purpose; our computer programs allow preselection.[1] From the demands for consumer goods, the derived demands for producer goods can be generated, and these are used in the solution of the model.

[1] The model can incorporate any continuous set of market demands that satisfy Walras law. Other functional forms may be programed in the future, but capability now exists to evaluate Cobb-Douglas, CES, or LES demand functions. The LES functions include minimum required purchase parameters, which must be separately estimated.

Consumer goods [2] are linked to producer goods through a transition matrix termed the G matrix. An element of this matrix, g_{ij}, is the amount of producer good i needed to produce one unit of consumer good j. The producer goods "retail and wholesale trade" and "transportation" are needed for the production of all (nonsavings) consumer goods. Savings is treated in the model as a separate consumer good that enters demand functions. It is assumed that savings earns a rate of return given by the current price of capital services corrected for changes in the price of capital goods.

The model incorporates income taxes using an average rate (AR) and a marginal rate (MR) for each consumer group. These data are obtained from the U.S. Treasury merged tax file and are reported in table 3. The average tax rates are used to estimate the group's income tax payments in 1973; however, the marginal tax rates are used to examine the effect of the income tax system on economic behavior. Consequently, each consumer group's income tax liabilities are given by the formula:

Income tax payments = $(AR_i) \cdot$ (1973 Income of group i in real terms) + $(MR_i) \cdot$ (Change in income from 1973 real value).

For present purposes the simplified treatment of the tax code in terms of average and marginal rates for each consumer group is quite adequate.[3] But a considerable elaboration would be required to study the effects of a complex reform of the income tax system. State and local income taxes are modeled as "piggyback" or percentage surcharge taxes applying to the Federal levy.

The model also includes a treatment of consumer taxes as ad valorem taxes on household purchases of commodities. Since none of the taxes considered in the model has a differential effect across households, a single vector of ad valorem consumer tax rates is used. These taxes are excise taxes on selected items and retail sales taxes. The complete treatment of these taxes appears along with other taxes in table 2.

In addition to the consumer groups, there are three special classifications of demand patterns for investment activity, government purchases, and foreign trade.

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[2] The classification of consumer goods is described in table 1.

[3] At the present stage of model construction, no labor/leisure choice has been incorporated. There are no programing or model difficulties in building in such a feature; the difficulties are purely those of data. Even without a labor/leisure choice, the marginal tax rates of consumers are important for the model treatment of housing.

TABLE 3.—*Average and marginal income tax rates by consumer groups*

(a) Gross income including transfers (in dollars)	(b) Federal, S&L income taxes ÷ gross of tax income excluding transfers (AR)	(c) Average marginal tax rate (MR)
0– 2,999	.0056	.0100
3,000– 3,999	.0320	.0608
4,000– 4,999	.0484	.1019
5,000– 5,999	.0604	.1228
6,000– 6,999	.0704	.1346
7,000– 7,999	.0818	.1570
8,000– 9,999	.0943	.1813
10,000–11,999	.1039	.2078
12,000–14,999	.1158	.2215
15,000–19,999	.1357	.2618
20,000–24,999	.1585	.2897
25,000+	.2556	.4067

Investment activity is modeled via the transition matrix relating producer to consumer goods. Consumer savings made on the basis of the anticipated rate of return on capital are converted into derived demands for producer capital goods by type, as appearing in the model. This treatment assumes an equality between savings and investment.

Government purchases are derived from a Cobb-Douglas demand function defined over producer goods which holds expenditure shares constant across these items. Government real expenditures are assumed to equal tax receipts plus government net borrowings less transfers, since the general equilibrium approach requires that the government budget must be balanced.

The foreign trade sector is treated simply so as to close the model. The net value of exports less imports for each producer good is assumed to be constant. This enables calculation of the net quantity transactions at any given vector of producer prices and transformation from domestic demands to market demands. The constancy in value terms allows for a zero trade balance to be maintained at any set of prices if it holds initially. This treatment of foreign trade is unsuitable for a detailed analysis of tariff policy, but meets our objective of a manageable model for analysis of domestic impacts of taxation policy.

Parameterization

The broad approach to the parameterization of our model uses the concept of a benchmark equilibrium data set. Parameters are chosen such that this data set is replicated by the model as an equilibrium solution. The technique involves the use of a number of detailed data sets that require adjustments to make them mutually consistent in the sense that they satisfy the equilibrium conditions of the general equilibrium model. We describe later the adjustments performed to transform our basic data into this form.

Once arranged in this form, the basic data are used to generate parameters for the behavioral equations of our model. This involves a prior step of decomposing our equilibrium observations on transactions in value terms into separate observations on equilibrium prices and quantities. For this purpose we follow Harberger 1959, 1962, 1966) by defining otherwise unobservable physical units of both factors and goods as those amounts that can be sold for $1 at the observed equilibrium.[5] Thus, our benchmark equilibrium data set can be separated into price and quantity observations; all benchmark equilibrium market prices are unity and all benchmark equilibrium quantities are those given by the data in value terms.

From the quantity and price observations and the assumption of agent optimization it is possible to infer behavioral equation parameter values that are consistent with the equilibrium data set. For instance, if we assume a given industry has a Cobb-Douglas production function and cost minimizes, the factor employments observed in that industry are the direct outcome of solving the cost minimization problem at prices of unity. This uniquely determines the weighting parameters of the Cobb-Douglas functions. Similarly on the demand side, if a given consumer has a Cobb-Douglas utility function his commodity purchases at equilibrium prices of unity imply unique values for the utility function exponents. Other equilibrium conditions are used to determine remaining parameters; for example, the zero profit conditions by

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[4] These procedures are explained more fully by Whalley and Piggott (1977).

[5] We define units of productive factors as those amounts capable of generating $1 of income net of factor taxes rather than net of all taxes. Because different income recipients face different marginal income tax rates, units must be defined by factor rewards before income taxes. The imputed capital income from home ownership is treated in the model as fully taxable, and a subsidy is given at each group's marginal tax rate on purchases of owner-occupied housing services.

industry are used to generate the normalization constant in each industry's production function. The data together with the equilibrium conditions thus determine all parameter values.

If more complex functional forms are used, additional parameter values are necessary before the same procedure can be used. In the case of constant elasticity of substitution, an extraneous estimate of the elasticity of substitution must be provided for each industry or consumer. While we believe there are procedures for crudely choosing among these (such as examining implied point estimates of the price elasticity of market demand functions at the benchmark equilibrium) the degree of arbitrariness in choosing any particular set of elasticities should not be ignored. It should be added, however, that this difficulty is not a shortcoming of our approach alone. It is exactly these elasticity margins which any model must specify in order to address the class of issues analyzed by our techniques.

The complexity of our model makes it impossible to estimate without a large number of identifying restrictions on parameter values. In the face of this identification problem, it might be appropriate to use extraneous econometric estimates of individual parameters instead of parameter values generated by the model. Such a procedure would require a search of the literature for estimates of production function and demand functions for use in the model. However, the implementation of this procedure faces a basic methodological difficulty. If extraneous parameter values are adopted, there is no test of the overall performance of the model. It is quite possible, for instance, that the chosen combination of parameters will yield an equilibrium that bears little relation to what is known from statistical evidence to occur. Therefore, we believe it more appropriate to use the equilibrium solution concept as an identifying restriction for the model.

Our procedures also have a number of practical advantages. First, they enable direct use of national accounts data, avoiding the difficulty of providing definitions of units in physical form. This means that, with the more complex functional forms, we are able to use extraneous parameter estimates for unit free elasticity parameters and avoid the problem of a conversion between units used in our model and extraneous estimation procedures. A further point is that extraneous estimates are surprisingly sparse, often inconclusive, and usually presented for classifications other than those with which we work.

Data Sources and Procedures

Much of the production data for our model comes from the July 1976 Survey of Current Business (SCB) and from disaggregated worksheets provided by the National Income Division (NID) of the Commerce Department. Some of these data are not compiled in a form suitable for this study; therefore, several adjustments must be made to obtain the necessary information. The adjustments we have made to the national income accounts data are summarized below. It should be noted that further adjustments are desirable but have not proven feasible.[6]

Labor Income and Tax

Our definition of labor return gross of tax is the sum of wages, salaries, employer contributions for social insurance programs, and the estimated return to labor of self-employed persons. This last category represents an unobservable fraction of the total return to the entrepreneur who invests his time and capital jointly; it is estimated by the product of average employee compensation and the number of proprietors and partners for each industry. This component of the return to labor is substantial only for agriculture, construction, services, and trade.

One difficulty with this handling of the self-employed occurs if the estimated labor component exceeds the total unincorporated income of an industry. In this case we have set the capital return at zero and assigned the total income to labor.

In the model the tax on labor services includes employer and employee contributions for social insurance. As mentioned earlier, these contributions are somewhat benefit related, but it is important to include those charges on labor income that discriminate among industries. The social security tax, for example, applies a fixed rate on wages up to some maximum per employee, so that industries with higher than average compensation of employees would tend to pay a lower effective rate of social security tax. Unemployment insurance discriminates by industry since the tax depends on the incidence of unemployment in that industry.

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[6] For example, the establishment basis is used to collect information on wages, noncorporate income, and interest paid, while the company basis is used for corporate profits and interest paid. A further point is that the national income accounts use a "national" definition to measure income to factors supplied by U.S. residents, while a "domestic" definition, which measures income of factors used domestically, is more appropriate for the model. Many of these adjustments are discussed by Rosenberg (1969).

TABLE 4.—*Labor income, tax, and effective rates by industry in the United States, 1973* [1]

Industry	(a) Labor income net of tax	(b) Tax on labor	(c) Effective tax rate (b) ÷ (a)
All industries	643,040	64,997	.1011
Ag., for., fish.	16,257	1,141	.0702
Mining	4,718	464	.0983
Crude petr. gas	3,415	308	.0902
Construction	50,908	5,308	.1043
Food, tobacco	16,964	1,859	.1096
Textiles, app., lea.	17,447	2,268	.1300
Paper, printing	18,996	1,948	.1025
Petrol. refin.	2,834	239	.0843
Chem., rubber	19,387	1,957	.1009
Lumber, furn., stone	17,419	1,930	.1108
Metals, machinery	87,996	9,167	.1042
Transp. equip.	13,738	1,393	.1014
Motor vehicles	15,064	1,358	.0901
Trans., comm., util.	59,086	6,188	.1047
Trade	130,239	13,745	.1055
Finance, insurance	32,839	3,161	.0963
Real estate	7,782	827	.1063
Services	112,785	10,179	.0903
Govt. enterprises	15,166	1,557	.1027

[1] All figures in millions of dollars. Component detail available upon request.

An industry breakdown of each employer payment was provided by NID, and the employee share of social security was derived from the employer share since they are matching contributions. The total for self-employed contributions, is given in the SCB and is allocated among industries by the proportion of self-employed labor income in each industry. Labor income, taxes, and effective rates are shown in table 4. The low rate for agriculture reflects noncoverage of employees by insurance programs. The lower than average rate for services is due to some noncoverage and some salaries above the maximum for the social security tax.[7]

Capital Income and Tax

The return to capital net of tax includes corporate profits after tax, the estimated return to noncorporate capital, net rents paid,

[7] The level of aggregation tends to average diverse rates. Legal services alone, for example, have an effective rate of tax of only .0827. At the other extreme, the high effective rate for textiles, apparel, and leather includes a rate of .1364 for apparel alone.

and net interest paid. The inventory valuation adjustment (IVA) and the capital consumption adjustment (CCA) are applied to these figures. Net realized capital gains are not included because they refer to accrued gains of earlier years. In fact, accrued gains on existing physical capital assets have not been included in our capital payments or income figures. This procedure is consistent with the assumption that such gains reflect only inflation, and it demands less data than alternative approaches. In the current model there are no corporate retained earnings: all capital income net of business taxes accrues directly to the shareholder. Consequently, real accrued financial capital gains of individuals, reflecting the retained earnings of corporations, are implicitly included.

The July 1976 SCB gives corporate profits after corporate taxes, property taxes, and other indirect business taxes; we aggregate these figures for each of our 19 industries. The corporate IVA has been obtained in sufficient detail from NID and reduces the corporate profit figures.[8] Wherever negative returns result, we resort to an average of several years in order to avoid the implication that an industry "supplies" rather than uses capital. Two special adjustments are necessary to the data. First, the national accounts for finance and insurance include the Federal Reserve Board earnings as corporate income and their payments to the Treasury as corporate tax. This government operation is exempt from the corporate income tax system, but its payments to the Treasury are included as a capital tax. Second, IRS corporate profits in extractive industries are understated by the combination of current expensing of exploration and allowances for depletion of reserves. We add to SCB income the portion of the percentage depletion deduction not included in Commerce Department adjustments. The result of these procedures are shown in column (a) of Table 5.

Unfortunately, the Commerce Department cannot provide the disaggregated CCA estimates necessary to measure income net of economic depreciation instead of tax depreciation. We use results from a study by Coen (1976) for the disaggregated manufacturing CCA, shown in column (b), table 5. The noncorporate farm and real estate income figures in the national income accounts include CCA adjustments; the remaining industries have no such adjustment because data are lacking.

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[8] Our measure of capital income is meant to approximate a real return and thus excludes all inflationary capital gains. The inclusion of the IVA, which places all firms on a LIFO inventory accounting basis, is therefore appropriate.

TABLE 5.—*Capital income components by industry in the United States, 1973* [1]

	(a) Corporate profits after tax with IVA	(b) Capital consumption adjustment	(c) Return to noncorporate capital	(d) Net rents paid	(e) Net interest paid	(f) Total capital income
All industries	45,633	8,221	33,541	21,237	65,530	181,973
Ag., for., fish.	523	[5]	22,865	4,067	3,323	30,778
Mining	840 [3]	—	37	80	179	1,136
Crude Petr., gas	2,446 [3]	—	561	304	59	3,370
Construction	500	—	0	75	448	1,023
Food, tobacco	335	572	0	64	846	1,817
Textiles, app., lea.	428 [2]	138	0	49	471	1,086
Paper, printing	2,376	−96	0	242	199	2,721
Petrol. refin.	3,583	3,578	0	640	481	8,282
Chem., rubber	3,172	132	0	71	535	3,910
Lumber, furn., stone	3,115 [3]	512	0	181	421	4,229
Metals, machinery	5,527	2,144	0	427	2,303	10,401
Trans. equip.	−91 [2]	61	0	22	176	168
Motor vehicles	2,785	1,180	0	30	852	4,847
Trans., comm., util.	4,292	—	0	357	8,606	13,255
Trade	7,198	—	367	898	1,258	9,721
Finance, insurance	6,843 [4]	—	809	188	0	7,840
Real estate	88 [2]	[5]	0	13,013	43,731	56,832
Services	1,673	—	8,902	529	1,642	12,746
Govt. enterprises	—	—	—	—	—	7,811 [6]

[1] In millions of dollars. [2] Averaged over 1971, 1972, 1973. [3] Includes depletion. [4] Includes FRB earnings. [5] CCA already included. [6] Imputed.

For noncorporate business, NID provides detailed income and IVA data. As with the figures for corporate business, negative income values were avoided by averaging several years together when necessary. For each industry, our earlier estimate of the labor return is subtracted from total income in order to obtain a residual estimate of the return to noncorporate capital. The resulting estimates appear in column (c) of table 5.

Net rents paid by an industry are payments for borrowed property, buildings, and machinery used in that industry. These payments are treated by the national income accounts as a cost deduction for the renting firm and as income to the owners of the rented property. Since we seek to measure all payments to capital used in each industry, we count as capital income net rents originating in the paying industry. NID has provided net rents for farm realty, the imputed net rent from owner occupied dwellings, and the net rent from tenant occupied dwellings. We place the first of these into agriculture and the latter two into real estate. Net rents paid by business are apportioned among the 18 private industries on the basis of the data on gross rents paid as given in the 1973 IRS Statistics of Income. Finally, in this category, royalties paid for natural resources, copyrights, and patents are counted as capital income in the industry in which these assets are used. The use of natural resources by industry is approximated by the depletion deductions taken for tax purposes in 1973. The combination of these rental imputations is shown in column (d) of table 5.[9]

The final component of capital income is the net interest paid by each industry. These may also be thought of as payments for borrowed capital services used in the industry. NID industry worksheets showing interest flows for 1973 were used. The dollar payments of interest by industry are referred to as net "monetary" interest paid. These payments are positive for all industries except finance and insurance (F&I), which has a large negative value for net monetary interest paid. The receipt of net monetary interest is a return for the financial intermediation services F&I firms provide. If, as for other industries, we add the (negative) net interest paid to profits, then the total return to capital in F&I will also be negative. We raise the F&I net interest paid figure to zero by imputing additional interest payments to other industries and to persons who then pay imputed finance charges to F&I. The Commerce Department NID has made some of these imputations but leaves a large negative value for F&I net interest paid. We allo-

[9] Note that the real estate industry no longer encompasses all rental income as it does in the national accounts.

cate the remaining imputed interest in the same proportions as that already allocated by NID.[10] Net interest paid, both monetary and imputed, is shown in column (e) of table 5. The sum of the first five columns, the total return to capital used in each industry, appears in column (f).

We consider three components of tax on capital income: the corporation income tax, the corporate franchise tax, and property taxes. Information on the corporation income tax by industry is given in the SCB; the figures for the 18 private industries in the model are shown in column (a) of table 6. The corporation franchise tax is treated as an indirect business tax in the national accounts. Data given in unpublished worksheets from NID are aggregated to 18 industries; these figures are given in column (b) of table 6. The same worksheets provide NID estimates of state and local property taxes paid by industry. Our movement of net rents paid out of real estate requires a further adjustment to these property tax figures. These adjusted property taxes are given in column (c) of table 6. Column (d) then gives the total of these three taxes on capital income, while column (e) repeats capital income from the previous table. Column (f) reports effective tax rates on net of tax income in each industry.

The low rates of tax in agriculture, real estate, and services reflect the discriminatory nature of the corporate tax since these industries are largely noncorporate. The low rates in the crude petroleum and the petroleum refining industries reflect large depletion deductions in those industries. Depletion deductions also play a role in the lumber industry.[11]

Intermediate Inputs and Production Taxes

The Bureau of Economic Analysis 1970 update of the 1967 I/O matrix is aggregated for our 19 industries and adjusted to 1973 levels. We scale up each industry's intermediate use of producer goods by the ratio of 1973 to 1970 value added for that industry.

In the I/O table, the total value of each producer good equals the value of intermediate inputs, intermediate input taxes, and value added. The latter includes labor services, labor tax, capital

[10] Since individuals receive some of the imputed interest, our accounts show greater national income and greater expenditures on F&I. Consumption-side data accomodates the change.

[11] At the other extreme, unusually high effective tax rates can be explained by low profits in 1973. An industry could include some firms with profits and tax liability and other firms with losses. The average income figure could even be negative at the same time that taxes are paid by the industry.

Table 6.—*Capital taxes by industry in the United States, 1973* [1]

	(a) Corporate income tax	(b) Corporate franchise tax	(c) Adjusted property tax	(d) Total tax on capital	(e) Capital income net of tax	(f) Effective tax rate (d) ÷ (e)
All industries	48,702	1,161	46,033	95,896	181,973	.5270
Ag., for., fish.	309	10	2,420	2,739	30,778	.0890
Mining	237	8	273	518	1,136	.4560
Crude petr., gas	194	4	804	1,002	3,370	.2973
Construction	1,012	18	334	1,364	1,023	1.3333
Food, tobacco	2,585	45	617	3,247	1,817	1.7870
Textiles, app., lea.	1,221	23	264	1,508	1,086	1.3886
Paper, printing	2,125	31	479	2,635	2,721	.9684
Petrol. refin.	1,282	92	256	1,630	8,282	.1968
Chem., rubber	3,573	44	574	4,191	3,910	1.0719
Lumber, furn., stone	1,647	28	422	2,097	4,229	.4959
Metals, machinery	8,094	138	1,979	10,211	10,401	.9817
Trans. equip.	536	7	542	1,085	168	6.4583
Motor vehicles	2,974	19	276	3,269	4,847	.6744
Trans., comm., util.	4,007	319	5,313	9,639	13,255	.7272
Trade	7,513	125	3,252	10,890	9,721	1.1203
Finance, insurance	9,457 [2]	178	968	10,603	7,840	1.3524
Real estate	700	47	25,354	26,101	56,832	.4593
Services	1,236	25	1,906	3,167	12,746	.2485
Govt. enterprises	0	0	0	0	7,811	.0000

[1] In millions of dollars.
[2] Includes FRB payments to the Treasury.

services, capital tax, and the taxes on output. Several of the indirect business taxes have been treated in the model as ad valorem taxes on the output of each industry at appropriate rates. For example, the public utilities taxes, severance taxes, and the business and occupation taxes apply to the outputs of particular industries. Other tax and nontax payments, although not legally defined as taxes on value of output, are so treated. Federal excise and customs duties are treated as ad valorem output taxes on producer goods. An adjustment is made to NID data to place retailers' excise taxes on corresponding producer goods instead of on retail trade.

Registration fees on motor vehicles are treated as a tax on their intermediate use by industry. This data appears with other indirect business taxes in the worksheets provided by NID.

Government

A separate, 19th industry represents the output of government enterprises, including the post office, TVA, mass transit, local utilities, and other government-run business. Total employee compensation for these Federal, State, and local operations is shown in the SCB, as are employer contributions for retirement programs, treated as a labor tax. Their use of capital services in 1973 must be imputed using a weighted average of the gross of tax capital/labor ratios for the private counterparts of these activities, including services, transportation, finance, and utilities. The weights are determined by the proportion of government enterprise value added in each of the above activities from the 1967 I/O table. Since our value added is greater than the input/output figure, we treat the difference between our capital use estimates and the recorded government enterprise surplus as an output subsidy. The effective rate of tax on the use of capital services is zero since no corporate income or property taxes are paid by government.

The intermediate input column for this industry is scaled up from 1970 to 1973 by the ratio of employee compensation between those years instead of value added, since the latter includes the "surplus" of government enterprises, which is often negative. The only indirect business tax paid by this industry is a Federal nontax payment, modeled as an ad valorem output tax.

Purchases for general government are modeled as if made by a single consumer, with demand functions defined over producer goods, capital, and labor. In order to finance the purchases of this consumer, a major fraction of tax revenue is retained in addition to government income from ownership of capital services. With this income, the government consumer purchases capital and labor services and outputs of all 19 industries. The 1970 I/O table shows purchases by general government in the four categories of Federal defense and nondefense and State and local education and non-education. Each of these are scaled to 1973 using totals from the SCB. An estimation problem is presented by the government use of capital services because figures for these are not available. A rate of return is imputed to government capital stock data for 1973.

Investment and Foreign Trade

Businesses invest in both capital formation and inventory accumulation. Gross private fixed capital formation requires the purchase of our 19 producer goods, scaled from 1970 to 1973 using SCB totals. Similar scaling is done for the net inventory change column, and the appropriate IVA is subtracted from each industry in order to measure only their purchases. Together, these columns represent the manner in which savings are spent. As stated earlier, one of our 16 consumer goods is savings purchased by each of our consumer groups.

The export column of the 1970 I/O table is replaced with information for 1973 from U.S. foreign trade statistics, and similar information is used on imports for both final and intermediate use.

Consumer Incomes and Expenditures

The capital and labor services used by producers and purchased by government are endowments of the consumer groups and government. These endowments valued at equilibrium factor prices determine factor incomes for each group, and the transfer shares applied to equilibrium tax revenue determine transfer incomes. Information on factor endowments and transfer shares of each consumer group is available on the Treasury Department merged tax file compiled from 1973 individual income tax returns. For each income range, the capital endowment is indicated by the sum of interest and rent receipts, financial capital gains, dividends, and the income from unincorporated enterprises. Labor endowments are indicated by wage and salary income, while transfers from government include a number of items such as social security and welfare payments.

The merged tax file also furnishes average and marginal tax rates for each income group. All disposable income after taxes and transfers is spent by each consumer since one of the purchased commodities is savings. Information on consumers' expenditures for the other 15 commodities is obtained from the 1973 Survey of Consumer Expenditures, which gives data for each income bracket used in the model.

We also require the effective rates of ad valorem tax on each of these purchases, since State and local sales tax are modeled as consumer taxes with different rates for each good. The total sales tax collections are an indirect business tax available from NID sources, and the distribution among commodities is determined from a weighted average of State rates scaled so that total collections are matched. The rate for each commodity reflects the proportions of expenditures that on a nationwide basis are exempt.

In order to estimate coefficients for the G transition matrix between consumer goods and producer goods, we use a February 1974 publication of the SCB. In the next section we describe our adjustments to this and other data to make them consistent.

The Construction of a Consistent Microeconomic Data Set

One of the important features of our model is its utilization of a consistent microeconomic tax data set, earlier termed our benchmark equilibrium. In this section some of the procedures we have used in constructing the data set are reported and described.

Adjustments must be made to basic data so that the equilibrium conditions of the model are satisfied. Total market demand for each commodity must equal the amount produced, zero economic profits net of tax must be made by each industry, disposable incomes must equal expenditures for each household, payments to factors by industry must equal the corresponding income receipts by source and by households, the Government's budget must be balanced by its receipts, and zero balance (after allowing for capital transactions) should prevail in terms of the value of foreign trade.

As the preceding section indicated, we use detailed national accounts data with a number of adjustments to provide estimates of use of capital and labor services by industry. A combination of national accounts and 1970 input/output data then provide the five components of final demands for producer goods: personal consumption expenditure, government purchases, gross private fixed capital formation, net inventory change, and net exports. The total 1973 final demand facing domestic industries is then adjusted so that, in total value terms, the sum of final demand equals the sum of value added by industry.

The RAS method [12] is used to modify our estimate of the aggregated 1973 I/O matrix into a form consistent with our 1973 value added and final demand. The I/O matrix violates the necessary condition that the sum of the value of intermediate inputs and value added equals the sum of intermediate uses and final demand for each product. The RAS method iterates successively on rows and columns of the matrix until the required consistency conditions are satisfied.

The RAS method is also used to adjust the G transition matrix between consumer and producer goods so that it is consistent with our 1973 data set. The vector of household purchases of consumer goods on our classification is scaled so that in value terms it equals the total personal consumption expenditures on producer goods. The row sums of the G matrix will not match the vector of producer good availabilities, requiring row adjustments to match these. In addition, column sums of the matrix will not equal consumer purchases, and the columns of the matrix can be adjusted to make these conditions hold. As with the I/O matrix, adjustments are made on rows and columns in turn until both sets of conditions are simultaneously satisfied.

A further set of adjustments is made to produce the component of the overall data set that describes the household sector of the economy. The total household receipts of income from ownership of capital and labor services are known from the data on the production side of the economy, and transfer incomes received and income taxes paid are known from the public sector accounts. From information on the merged tax file reporting income by source and income taxes paid it is possible to apportion these totals among our household groups. Total household disposable incomes then equal the value of household purchases of consumer goods.

The 1973 Consumer Expenditure Survey data is aggregated to our 16 consumer goods shown in table 1, and where the expenditure data is deficient, other sources are used. The expenditure data fail to meet exactly the equilibrium conditions of the model; column sums do not match consumer disposable incomes, and row sums do not match aggregate consumer purchases of products. Thus, by repeatedly operating on the rows and then on the columns of the expenditure matrix, the matrix is transformed into a consistent form. This represents the third and final application of the RAS consistency technique.

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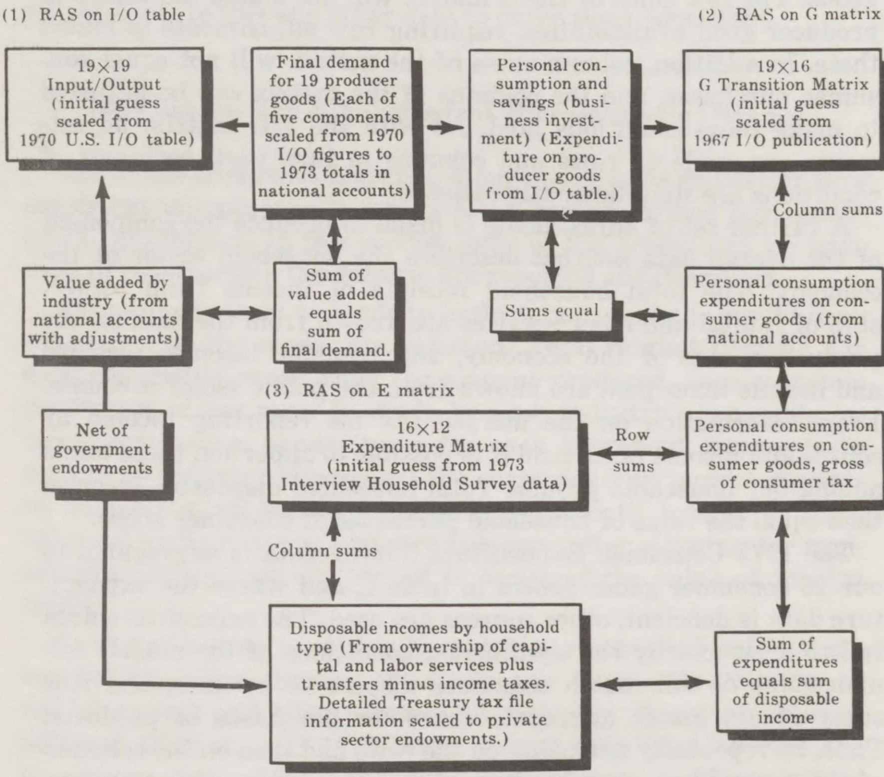
[12] See Bacharach (1971) for a complete presentation of this technique.

The major adjustments we make in order to produce a consistent microeconomic data set are outlined in chart 2. Other conditions must be satisfied by our data, and these involve more minor adjustments. The model requires that the total Government budget be in balance in equilibrium. Because of this, we incorporate the Government deficit or surplus into the model through real transactions, although the surplus involved for 1973 is, at $6 billion, small. Foreign trade must also be in overall balance; this involves incorporating the trade imbalance. The combination of these adjustments along with other more minor data modifications results in our benchmark equilibrium data set.

CHART 2.—*Microeconomic data set modifications to produce overall consistency*



Computer Software and the Solution of the Model

The model described above has been programed in a computer package that allows users to consider the effects of various tax policy changes on the general equilibrium behavior of the economy. This computer package embodies a number of features and uses particular characteristics of the model in its solution. In this section we explain these points.

Factor Price Computation

Although the model involves prices for productive factors, producer goods, and consumer goods, there is a computational saving in solving the model by using factor prices alone.[13] This substantially reduces required execution times.

The procedure is to use factor prices to generate zero-profit producer good prices, which can then be used (via the G matrix) to generate consumer good prices. These consumer good prices are used to evaluate individual, and hence aggregate, demands for consumer goods. From these, industry gross output levels, and hence the derived demand for factor inputs, can be generated. This allows the computational solution of the model to work in the space of factor prices (augmented in one dimension to allow for the presence of the tax system), and an equilibrium solution is obtained by finding a situation in which the excess demand for factors and excess tax receipts are equal to zero. At such a point, all other equilibrium conditions are automatically satisfied.

Equal Yield Computation [14]

Our model also embodies a capability for consideration of tax changes beyond those described simply by changes in tax rates. On many occasions policymakers are primarily concerned with a replacement tax structure (such as an integrated corporate tax) for which a tax rate or rates are chosen with the objective of preserving the existing yield from the taxation system. This capability has been built into our model by maintaining the yield of the tax system in real terms using a Laspeyres price index to correct the existing tax revenue. Alternative replacement tax schemes such

[13] This point is also made by Taylor (1975), and the procedure has been termed "indirect computation" by Ginsburgh and Waelbroeck (1976). Dixon (1974) also uses this approach.

[14] These procedures are explained more fully by Shoven and Whalley (1977).

as an income tax surcharge or a broadly based sales tax are provided, and the tax rate assuring full equilibrium under the new scheme is computed. This capability supplements rather than replaces the examination of the implications of changes in tax rates.

Tax Modification Capability

Because of the model form in which we consider the operation of the U.S. taxation system, it is necessary to convert tax law changes into "model equivalent" tax changes. Thus, were the property tax to be abolished, the effective tax rates on capital services by industry implied by the remaining capital taxes need to be calculated. This general capability is a part of our programs.

Solution Procedure

The user is offered a choice of solution techniques between a fixed point algorithm (similar to Scarf, 1973) and a Newton-Raphson method. The reader interested in the details of these approaches is referred to Shoven and Whalley (1972, 1973). Further, the current computer package includes a subroutine that compares the equilibrium resulting from one tax package with another equilibrium resulting from an alternative policy.

Nonunique Equilibria

A further point is that in a model this complex, the possibility of nonuniqueness of equilibrium solutions cannot be ruled out. We believe that equilibrium solutions for our model will be unique on the basis of ad hoc tests of approaching equilibria at different speeds and from different directions, as done by Whalley (1973, 1975, 1977) with his model of the United Kingdom economy and tax system and by Shoven (1973, 1976) with his earlier and simpler model of the U.S. system. Nonunique solutions, however, cannot be ruled out on a priori grounds.

Uses and Extensions of the Model

The Range of Proposals That May Be Considered

In addition to outlining the structure of our model, we seek to describe the class of policy issues it is capable of analyzing. While in principle all taxation changes generate general equilibrium effects as their induced price changes feed through the economy, these effects are clearly more important for some types of tax changes than for others. As more specific tax changes are examined by our approach, it may prove desirable to treat in more detail those aspects of the model addressed to the issues involved. As we have already mentioned, an examination of income tax reform issues with these techniques would require a more sophisticated modeling of the U.S. income taxation system.

The class of taxation proposals our model can consider are divided into "legal" tax changes and "system" replacements. Legal tax changes refer to those proposals raised in public policy debate in which actual or proposed legislative changes are at issue; system tax changes refer to replacements of subsystems of taxation in our model (such as factor taxation, output taxation, income taxation) by some broadly based alternative. In the first case, we evaluate legislative proposals; in the second, we seek to provide estimates of economy-wide impact by which to evaluate major components of the tax system.

Under legal tax changes, our plan is to consider first the effects of integrating personal and corporate income taxes. The proposals being actively discussed at the present time include "full integration" and "partial integration." Under full integration the present corporate tax would function solely as a withholding tax; individual stockholders in companies would be fully taxed on their earnings per share rather than on dividends only and would be eligible for an income tax credit for corporate taxes withheld. Under the partial integration plan, corporations would be liable for corporation income tax as at present, and individual stockholders would receive a dividend tax credit in the amount of corporate taxes attributable to dividends.

To evaluate each of these integration schemes, it is first necessary to calculate for each industry the new implied effective tax rate on use of capital services. This calculation requires an assessment of dividend payout behavior by firms, the likely adjustments to this behavior implied by the partial integration scheme, and, finally, the implications of these adjustments for effective tax rates. Once obtained, these rates can be used to calculate a new equilibrium for comparison with the existing equilibrium.

Other legal tax changes that could be considered in this general framework include income tax reform, taxes directed at energy conservation, replacement of property taxation by higher sales or income taxes, reform of social security tax, and the introduction of a value-added tax. In each case, the new effective tax rate implied by the change must be calculated and entered in the model.

System tax replacements are tax changes of a more substantial form than are ever likely to be considered by legislative bodies. These types of changes may be considered as polar cases that provide results for evaluation of the economic impact of the entire tax system. This form of analysis is able, for instance, to complement existing incidence studies that assume that no change in relative prices will occur as current tax systems are replaced by a broadly based alternative tax.

An important feature of our approach is the capability for examining the interactive effects of taxation instruments. It is well known that taxes viewed in combination can compound or offset the effects they may produce when examined in isolation. It is misleading, for example, to consider the discriminatory aspects of the corporate tax in isolation from those arising from the property tax. The distortions that each introduces are more satisfactorily examined in combination.

This aspect of our analysis—that we not only examine the general equilibrium aspects of any tax change on the economy, but also take into account interactive aspects with other taxation instruments—is a particular strength of our approach. The preexisting institutional complexity within which all taxation change takes place is an important ingredient of our analysis.

Welfare, Distribution, and Efficiency Aspects of Our Analysis

Another particular strength of our method is that it can provide a wide range of estimates of different effects of tax policy changes. Since we are able to compute a complete new competitive equilibrium, we obtain all the detailed information that describes that equilibrium. We compute not only the new equilibrium prices, but also the new equilibrium quantities, the aggregate amount of production of each good, the usage of productive factors and other goods in each industry, and the purchases of each product by each consumer group. We also obtain the taxes paid on each transaction. If consumer demands are derived by a process of utility maximization subject to a budget constraint, we are able to compute the utility level of each household group before and after the tax change. The ability to determine numerically these detailed results differentiates our approach from those used by other researchers.

The detail generated by our approach does create a problem: to evaluate and compare the overall impacts of tax changes on the economy, some set of summary statistics is needed. This obviously recalls many of the traditional difficulties of index number theory; in our complex model we have no exact properties of indices to appeal to.

Our procedure has been to compute indices of three broad types. We compute the changes in national income magnitudes by calculating the total value of production in each equilibrium first at old, then at new, equilibrium prices. These measures may be loosely interpreted as measures of efficiency gain or loss. Harberger (1976) has recently suggested the calculation of aggregate compensating and equivalent variations as measures of efficiency impact. He has argued that such measures not only provide a more useful index than national income-type measures but also largely avoid the index number difficulties the latter often raise. Such measures can also be computed by our approach. We also compute variations in the distribution of income both by comparing points on Lorenz curves and by computing traditional summary measures such as the Gini coefficient. Implied adjustments in factor usage by industry, industry levels, and relative prices are also calculated.

Our model thus produces a richness of detail and a wide range of summary measures of change. Many alternative measures can also be computed; for this reason, the techniques we present cannot dispense with personal judgment in deciding which are the important elements of change between equilibria.

Future Extensions of the Model

The model as presented provides a comparative static analysis of changes in tax policy; it does not provide a projection of the time path of the economy. A major aspect not captured is that of possible adjustments in the capital stock of the economy. At the present time the analysis focuses on reallocation rather than on accumulation.

A future extension of our approach will incorporate dynamic considerations by calculating the augmentation of the capital stock resulting from both individual decisions with respect to savings and the depreciation of the aggregate capital stock. Individual capital endowments are thus determined by the model for the next period, and the model can be solved for a sequence of equilibria rather than a single static equilibrium.

Further elaborations on our approach may also include a detailed analysis of the energy sector, a disaggregation of capital and labor into types, and the inclusion of consumer groups distinguished by demographic characteristics. Changes in demographic patterns over time can then be considered in a fashion similar to changes in capital stock, by a sequence of equilibria.

Computational Example

The calculations presented in tables 7 and 8 are suggestive of some of the capabilities of our approach. Not all of the features described above have been included here since neither data nor programs were complete at the time of these computations. Sales and incomes taxes are excluded, as is the distinction between producer and consumer goods. In this particular example, a single consumer has Cobb-Douglas demands for 19 goods with a substitution elasticity of 1. Each of the 19 producers uses other outputs as intermediate inputs in fixed coefficients, while each uses capital and labor in Cobb-Douglas production functions with a substitution elasticity of 1.

Table 7 first shows the demand components of each good in the replicated 1973 equilibrium. Total consumption now includes general Government purchases and investment since there is only one consumer who accrues all income. Final demand plus intermediate demand equals total output, which is reproduced on the second page of the table along with labor, capital, and tax levels. Given only functional parameters and total endowments, the computer has solved for levels that replicate our 1973 data, including the data shown in tables 4, 5, and 6 of this paper.

Table 8 shows the percentage changes in all of these levels when we calculate a second equilibrium using all of the same functional forms and parameters except for the rate of tax on use of capital. All industries now pay the same rate, equal to the average tax rate in the previous equilibrium. Table 8 also shows the change in national income using both Laspeyres and Paasche indices, revealing that income could be higher by $5.85 to $7.77 billion without the distortions introduced by the corporate income and property taxes' differing effective rates by industry.

A number of interesting points can be drawn from this set of calculations. First, note that all eight industries whose capital tax rates have been increased (industries 1, 2, 3, 8, 10, 17, 18, and 19) will now use absolutely less capital and absolutely more labor. All their output prices also increase. Second, the price of capital increases, even though these eight industries have very capital-intensive production processes. One might expect that higher

TABLE 7.—*Equilibrium solution replicating the benchmark equilibrium*

[In millions of dollars]

Good number [1]	Total consumption	Exports	Imports for consumption	Imports for production	Final demand	Intermediate production	Total
1	10,405.9	10,313.2	2,368.1	2,339.2	16,011.8	96,308.5	112,320.3
2	1,700.5	1,253.3	140.7	1,080.8	1,732.3	14,270.3	16,002.6
3	367.7	103.1	311.6	4,879.0	–4,719.8	21,190.4	16,470.6
4	132,143.8	0.0	0.0	0.0	132,143.8	27,924.0	160,067.8
5	92,318.5	6,831.7	984.3	4,706.1	93,459.8	37,402.9	130,862.7
6	31,979.2	3,475.3	3,438.3	2,303.2	29,713.0	35,650.0	65,363.0
7	10,230.1	1,405.6	154.4	2,015.6	9,465.7	47,423.2	56,888.9
8	15,832.1	556.7	144.9	2,994.8	13,249.0	27,906.0	41,155.1
9	20,358.0	6,259.0	0.0	3,509.5	23,107.5	66,684.4	89,791.9
10	11,751.3	1,700.9	422.0	2,338.9	10,691.3	55,121.7	65,813.0
11	91,677.2	27,499.4	2,537.4	22,712.8	93,926.3	218,863.2	312,789.5
12	24,020.9	4,653.3	664.1	420.1	27,590.0	12,810.5	40,400.6
13	33,586.4	6,080.0	6,962.5	3,276.4	29,427.5	30,654.3	60,081.8
14	62,767.3	8,662.3	6,297.3	5,287.0	59,845.3	111,096.2	170,941.5
15	185,585.0	0.0	0.0	0.0	185,585.0	65,348.9	250,934.0
16	37,850.3	0.0	0.0	0.0	37,850.3	46,242.5	84,092.8
17	111,252.2	0.0	0.0	0.0	111,252.2	51,906.1	163,158.3
18	132,066.7	5,805.0	280.8	2,028.8	135,562.1	121,578.4	257,140.5
19	4,100.7	0.0	0.0	0.0	4,100.7	24,887.8	28,988.4

CONSUMER INCOME SUMMARY

Before-tax income	After-tax income	Sales taxes paid	Income taxes paid	Transfer income	Value of labor supplied	Value of capital supplied
825,013.0	1,099,994.1	0.0	0.0	184,981.1	643,040.0	181,973.0

TABLE 7.—*Equilibrium solution replicating the benchmark equilibrium*—Continued

[In millions of dollars]

PRODUCTION SECTION

Producer	Output	Relative price	Labor utilized	Labor taxes	Capital utilized	Capital taxes	Output taxes
1	112,320.3	1.0000	16,257.0	1,141.0	30,778.0	2,739.0	68.0
2	16,002.6	1.0000	4,718.0	464.0	1,136.0	518.0	73.0
3	16,470.6	1.0000	3,415.0	308.0	3,370.0	1,002.0	826.0
4	160,067.8	1.0000	50,908.0	5,308.0	1,023.0	1,364.0	334.0
5	130,862.7	1.0000	16,964.0	1,859.0	1,817.0	3,247.0	9,407.0
6	65,363.1	1.0000	17,447.0	2,268.0	1,086.0	1,508.0	28.0
7	56,888.9	1.0000	18,996.0	1,948.0	2,721.0	2,635.0	38.0
8	41,155.1	1.0000	2,834.0	239.0	8,282.0	1,630.0	4,202.0
9	89,791.9	1.0000	19,387.0	1,957.0	3,910.0	4,191.0	926.0
10	65,813.0	1.0000	17,419.0	1,930.0	4,229.0	2,097.0	24.0
11	312,789.5	1.0000	87,996.0	9,167.0	10,401.0	10,211.0	199.0
12	40,400.6	1.0000	13,738.0	1,393.0	168.0	1,085.0	81.0
13	60,081.8	1.0000	15,064.0	1,358.0	4,847.0	3,269.0	629.0
14	170,941.5	1.0000	59,086.0	6,188.0	13,255.0	9,639.0	5,919.0
15	250,934.0	1.0000	130,239.0	13,745.0	9,721.0	10,890.0	3,237.0
16	84,092.8	1.0000	32,839.0	3,161.0	7,840.0	10,603.0	1,155.0
17	163,158.3	1.0000	7,782.0	827.0	56,832.0	26,101.0	2,856.0
18	257,140.5	1.0000	112,785.0	10,179.0	12,746.0	3,167.0	218.0
19	28,988.4	1.0000	15,166.0	1,557.0	7,811.0	0.0	−6,132.0
20[2]	0.0	1.0000	0.0	0.0	0.0	0.0	0.0
21[3]	0.0	1.0000	0.0	0.0	0.0	0.0	0.0
Total			643,040.1	64,997.0	181,973.0	95,896.4	24,088.0

Government expenditures	184,981.1
Total tax revenues	184,981.0
National income	1,009,994.1

[1] Numbers correspond to industries listed in table 2. [2] Labor [3] Capital

TABLE 8.—*Percentage changes from benchmark equilibrium when capital tax rates are all set to the average tax rate*

Good number [1]	Total consumption	Exports	Imports for consumption	Imports for production	Final demand	Intermediate production	Total
1	–15.53	–16.37	–16.37	–16.37	–15.82	–4.60	–6.20
3	–5.66	–6.70	–6.70	–1.15	–0.03	1.43	1.25
4	1.85	0.0	0.0	–6.70	–6.78	–2.09	–0.74
5	–5.02	–6.08	–6.08	0.0	1.85	–1.21	1.32
2	–0.01	–1.18	–1.18	–6.08	–5.04	–3.30	–4.54
6	3.30	2.06	2.06	2.06	3.39	2.44	2.87
7	3.62	2.38	2.38	2.38	3.73	0.86	1.34
8	–9.99	–10.95	–10.95	–10.95	–9.81	0.10	–3.09
9	3.52	2.28	0.0	2.28	3.38	0.95	1.57
10	–0.13	–1.30	–1.30	–1.30	–0.02	0.99	0.82
11	3.68	2.44	2.44	2.44	3.65	2.01	2.50
12	7.95	6.61	6.61	6.61	7.78	4.82	6.84
13	2.86	1.63	1.63	1.63	3.03	2.14	2.58
14	0.93	–0.26	–0.26	–0.26	0.99	0.54	0.70
15	3.07	0.0	0.0	0.0	3.07	0.55	2.41
16	11.70	0.0	0.0	0.0	11.70	1.67	6.18
17	–4.18	0.0	0.0	0.0	–4.18	0.41	–2.72
18	–0.66	–1.81	–1.81	–1.81	–0.69	0.93	0.08
19	–9.10	0.0	0.0	0.0	–9.10	0.85	–0.55

CONSUMER INCOME SUMMARY

Before-tax income	After-tax income	Sales taxes paid	Income taxes paid	Transfer income	Value of labor supplied	Value of capital supplied
1.37	1.19	0.0	0.0	0.35	0.0	6.23

TABLE 8.—*Percentage changes from benchmark equilibrium when capital tax rates are all set to the average rate* (Cont.)

PRODUCTION SECTION

Producer	Output	Relative price	Labor utiliized	Labor taxes	Capital utilized	Capital taxes	Output taxes
1	−6.20	19.5769	20.23	20.23	−17.52	392.28	12.16
2	1.28	1.1895	3.49	3.49	−5.36	10.25	2.48
3	−0.74	7.1842	10.80	10.80	−9.61	61.48	6.39
4	1.32	−0.6403	−0.23	−0.23	45.54	−42.02	0.67
5	−4.54	6.4753	−15.09	−15.09	47.69	−56.10	1.64
6	2.87	−2.0216	−1.80	−1.80	46.60	−43.92	0.79
7	1.34	−2.3259	−2.88	−2.88	19.71	−34.34	−1.02
8	−3.09	12.2973	20.33	20.33	−9.37	144.59	8.83
9	1.57	−2.2303	−5.43	−5.43	22.64	−39.23	−0.69
10	0.82	1.3183	2.39	2.39	−3.82	3.03	2.15
11	2.50	−2.3789	−1.29	−1.29	22.49	−33.73	0.06
12	6.84	−6.2037	−4.86	−4.86	338.53	−63.93	0.21
13	2.58	−1.6069	0.93	0.93	6.00	−16.51	0.93
14	0.70	0.2563	−1.36	−1.36	6.83	−21.97	0.96
15	2.41	−1.8010	−1.15	−1.15	31.16	−37.81	0.57
16	6.18	−9.3215	−6.80	−6.80	37.05	−46.17	−3.71
17	−2.72	5.5500	5.27	5.27	−3.52	11.59	2.68
18	0.08	1.8442	2.89	2.89	−19.19	72.75	1.92
19	−0.55	11.2055	15.21	15.21	−27.37	0.0	10.59
20 [2]	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 [3]	0.0	6.2336	0.0	0.0	0.0	0.0	0.0
Total			−0.00	−0.27	−0.00	0.79	0.22

Government expenditures	0.35
Total tax revenues	0.35

National income:

	at base case prices		at revised case prices
base case	1,009,993.63	base case	1,016,121.56
revise case	1,017,766.13	revise case	1,021,975.50
% change	0.77	% change	0.58

[1] Numbers correspond to industries listed in table 2. [2] Labor [3] Capital

prices here would imply lower output, lower demand for capital, and thus a lower capital price. But it turns out that these particular outputs are used much more for intermediate purposes than for final demand, so that lower prices and greater outputs elsewhere mean that more of these intermediate goods must be produced in spite of their higher prices. Greater output in these capital-intensive industries drives up the price of capital.[15]

Third, it should be noted that while the magnitudes of these changes depend on the elasticity parameters utilized, the direction usually does not. In a separate computation, identical except for a .5 substitution elasticity in production, the percentage changes from benchmark were all smaller. The change in national income from removing capital tax distortions in this case was $1.67 to $3.33 billion.

Finally, we suggest that by varying the substitution elasticities and other parameters across industries or across consumers, we can derive relationships relevant to tax incidence analysis in addition to calculating point estimates of likely tax burdens.

We made four runs in which capital income tax distortions were eliminated in stages. Table 9 shows the increase in national income measured by old or new prices when part or all of the corporate income tax is eliminated. An effort to eliminate the corporate income tax would seem to have some diminishing returns, with gains from eliminating the first tenth larger than gains from the last tenth.

Another four runs were made in which the corporate income tax was eliminated, but the elasticity of substitution in production was varied. Table 10 shows the increase in national income for each case. It appears that the welfare gain is almost linearly related to this elasticity, at least for the case in which consumers' elasticity of substitution in the utility function is 1.

Conclusion

In this paper we have described a numerical general equilibrium model of the U.S. economy and taxation system presently being constructed. This model incorporates all the major taxation instruments currently operating in the United States and allows for consideration of a wide variety and combination of policy varia-

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[15] In a separate calculation in which all capital tax rates were set to a higher .7, the price of capital fell below the benchmark price, as we would have expected here.

TABLE 9.—*Welfare gains in the Cobb-Douglas case* [1]

Elimination of	(a) Paasche (lower bound)	(b) Laspeyres (upper bound)	(c) Geometric mean
One-tenth the corporate tax	.67	.69	.68
One-half the corporate tax	2.88	3.28	3.07
All corporate income tax	3.45	5.63	4.41
All capital income tax	5.85	7.77	6.74

[1] In billions of 1973 dollars.

TABLE 10.—*Welfare gains with elimination of the corporate income tax* [1]

Elasticity of substitution in production	(a) Paasche (lower bound)	(b) Laspeyres (upper bound)	(c) Geometric mean
.5	1.67	3.33	2.36
1.0	3.45	5.63	4.41
1.5	5.51	7.94	6.61
2.0	7.64	10.21	8.83

[1] In billions of 1973 dollars.

tions. At this stage, the focus has been on constructing a manageable, but nonetheless realistic, model that provides a basis for further elaboration.

A major contribution of this work is the assembling, for a recent year, of a consistent microeconomic data set for tax analysis. Such a data set has not previously been constructed for the U.S. economy and is an indispensable component of a complete general equilibrium analysis of tax policy. Because national accounting at the present time is oriented toward production of macroeconomic data, we have had to use a number of diverse data sets between which there are inconsistencies. We have therefore devoted a portion of our paper to a description of our consistency procedures.

After construction of this model is complete, the general equilibrium implications of alternative schemes of integration of corporate and personal income taxation will be analyzed. Other investigations using the model are also anticipated.

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COMMENT

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The present paper is so much in the "tradition" of my own work on related topics that I faced something of a dilemma in framing my comments on it. Should I frankly recognize the similarity (at the risk of intruding myself into the authors' story) or should I couch my comments in a more "objective" tone, dissimulating my long involvement in the field? For better or worse, I have taken the first option. In the final analysis, this choice could not be avoided, for the structure of my own thinking on economic problems, as it has evolved through time, is simply too much a part of me to be hidden behind any plausible disguise.

That said, let me straightforwardly take the role of an intellectual grandfather in approaching the paper. It does not really matter to what degree my work had a direct influence on the evolution of the paper; indeed, if many of the judgments on which the authors and I coincide were reached independently, it is in some sense even more impressive. After all, grandparents *should* prefer it when grandchildren come to share their views via an independent route rather than through direct inculcation.

So it is with pleasure that I note

1. that the authors present a general equilibrium framework for taxation;

2. that they amalgamate property taxes with corporation income (and franchise) taxes in each sector and treat the result as a single tax on capital income (the percentage rate of tax differing by sector according to the weight of these combined taxes in total (gross-of-tax) income from capital);

3. that they similarly amalgamate social security, workmen's compensation, and unemployment compensation contributions (regardless of whether they are allocated to employer or employee) as a single tax on labor input, with rates varying by sector according to the weight of these taxes in total (gross-of-tax) income from labor;

4. that they use a production-function framework that allows for substitution between labor and capital at the industry level, but not between these primary factors on the one hand and ma-

terial inputs on the other (fixed coefficients are assumed for material inputs);

5. that the principle of aggregation used (separately) for the capital and labor inputs was that the unit of capital (labor) was the amount that generated one dollar of income in the base (equilibrium) period;

6. that, as tax changes and other disturbances are introduced into the system, capital and labor are assumed to be reallocated so as to maintain equality in the net-of-tax rate of return (and net-of-tax wage) across different industries and sectors; and

7. that consumer demand is assumed to obey a specified functional form (e.g., CES), with consumer prices reflecting, in equilibrium, the rewards paid to primary factors plus factor taxes paid (see items 2 and 3) plus indirect taxes (on both intermediate and final products).

All of the above are close enough to assumptions used in my own work (both in the papers cited by the authors and in others [1]) that I would be embarrassed were I now to find fault with them.

The same goes for some of the technical procedures adopted in the process of reducing an infinitely complex reality down to the dimensions of the model:

8. Income of unincorporated enterprises is divided between labor and capital on the assumption that the labor of the self-employed (proprietors, partners, etc.) in any industry has a value (per person) equal to the average compensation of employees in that industry.

9. Capital's return is defined to include net interest paid (after imputing to financial intermediaries a payment of interest from them to their depositors, balanced by an imputed service charge from their depositors to them), plus net rents paid, plus corporate profits plus the part of the income of unincorporated enterprises that remains after the labor allocation specified in h) has been made.

10. The equalization of the net-of-tax return to capital is assumed to take place at the level where the market meets—i.e., after corporation and property taxes but before personal taxes. This means that corporate savings are automatically counted as part of the net return to capital and that the subsidy to owner-occupied housing occasioned by the nontaxation of imputed income from it is treated as if it were explicit (and divorced from the personal

[1] Especially "The Measurement of Waste," *American Economic Review* 54:3 (May 1964), pp. 58–76.

tax), with housing income (including such subsidy) then being subject to full personal taxation at normal rates.

These are not the only ways of handling the specific problems the authors address; but, while being arbitrary in a sense, these procedures nonetheless reflect what I consider to be sound and sensible judgment.

The specific application of the model reported in the section titled "Computational Example" and dealing with the hypothetical equalization of the tax rates applying to income from capital generated in different industries, is unexceptionable. It shows what the model can do when it is used to analyze one of the specific class of problems for which it was built.

My only quarrel is with the authors' penchant for reporting changes in welfare by calculating the total value of production in each equilibrium first at old, and then at new, equilibrium prices. I have suggested elsewhere that far better measures are available, and the authors are kind enough to cite me to this effect; but they proceed (stubbornly in my view) to compute and report inferior rather than superior measures. (Actually, they give in tables 9 and 10 the geometric mean measure of welfare gain, which is far better than either of the two component measures they report, but they neither explain what it does, nor encourage its use by others.)

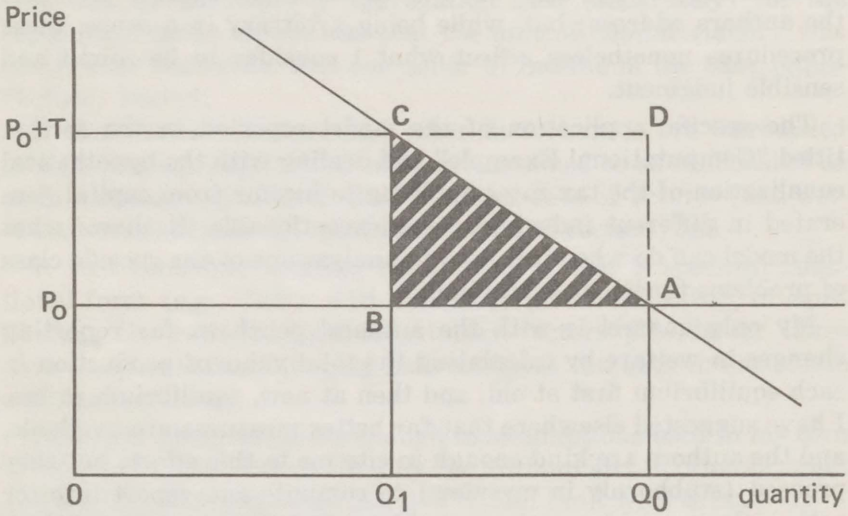
Lest these grandfatherly remarks be interpreted as signs of senility, let me justify them by an appeal to the very simple and familiar example of the welfare loss from an excise tax. Assuming the tax in question to be the only distortion, and production costs to be constant (linear production possibility locus for the economy as a whole), the familiar triangle between the demand and supply curves (ABC in figure 1) gives the "right" measure of the loss. The authors' preference, however, seems to be to report an upper bound of the rectangle ABCD and a lower bound of zero ($\Sigma p_i^o \Delta x_i = 0$ for movements along the linear production constraint $\Sigma p_i^o x_i = K$). Why, I ask, be so inelegant in reporting results after going to all the work of constructing a very elegant model?

If I were they, having gone so far as to produce the model, I would program it to approximate a Divisia measure of welfare change. The basic measure of such a change is

$$\int \sum_i T_i(z) \frac{\partial x_i}{\partial z} dz.$$

For a change in a vector of taxes from T_i^o to T_i^*, let $T_i(z)$ be equal to $T_i^o + z(T_i^* - T_i^o)$, and let the line integral then be taken from

FIGURE 1



$z=0$ to $z=1$. To approximate this, I would suggest programing the calculation of ten steps, the first going from $z=0$ to $z=0.1$, the second going from $z=0.1$ to $z=0.2$, etc.; we might even have only four or five steps—but I feel that having more than ten would be gilding the lily. And within each step I would evaluate the change in welfare at $T_i(z)$ for z at the midpoint of the step. Actually, the authors report in table 9 calculations that bear a family resemblance to what I have here suggested—they measure the welfare gains of eliminating a) one-tenth of the corporation income tax, b) one-half of the corporation income tax, c) all of the corporation income tax, and finally d) all taxes on income from capital. However, they do not evaluate the change in increments, at prices corresponding to each step, and they continue to pay far too much attention to their upper and lower bounds.

My main criticism (if it can be called that) of the paper is really a sort of warning, perhaps directed more to the authors than to their readers. It concerns the possibilities of getting interesting or useful results out of applications of the model to problems connected with the size distribution of income.

So far as I can see, the division of consumers into 12 income groups is an interesting frill but not a fundamental feature of the model. So long as the model itself discriminates only between two primary factors, L and K, it cannot really explain why some families are in group 1, others in group 6, and others in group 12.

What the model can and does do is show how a given change in relative factor rewards will affect the size distribution of income. If the net return to capital rises by 10 percent while that to labor falls by 5 percent, a group whose income comes 80 percent from capital will enjoy a rise of 7 percent, while a group whose income comes 90 percent from labor will suffer a fall of 3.5 percent.

It is easy to appreciate that this information adds to the richness of our understanding of the effects of a disturbance like the reduction of the corporation tax rate. However, the model is not built to help decide how progressive the tax system ought to be or to analyze the effects of changes in, say, the progressivity of the personal income tax.

For such matters one would want to know much more than this model tells about the anatomy of income distribution—how education and skills are distributed, how their economic rewards are determined, how various tax provisions (e.g., those relating to capital gains, gifts, trusts, estates) impinge differentially on different layers of the income distribution.

To my mind, this model does not provide what is needed, nor is it the proper starting point from which to build what is needed. The division of the economy into 19 industries is a sensible classification for answering certain questions; it is not so for answering others. Serious work focusing on Gini coefficients and Lorenz curves would call for a totally different model.

This simply calls attention to a general proposition that is widely—but perhaps not widely enough—appreciated among practitioners of empirical economics. That proposition is that it is *never* worthwhile to build a model to replicate the economy. *All* models are partial in the sense that they fail at this impossible task. To be useful, a model must be well suited to the problem being addressed (even though the model may not be explicitly built for that problem). More generally, however, the advice that economic models should in principle be separately tuned (if not built) for each problem is clearly better than the suggestion that one grand model that will handle a broad gamut of questions (many not even perceived by the builders) should be sought.