Volume Title: Behavioral Simulation Methods in Tax Policy Analysis

Volume Author/Editor: Martin Feldstein, ed.

Volume Publisher: University of Chicago Press

Volume ISBN: 0-226-24084-3

Volume URL: http://www.nber.org/books/feld83-2

Publication Date: 1983

Chapter Title: Domestic Tax Policy and the Foreign Sector: The Importance of Alternative Foreign Sector Formulations to Results from a General Equilibrium Tax Analysis Model

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Chapter URL: http://www.nber.org/chapters/c7713

Chapter pages in book: (p. 333 - 368)

10 Domestic Tax Policy and the Foreign Sector: The Importance of Alternative Foreign Sector Formulations to Results from a General Equilibrium Tax Analysis Model

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10.1 Introduction

There is a growing recognition among public finance economists of the inappropriateness of closed economy models for analyzing alternative United States tax policies. Foreign trade has increased fairly sharply as a fraction of GNP and capital markets have become more international in scope since the early 1960s. United States investors participate in foreign capital markets both directly and indirectly through multinational corporations, and foreign direct investment in the United States has grown enormously since the early 1970s. In this paper we report on some alternative treatments of the external sector within an empirical general equilibrium model of the United States economy and tax system. This general equilibrium model has been described elsewhere (Fullerton, Shoven, and Whalley 1978; Fullerton, King, Shoven, and Whalley 1981). The new specifications of the external sector are motivated by the twin concerns of developing a general equilibrium analysis of tax policy where foreign trade issues enter, and of assessing the sensitivity of earlier results concerning alternative domestic tax policies to the specification of the external sector.

In previous analyses employing this general equilibrium model, we have given little emphasis to foreign trade. The external or foreign sector

was modeled quite simply, and relatively little attention was given to how the foreign sector might influence the United States economy. One simplifying assumption employed in previous versions of the model was that for each commodity the value of net trades between the United States and the rest of the world remained unchanged as prices changed. This assumption provided us with a convenient way of closing the model but was difficult to reconcile with utility maximization. Our alternative specifications are somewhat more complex but more plausible.

The first alternative we explore is the use of constant-elasticity excess demand functions (a constant-elasticity offer curve in the two-good case) to describe foreigners' merchandise trade behavior. We also consider a variant of this formulation in which certain imports are treated as imperfect rather than perfect substitutes for comparable domestic products. For both of these formulations, we consider several different elasticity parameters to evaluate model sensitivity. We then present two formulations which model capital mobility between the United States and the rest of the world. The first of these formulations introduces flows of capital services between the United States and abroad which depend on the difference between domestic and foreign rental rates. An elasticity parameter controls the sensitivity of capital service flows to differences in rental rates. The second of these formulations is similar but involves capital goods rather than capital services. These last two formulations permit us to model the United States as a taker of the rental prices of foreign capital. We were motivated to introduce these formulations partly by the belief that treating the United States in this way might significantly affect the model's evaluation of alternative tax policies.

In order to evaluate the sensitivity of the model to these different specifications, we analyze the integration of corporate and personal income taxes (Fullerton, King, Shoven, and Whalley 1981) and the elimination of savings distortions in the United States income tax (Fullerton, Shoven, and Whalley 1982) under each of these alternative formulations. We also consider the effects of adopting alternative forms of value-added tax (VAT) in the United States. We consider VATs of both the income and consumption type, and on both destination and origin bases.

The plan of the paper is as follows. First, we outline the structure of the basic tax model before any of the modifications we describe are incorporated. Then, we present our alternative foreign sector formulations and discuss the linkage between foreign trade issues and tax policy design. A final section of the paper presents results and major findings.

10.2 Main Characteristics of the Fullerton-Shoven-Whalley General Equilibrium Tax Model

The Fullerton-Shoven-Whalley general equilibrium tax model of the United States can be regarded as a higher-dimensional extension of

traditional Edgeworth box analysis, with particular functions and parameter values used to represent preferences and production possibilities.[1] Taxes enter as ad valorem distortions of factor use, production decisions, and consumer purchases. The model generates sequences of equilibria through time. The equilibria are connected through savings decisions that imply different augmentations to the capital service endowment passed between periods. The model is calibrated to 1973 benchmark data assumed to lie on a balanced growth path for the economy.

The production side of the model includes nineteen profit-maximizing industries which use labor and capital according to constant elasticity of substitution (CES) or Cobb-Douglas production functions. Substitution elasticities are chosen for each industry as the central figures in Caddy's (1976) survey of the literature and range from 0.6 to one. We use data from the *Survey of Current Business* and unpublished data from the Commerce Department's National Income Division to obtain each industry's payments for labor and capital.[2] Base year quantities are derived according to the convention that a unit of each primary factor is that amount which earns one dollar net of taxes in the 1973 benchmark year. A fixed coefficient input-output matrix is derived from Bureau of Economic Analysis tables.

The ad valorem tax on each industry's use of capital comprises the corporation income tax, state corporate franchise taxes, and local property taxes. The social security tax and contributions to workmen's compensation are modeled as an ad valorem tax on industry's use of labor. Various federal excise taxes and indirect business taxes are modeled as output taxes; a different tax rate applies to each of the nineteen industries. State and local sales taxes apply to each of the fifteen consumer goods in the model.

The nineteen producer goods can be used directly by government, for export, or for investment. These producer goods can also be translated into the fifteen consumer goods which enter consumer demand functions. This translation is made possible by a fixed-coefficient G matrix.[3] The G matrix is necessary because the Commerce Department production side data include industries such as mining, electrical manufacturing, and trade, while the Labor Department's *Survey of Consumer Expenditures* provides data on purchases of goods like furniture, appliances, and recreation.

1. The model description given in the present paper draws heavily from section 2 in Fullerton (1980).
2. Labor compensation includes all wages, salaries, commissions, and tips, while capital earnings include net interest paid, net rent paid, and corporate profits with capital consumption adjustments and inventory valuation adjustments. Noncorporate profits were divided between labor and capital on the basis of full-time-equivalent hours and average wage for each industry. Some industries were averaged over several years to avoid recording transitory effects.
3. The G matrix derives from data in the February 1974 *Survey of Current Business*.

Industry and government payments to buy labor and capital services are exactly matched by total household receipts from the supply of each factor. The Treasury Department's Merged Tax File provides information on labor and capital income for each of our twelve consumer classes, as well as tax payments and an estimate of the average marginal income tax rate τ_j for each group. These range from a 1% average marginal rate for the first income class to a 40% rate for the highest income class. A progressive income tax system is then modeled as a series of linear schedules, one for each group. Pensions, IRA plans, and Keogh plans are modeled as a 30% saving subsidy to capture the proportion of saving that now has such tax-sheltered treatment.

We also model a "personal factor tax," a construct designed to capture discrimination among industries by the personal income tax. Each industry is assigned a fraction f_i representing the proportion of capital income from industry i which is fully taxable at the personal level. This fraction is determined from proportions of capital income paid as noncorporate income, dividends, capital gains, interest, and rent.[4] Taxable capital income is subject to τ, the overall capital-weighted average marginal personal income tax rate. At the consumer level, rebates are given to groups with a τ_j less than τ, while additional tax is collected from others. The personal factor tax acts as a withholding tax at the industry level, and corrections at the consumer level sum to zero. The model thus captures the favorable tax treatment given to industries with noncorporate investment tax credit and to the housing industry.

The expanded income of each consumer group is given by transfer income plus capital and labor endowments.[5] The latter is defined as 7/4 of labor income. The figure 7/4 results from our estimate that in the benchmark, forty hours are worked out of a possible seventy hours. Consumer demands are based on budget-constrained maximization of the nested CES utility function:

$$(2.1) \qquad U = U\left[H\left(\sum_{i=1}^{15} X_i^{\lambda_i}, l\right), C_f\right].$$

In the first stage, consumers save some income for future consumption C_f and allocate the rest to a subutility function H over present consumption goods X_i and leisure l. The elasticity of substitution between C_f and H is based on Boskin's (1978) estimate of 0.4 for the elasticity of saving with

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4. All dividends are 96% taxable, because of the 4% that fell under the $100 exclusion in 1973. All retained earnings are 73% taxable. This results from the value tax deferral and rate advantages for capital gains, as well as the taxation of purely nominal gains. Interest and rents are fully taxable except for the imputed net rent of owner-occupied homes, while the noncorporate investment tax credit also appears as a personal tax reduction varying by industry.

5. Portfolio effects are ignored because dividends, capital gains, interest, rent, and other types of capital income are summed to obtain capital endowments.

respect to the net-of-tax rate of return. Saving in the model derives from consumer demands for future consumption under the expectation that all present prices, including the price of capital, will prevail in all future periods. Then income for H is divided between the purchase of leisure l and the purchase of a bundle of fifteen consumer goods. The composition of the consumer-good bundle derives from the maximization of a Cobb-Douglas function. The elasticity of substitution between leisure and consumer goods is based on an estimate of 0.15 for the elasticity of labor supply with respect to the net-of-tax wage.

Consumer decisions regarding factor supplies are thus made jointly with consumption decisions. Demands for leisure and for saving will depend on all relative prices, whether for factor endowments or for commodity purchases. Saving is converted immediately into investment demand for producer goods, with proportions based on national accounting data for fixed private investment and inventories.

In previous versions of the model, the foreign trade sector has been modeled such that the net value of exports less imports is constant for each producer good. This simple treatment closed the model, maintained zero trade balance, and allowed easy calculation of trade quantities, given prices. As we shall see in the next section, however, this specification was hard to reconcile with traditional trade theory; hence the alternative external sector formulations.

The specification of the government sector completes the model. Revenues from the various taxes described above are used for transfers, labor, capital, and producer goods. Lump-sum transfers to each consumer group are based on Treasury Department data for social security, welfare, government retirement, food stamps, and similar programs. Government demands for factors and commodities are represented by a linear expenditure system derived from a Stone-Geary utility function. In equilibrium the government budget is balanced.

Because the benchmark data required for this model are so comprehensive, the sources are necessarily divergent. The two sides of a single account are often collected by different agencies with different procedures, and thus do not match. In order to use all of these data together, there must be adjustments to ensure that each part is consistent with the rest. To do this we accept some data as superior and other data are adjusted to match. All industry and government uses of factors are taken to be fixed, so consumers' factor incomes and expenditures must be scaled. Tax receipts, transfers, and government endowments are fixed, so government expenditures must be scaled to balance their budget. Similar adjustments ensure that supply equals demand for all goods and factors.[6]

6. In particular, the input-output matrix does not conform to the requirement that gross output of each good can be measured by the column sum plus value added, or the row sum plus final demand. An iterative row and column scaling method is employed to generate a consistent matrix, and similar scaling satisfies similar conditions for the expenditure matrix.

The fully consistent data set then represents a benchmark equilibrium, where values are separated into prices and quantities by assuming that a physical unit of each good and factor is the amount that sells for one dollar. Certain elasticity parameters are imposed exogenously, and the model's equilibrium conditions are used to generate remaining behavioral equation parameters which are consistent with the data set. Factor employments by industry are used to derive production function weights, and household expenditures are used to derive utility function and demand function weights. We can use the resulting tax rates, function parameters, and endowments to solve the model, perfectly replicating the benchmark equilibriunm. This calibration allows for a test of the solution procedure and ensures that the various agents' behaviors are mutually consistent in our benchmark data set.

We use the Merrill (1971) variant of Scarf's (1973) algorithm to solve in each period for a competitive equilibrium in which profits are zero and supply equals demand for each good or factor. Simplex dimensions are required only for labor, capital, and government revenue, since a knowledge of these three "prices" is sufficient to evaluate all agent behavior. Producer-good prices are calculated on the basis of factor prices and the zero-profits condition, while consumer-good prices derive from producer-good prices through the G transition matrix. A complete set of prices, quantities, incomes, and allocations is calculated for every equilibrium. Since it is not based on differential calculus, the computational model can accommodate discrete changes in any tax or distortion without linearity assumptions and without ignoring income effects. There can be any number of sectors and agents, and any specifications of demand, so long as Walras's law holds.

The dynamic sequencing of single-period equilibria in the model first assumes that the 1973 consistent data set or benchmark equilibrium lies on a steady-state growth path. Observed saving behavior and the capital endowment are translated into an annual growth rate for capital (approximately 2.75%), and this growth is also attributed to effective labor units. This exogenous growth rate for labor is split evenly between population growth and Harrod-neutral technical progress. The benchmark sequence of equilibria is then calculated by maintaining all tax rates and preferences, increasing labor exogenously, and allowing saving to augment capital endowments over time.[7] By construction, this sequence will have constant factor ratios and constant prices all equal to one.

Policy change simulations are performed by altering tax rates while retaining preference parameters and the exogenous labor growth rate.

7. We convert a dollar of saving into capital service rental units through multiplication by γ, the real after-tax rate of return. The model assumes that twenty-five dollars of saving can purchase a capital asset that will earn one dollar per period net of depreciation and taxes. That is, a value of 0.04 is used for γ.

Saving and other behavior then conform to the specified elasticities, growth of capital diverges from the steady-state rate, and the economy begins to approach a new steady-state path with a new capital/labor ratio. Sequences are compared by discounting the H composites of instantaneous consumption through time with appropriate terminal conditions. Only leisure and present consumption are included in this welfare measure because saving is reflected in later consumption of the sequence. The sequence is discounted at a 4% rate and includes only the initial population. Otherwise, the importance of future periods would be sensitive to population growth.

The welfare gain or loss of a tax change is the aggregate compensating variation, defined as the number of dollars at new prices that would be required for each consumer to attain the old sequence of consumption values. The model thus incorporates both interindustry and intertemporal tax distortions and efficiency changes.

10.3 Different External Sector Formulations

In this section we outline alternative ways of modeling external sector behavior in the general equilibrium tax model of the United States. In section 10.4 we explore the sensitivity of results from various policy simulations to the external sector specifications.

10.3.1 The Existing Foreign Sector Specification

The external sector modeling currently used in the United States general equilibrium tax model focuses solely on commodity trade and ignores all capital transactions. Exports and imports are classified into three categories of producer goods: those for which there are net imports (seven commodities); those for which there are net exports (seven commodities); and those which are not traded (five commodities). The benchmark data set for 1973 is adjusted to guarantee that the value of total exports equals the value of total imports. The model then assumes that the value of net exports remains constant for each export commodity and the value of net imports remains constant for those commodities which are imported. For each of the import commodities we have

$$(3.1) \qquad P_i M_i = M_i^0,$$

and for the export commodities we have

$$(3.2) \qquad P_j E_j = E_j^0,$$

where M_i^0 and E_j^0 are the benchmark net import and export quantities, respectively. Recall that the benchmark prices are unity, by the units assumptions. P_i, M_i, P_j, and E_j are the current prices and quantities for imports and exports. Since initially

(3.3) $\sum_j E_j^0 = \sum_i M_i^0,$

we always have the condition that

(3.4) $\sum P_j E_j = \sum P_i M_i,$

or the value of exports equals the value of imports. This trade balance condition is necessary in a general equilibrium model that does not allow for international capital flows.

This modeling has several drawbacks. First, commodities cannot switch between being imported and being exported. Far more serious is the feature that import supply by foreigners reacts perversely to changes in commodity prices: this specification has import supplies negatively related to prices with an elasticity of -1.

A related problem with this treatment is that in the two-good analogue it implies an offer curve which is different from those usually found in traditional trade theory. This difficulty is transparent if we plot, for the two-good case, the foreign offer curve the United States economy is assumed to face. Suppose E and M each now refer to scalars rather than vectors; the constant-value net trade formulation implies

(3.5) $E = E^0 P_E^{-1},$

(3.6) $M = M^0 P_M^{-1},$

where E^0 and M^0 are base year exports and imports, and P_E and P_M are export and import prices, respectively. When superimposed on a diagram incorporating the usual form of home country offer curve (figure 10.2), this is seen to violate traditional trade theory on two counts: (a) the foreign offer curve does not go through the origin; and (b) the foreign offer curve is concave rather than convex to the M axis.

Clearly this simple formulation contains some major departures from traditional trade theory; consequently, we consider a number of alternative external sector formulations.

10.3.2   General Constant Elasticity Specification

The first alternative specification differs from the simple specification above in two main ways.[8] First, import supply functions are modeled so as to have a positive price elasticity. Second, the restrictive Cobb-Douglas type assumption of the previous specification—the assumption that the value of net exports remains constant for each commodity—is no longer employed.

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8. This section relies on material presented in Whalley and Yeung (1980), which analyzes the external sector equation system discussed in Boadway and Treddenick (1978).
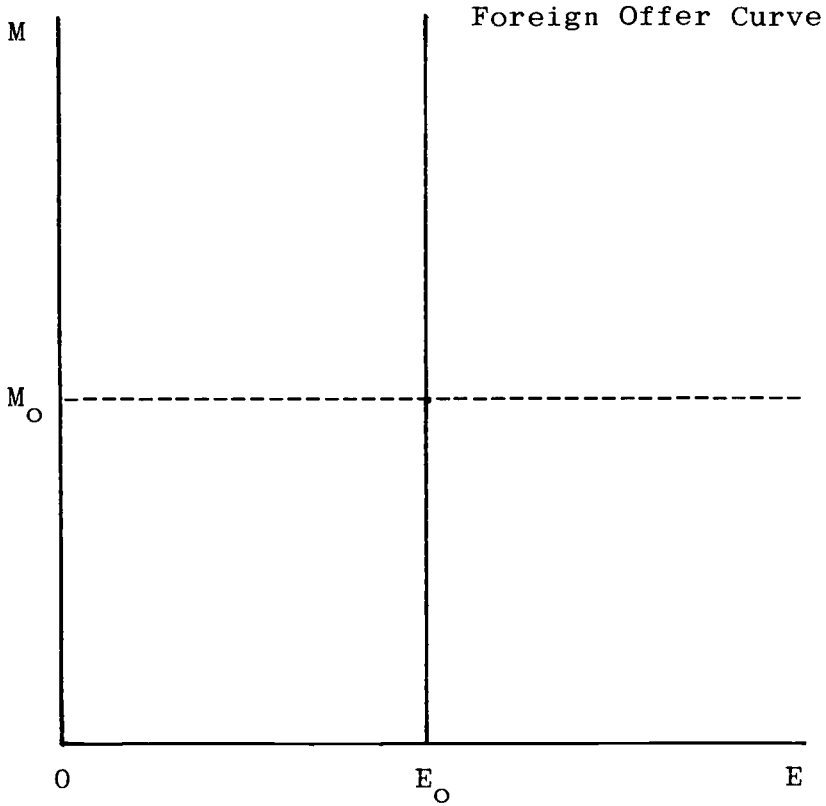
M | Foreign Offer Curve

Fig. 10.1   Diagram of foreign offer curve.

In this formulation, the relative prices of traded goods are endogenously determined in the model. Trade balance is assured since foreigners' excess demand functions (export demand and import supply) satisfy budget balance.

This specification operates as follows. For each of the n producer goods (in the case of our model, $n = 19$), we specify an import supply function and an export demand function, with parameters μ and η as price elasticities of import supply and export demand, respectively:

$$(3.7) \qquad M_i = M_i^0 \left(\frac{P_{M_i}}{e}\right)^{\mu} \quad \begin{array}{l} 0 < \mu < \infty, \\ i = 1, \ldots, n \end{array}$$

$$E_i = E_i^0 \left(\frac{P_{E_i}}{e}\right)^{\eta} \quad \begin{array}{l} -\infty < \eta < 0, \\ i = 1, \ldots, n \end{array}$$
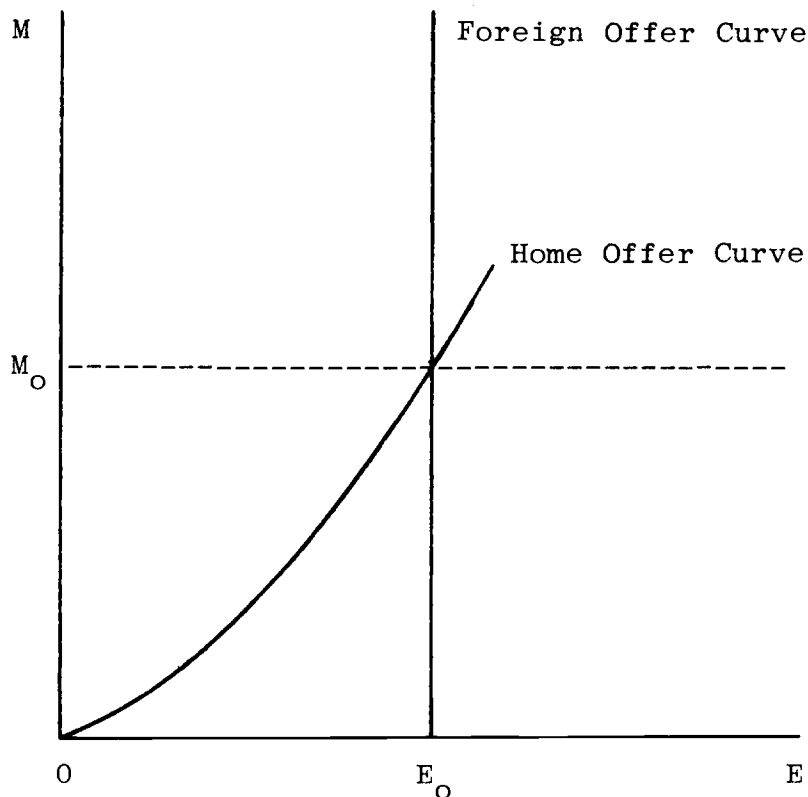
Fig. 10.2   Diagram of foreign offer curve with superimposition of traditional home offer curve.

where P_{M_i} is the domestic price of imports and P_{E_i} is the domestic price of United States exports (cost-covering price received by United States producers). The variable e can be interpreted as an exchange rate between domestic and foreign prices although we will show below how e can be removed by a simple substitution into the trade balance equation. As in all classical general equilibrium models which focus solely on relative goods prices, this exchange rate is a purely financial magnitude with no significance for real behavior in long-run equilibrium, although it is helpful for our exposition if we use this terminology.[9] P_{M_i}/e is the price the foreign exporter receives, and P_{E_i}/e is the price foreign purchasers must

9. No well-defined financial sectors are specified in our model; there is no domestic or foreign demand-for-money function which determines the relative prices of domestic and foreign monies (the exchange rate) in a purely monetary sense.

pay for United States exports. The sign restrictions on μ and η are discussed below.

In order to close the system and solve the general equilibrium model, we add the trade balance constraint that

$$(3.8) \qquad \sum_{i=1}^{n} P_{M_i} M_i = \sum_{i=1}^{n} P_{E_i} E_i .$$

If we substitute for M_i and E_i from equation (3.7), we have

$$(3.9) \qquad \sum_{i=1}^{n} P_{M_i} M_i^0 \left(\frac{P_{M_i}}{e}\right)^{\mu} = \sum_{i=1}^{n} P_{E_i} E_i^0 \left(\frac{P_{E_i}}{e}\right)^{\eta}$$

If we now define

$$(3.10) \qquad \begin{aligned} \alpha_1 &= \sum_{i=1}^{n} (P_{M_i})^{\mu+1} M_i^0, \\[2ex] \alpha_2 &= \sum_{i=1}^{n} (P_{E_i})^{\eta+1} E_i^0, \end{aligned}$$

equation (3.9) can be solved for the exchange rate parameter

$$(3.11) \qquad e = \left(\frac{\alpha_2}{\alpha_1}\right)^{1/(\eta-\mu)} .$$

Finally, substituting this result in (3.7) gives

$$(3.12) \qquad M_i = M_i^0 P_{M_i}^{\mu} \left(\frac{\alpha_2}{\alpha_1}\right)^{\mu/(\mu-\eta)} ,$$

$$(3.13) \qquad E_i = E_i^0 P_{E_i}^{\eta} \left(\frac{\alpha_2}{\alpha_1}\right)^{\eta/(\mu-\eta)}$$

Note that α_1 and α_2 are themselves functions of import and export prices, respectively. Equations (3.12) and (3.13) can be thought of as reduced-form import supply and export demand equations. Another interpretation is that they are the external sector behavior equations compensated for zero trade balance. They reflect the fact that one cannot simply specify an import supply elasticity and an export demand elasticity, and simultaneously assume zero trade balance. The trade balance condition provides a cross-equation restriction implicit in our solution procedure for equations (3.12) and (3.13).

Another thing to note about the reduced-form import supply and export demand equations is that they depend only on domestic prices: the exchange rate has been eliminated by substitution. Thus equations (3.12) and (3.13) depend only upon the real terms of trade given by the (α_2/α_1) term.

In the case where only two commodities are involved, the equation

system (3.7) specifies an offer curve of constant elasticity which describes the excess demand functions for the foreign sector. The elasticity of the offer curve is

$$(3.14) \qquad \epsilon^{OC} = \frac{\eta}{1 + \eta} \frac{1 + \mu}{\mu},$$

and this parameter ϵ^{OC} is related to the price elasticity of both foreign export demand and foreign import supply through the equation (see Johnson 1953, chapter 2, appendix)

$$(3.15) \qquad \epsilon^{OC} = \frac{\epsilon_E^{FD}}{\epsilon_E^{FD} + 1} = \frac{\epsilon_M^{FS} + 1}{\epsilon^{FS}},$$

where ϵ_E^{FD} and ϵ_M^{FS} define the foreign price elasticities of export demand and import supply.

This implies that in terms of the reduced-form equations characterizing the system,

$$(3.16) \qquad \epsilon_E^{FD} = \frac{\eta(1 + \mu)}{\mu - \eta},$$

which for $\eta \leq -1$, $\mu > 0$ implies $\epsilon_E^{FD} \leq 0$. Also,

$$(3.17) \qquad \epsilon_M^{FS} = \frac{-\mu(1 + \eta)}{\mu - \eta}$$

and for $\mu \geq 0$, $\eta \leq -1$, $\epsilon_M^{FS} > 0$.

These elasticities imply that the true price elasticities of the system of foreign excess demand functions are not in fact given by η and μ as the equations (3.7) might seem to suggest, but by the more complicated forms described above. Furthermore, μ and η are not independent parameters but jointly imply an elasticity for the offer surfaces we use. To have the appropriate sign for the value of ϵ_M^{FS}, η must be less than -1 rather than simply negative as stated above.

Because of the form properties of this system, we describe this specification of the external sector as one where the United States is a taker of a foreign offer surface (satisfying a foreign economy version of Walras's law) of constant-elasticity form. The form of utility functions necessary to generate such surfaces is discussed more fully in Johnson (1953), and Gorman (1957). In the section in which we present our results, we discuss further our choice of μ and η.

When we analyze trade in homogeneous products, it is natural to assume that a country will not import and export the same good. This assumption can be expressed as

$$(3.18) \qquad E_i^0 M_i^0 = 0 \quad i = 1, \ldots, n.$$

However, the assumption is violated by empirical data: there are a number of commodities which are both exported and imported by the United States. This phenomenon of "cross-hauling" is evident from trade statistics, even with finely aggregated data, and underlies much of the recent literature on intraindustry trade (see Grubel and Lloyd 1975 and the subsequent literature).

There are many reasons for this phenomenon. In some cases, cross-hauling is dictated by explicitly noncompetitive behavior, such as that mandated by the United States–Canada automobile manufacturing agreement. However, it is also possible to reconcile cross-hauling with competitive behavior. One explanation asserts that foreign commodities are qualitatively different from domestic goods. This assumption of qualitative difference by country (e.g. United States and foreign cars being treated as close but not perfect substitutes) is referred to as the "Armington assumption," following Armington (1969). Cross-hauling can also be explained by reference to geography and transportation costs. For example, it may be perfectly sensible for the United States to export Alaskan oil to Japan and at the same time import oil through ports on the East Coast and the Gulf of Mexico, given the cost of delivering Alaskan oil to the eastern United States.

Previous versions of the model dealt only with net trade flows, as if trade occurred only in one direction for each commodity and there were no cross-hauling. In each of the new formulations, it is possible to deal only with net trades, as before, or alternatively to allow for cross-hauling. When cross-hauling is specified, it is necessary to substitute gross trade flows for net trade flows in the export demand and import supply equations. (For example, E_i^0 and M_i^0 would represent gross magnitudes in the base year in the previous equations in this section.) Although our formulations can incorporate cross-hauling, the reasons for the cross-hauling are not explicitly provided by the model.

10.3.3 Trade Modeling with Imperfectly Substitutable Imports

Our second external sector specification separates imports into two broad categories, depending on whether they are perfect or imperfect substitutes in production for domestically produced intermediate goods. We treat all of the imports discussed in previous subsections as perfect substitutes in production for United States producer goods. We then represent these imports as a negative component of final demand; as a consequence, every additional unit of import of producer good i reduces the gross output requirement of industry i in the model. Industries demanding intermediate goods from industry i are assumed to be indifferent as to whether those goods are produced at home or imported.

We now consider a model specification which allows some imports to be imperfect substitutes for domestic goods in production. Under this

specification, we introduce a single new aggregated import commodity which enters the production structure as an imperfectly substitutable input.[10] This specification invokes the Armington assumption, since it assumes that there is a qualitative difference between the imported input and any domestic inputs used in production (Armington 1969).

The foreign excess demand equations are now

$$(3.19) \qquad M_i = M_i^0 \left(\frac{P_{M_i}}{e}\right)^\mu \quad 0 < \mu < \infty,$$
$$i = 1, \ldots, n,$$

$$(3.20) \qquad E_i = E_i^0 \left(\frac{P_{E_i}}{e}\right)^\eta \quad -\infty < \eta < -1,$$
$$i = 1, \ldots, n,$$

and

$$(3.21) \qquad R = R^0 \left(\frac{P_R}{e}\right)^\mu \quad 0 < \mu < \infty,$$

where (3.21) is the supply function for the import commodity ("resource") which enters the production structure. This commodity is different from all domestically available goods. The demand for imported resources is a derived demand based on production requirements (as with the other factors of production, labor and capital). M_i^0 and E_i^0 may represent either gross or net magnitudes as desired.

The trade balance condition is now

$$(3.22) \qquad P_R R + \sum_{i=1}^{n} P_{M_i} M_i = \sum_{i=1}^{n} P_{E_i} E_i.$$

Let

$$(3.23) \qquad \gamma_1 = R^0 (P_R)^{\mu+1} + \sum_{i=1}^{n} (P_{M_i})^{\mu+1} M_i^0$$

and

$$(3.24) \qquad \gamma_2 = \sum_{i=1}^{n} (P_{E_i})^{\eta+1} E_i^0.$$

Then, substituting (3.19), (3.20), and (3.21) into (3.22) and using the above notation, we get

$$(3.25) \qquad e = \left(\frac{\gamma_2}{\gamma_1}\right)^{1/(\eta-\mu)}$$

and

10. The quantities of this imperfectly substitutable import into each industry were based on rows 80A and 80B of the 1971 United States input-output matrix published by the Bureau of Economic Analysis of the Department of Commerce.

$$(3.26) \qquad M_i = M_i^0 P_{M_i}^\mu \left(\frac{\gamma_2}{\gamma_1}\right)^{-\mu/(\mu-\eta)},$$

$$(3.27) \qquad E_i = E_i^0 P_{E_i}^\eta \left(\frac{\gamma_2}{\gamma_1}\right)^{-\eta/(\mu-\eta)},$$

$$(3.28) \qquad R = R^0 P_R^\mu \left(\frac{\gamma_2}{\gamma_1}\right)^{-\eta/(\mu-\eta)}$$

As in the previous section, these are the reduced-form or (trade balance) compensated import supply and export demand equations. They provide a constant elasticity set of excess demand functions to describe foreign behavior.

With this formulation, the production structure has also been modified to incorporate the imported resource. In the previous version of the model, the production function for each sector could be written as

$$(3.29) \qquad Q_j = \min\left[\frac{1}{a_{0j}} VA(K_j, L_j), \frac{x_{1j}}{a_{1j}}, \ldots, \frac{x_{nj}}{a_{nj}}\right],$$

where the a_{ij} $(i = 1, \ldots, n)$ are the fixed per unit intermediate input requirements, x_{ij} are the available intermediate inputs, $VA(\cdot, \cdot)$ is a CES value added function with capital (K_j) and labor (L_j) as inputs, and a_{0j} is the requirement of value added per unit of output.

Under this new specification, the production function is

$$(3.30) \qquad Q_j = \min\left\{\frac{1}{a_{0j}} J[VA(K_j, L_j), R], \frac{x_{1j}}{a_{1j}}, \ldots, \frac{x_{nj}}{a_{nj}}\right\},$$

where J is a CES or Cobb-Douglas function for each sector, and a_{0j} now represents the requirements of the resource/value added composite per unit of output. A critical parameter in this formulation is the value chosen for the elasticity of substitution between R and $VA(K_j, L_j)$ for each sector. We denote these elasticities by σ_{VA}^R. We will return to the choice of values for σ_{VA}^R.

The solution procedure takes advantage of the separability of the production structure, as in the original Fullerton-Shoven-Whalley model. Each producer first calculates the optimal factor proportions to use in his value added function, given the minimum factor costs of production. From this information, the optimal combination of domestic factor value added and imported resources can be determined by minimizing the per unit cost of the J function. From this solution, we can compute all domestic producer prices using the Samuelson nonsubstitution theorem. These prices can be used to determine the government's demand for producer products, the foreign demand for producer goods (exports), and the supply of both producer-good imports and resource imports. The producer-good prices determine consumer-good prices,

while the factor prices and the government revenue determine consumer incomes. Consumer demands are evaluated, and the derived demands for producer goods necessary to meet consumer demand for consumption and investment goods are computed. With these components, we can obtain the demand for domestically supplied producer goods, from which the derived demand for labor, capital, and imported resources is determined. Further, from all the transactions in the model, government tax receipts can be calculated. The excess demand for labor, capital, resources, and government revenue is then computed, and the model proceeds as in earlier versions, until an equilibrium set of prices and tax revenue is found where all markets clear.

This specification presents two additional data requirements. We use a modified version of the 1970 United States input-output table underlying our 1973 benchmark data, to separately identify a row of factor imports by industry in our input-output data. We also need to specify a substitution elasticity between United States value added and R. For these, we use estimates of the aggregate import price elasticity of import demand for the United States. In the central case we take the value (from Stern, Francis, and Schumacher 1977) of 1.7 to represent the pure substitution effect between domestic value added and imported resources, and take 0.5, 1.0, and 3.0 as sensitivity cases.

10.3.4   A Simple Modeling of International Capital Flows

To this point, our model formulations have not accounted for international capital flows. From a modeling perspective, however, it is very important whether a single international capital market or separate national capital market is considered, since this choice may significantly affect the perceived impact of a tax change. In this subsection, we present a simple formulation of international capital flows which allows foreign rental rates on capital to affect rental rates in the United States.

Here we add one consumer to the model—a "foreigner" endowed with large quantities of those commodities which the United States imports or exports, and with a large amount of capital services. In the benchmark year, the foreigner's endowment of each import or export commodity is usually set at five times the benchmark level of imports of that commodity by the United States, while the foreigner's capital services endowment is five times the United States capital services endowment in the benchmark. As part of a sensitivity analysis we have varied the magnitudes of the foreigner's endowments of goods and capital services. The foreigner "consumes" most of his endowments; that is, most of these import goods and capital services are used by the foreign economy rather than sold or rented to the United States. In the benchmark, in particular, the foreigner sells just the observed amount of import commodities (a fifth of his endowment) to the United States economy and purchases the observed

quantity of export commodities (also a fifth of his endowment) from the United States. The foreigner rents no capital services to the United States in the benchmark; he thus consumes his entire endowment of capital services. A loose interpretation would be that these capital services are foreign resources which provide directly consumable output to the foreigner.

As United States prices change with a tax change, however, the foreigner alters his behavior. If the United States rental price of capital increases above the foreign rental price (exogenously fixed in real terms), the foreigner will "rent" some of his endowment to be used in United States production (i.e. there will be a capital inflow from the perspective of the United States). On the other hand, should the United States rental price of capital fall below the foreign rental price, the foreigner may "rent" United States capital for his foreign consumption (i.e. a capital outflow from the United States perspective).

This behavior is specified as

$$(3.31) \qquad W_K - X_K = W_K (P_K/P_{KF})^{E_K},$$

where W_K is the capital service endowment of the foreigner, X_K are capital services rented to the United States by the foreigner (or rented from the United States if X_K is negative), and E_K is an elasticity parameter controlling capital flow responses in the model. P_K and P_{KF} are the rental rates of capital in the United States and abroad, respectively. Since $P_K = P_{KF} = 1$ in the benchmark, the benchmark value of X_K is zero.

The critical parameters in this formulation are the ratio of W_K to the United States capital service endowment (five in our central case analysis) and E_K. E_K should be negative to give the capital service flow responses we require. In our central case E_K is -1.0. For sensitivity analysis, we use values for E_K ranging from zero to -10.0.

Equation (3.31) thus determines capital service flows in the model, once factor prices are known. A two-stage procedure is thus involved in determining foreign behavior. We first determine X_K, and from this we calculate income remaining to be spent on all other goods. For simplicity, the expenditure on other goods follows a Cobb-Douglas specification, with weights determined from benchmark data. A point worth noting is that equation (3.31) is not explicitly derived from utility-maximizing behavior of the foreigner. We focus on welfare evaluations for the United States only, and treat our model of the foreign sector as a model closure system which satisfies external sector balance and has the qualitative properties we desire.

Our motivation for this formulation incorporating capital service flows relates to the recent debate between Feldstein (see Feldstein and Horioka 1980) and Harberger (1980) about the degree to which the United States operates in a relatively competitive world capital market.

Feldstein, observing a high correlation between the savings of countries and their investment, argues that there are severe restrictions on the operation of a world capital market. Harberger asserts that this correlation is not so large and that this statistic is not sufficient evidence for concluding the malfunctioning of the world capital market.

This issue is important because of its implications for policy evaluation from general equilibrium tax models. In a world with a perfect, frictionless international capital market, the domestic choice between an income and consumption tax would not affect the aggregate employment of capital in the United States. Despite the fact that an income tax discourages saving by United States consumers and thus tends to discourage capital formation, the rest of the world would provide United States industry with capital until its rate of return was equal to the world level. However, an origin-based tax such as the United States corporation income tax would still be distortionary, affecting both the amount of capital in the economy and its allocation across industrial sectors. In their most recent exchange, Feldstein and Harberger seemed to be converging to the view that, while there is some pressure toward equalizing the rates of return to capital across world markets, this equilibrium is incomplete and even the partial movements observed take substantial amounts of time. We can capture the key aspects of this debate by altering E_K, the elasticity parameter for the demand for capital services by foreigners.

10.3.5 An Extension of the Capital Flows Modeling

The previous subsection has the rest of the world endowed with a large amount of capital services which it "rents" to the United States if the United States offers a higher rental price. If the rental price in the United States falls, the foreigner rents capital from the United States. While this is a step toward including world capital markets in our model, it fails to capture important aspects of foreign investment. Under this specification, a capital inflow involves a financial outflow (the United States must make the rental payments). In fact, the principal response to high United States rates of return is more likely to be direct foreign investment in the United States rather than the rental to the United States of foreign-owned capital. The rest of the world would *purchase* United States capital goods, providing an immediate financial inflow. Foreigners would then accumulate a claim on the future earnings of their acquired capital rather than receive immediate financial compensation.

This behavior can be incorporated in our model using a somewhat different representation of the "foreigner." The initial United States capital endowment of the foreigner is taken as zero. The foreigner, however, can acquire United States capital by purchasing the savings good (the 16th consumer good, which is a fixed proportion portfolio of real investment goods). He will do this if the expected rate of return on

United States investments rises above the expected rate of return on foreign investments. This will generate a capital and monetary flow. He is interested in the rate of return net of the corporation income tax, the corporation franchise tax, and property taxes. Should the United States rate of return fall relative to the foreign rate, he may sell foreign capital to domestic savers. Once again, we do not model the production structure of the rest of the world; rather, the foreigner simply "consumes" foreign capital as in the previous subsection.

This formulation is reasonably complex in terms of modeling. There now are two kinds of capital goods, foreign and domestic, offering separate (although conceivably identical) rates of return. Initially, domestic consumers own only domestic capital and the foreigner owns only foreign capital. The demand functions are structured such that the foreigners will save in the United States only if the United States rate of return rises above the foreign rate, whereas the United States consumers will purchase foreign capital service endowments only if the United States rate of return falls below the foreign rate. While the United States rate of return is endogenous in the model, the foreign rate is usually set at the benchmark rate, although it can be influenced by certain tax policies of the United States.[11]

Savings behavior in the United States stems from the same demand functions as in the Fullerton-Shoven-Whalley model, except that it involves not just a domestic savings good but a composite savings good aggregated over domestic and foreign savings goods. For each household,

$$(3.32) \qquad S^D = \beta S,$$
$$S^F = (1 - \beta)S,$$

where S is total savings, and S^D and S^F are domestic and foreign savings goods acquired. β is a distribution parameter which depends on the relation between domestic and foreign rates of return (r^F, r^{US}):

$$(3.33) \qquad \beta = 1 \qquad\qquad\qquad\qquad\quad \text{if } r^{US} \geq r^F,$$
$$\beta = \exp\left[-Z_1\left(r^F - r^{US}\right)\right] \quad \text{if } r^{US} < r^F.$$

Here r^F and r^{US} are expected rates of return to United States consumers. Because of differences in marginal tax rates, r^F and r^{US} each will differ across the twelve household classes distinguished by the model. We account for these differences in the model, although for convenience we speak of a single r^F and r^{US} in this discussion.

11. For example, in this model the foreign rate of return would be affected by a United States policy changing the percentage of United States consumers' savings which can be deducted from taxable income. Such a policy alters the after-tax price of savings to United States consumers, whether the savings are at home or abroad. Consequently, the policy affects the foreign rate of return to United States consumers of saving abroad.

In the benchmark $r^F = r^{US} = 1$ and $\beta = 1$ (United States households buy no foreign capital goods). In the solution of the model, β for each household is used to form a composite price for savings goods which enters household budget constraints. Household utility functions only have an interpretation over composite goods since we do not investigate real characteristics of assets (such as risk) which would account for a diversified portfolio by savers. We set Z_1, the elasticity parameter in equation (3.33), at 250 in our central case. We consider this figure to be roughly comparable to the E_K value of -1.0 in the previous specification.

The foreigner's savings in the United States, S^F_{US}, are given by

$$(3.34) \qquad S^F_{US} = 0 \qquad\qquad \text{if } r^{US}_F \le r^F_F,$$
$$S^F_{US} = Z_2\left(r^{US}_F - r^F_F\right)^{Z_3} \quad \text{if } r^{US}_F > r^F_F.$$

Here r^{US}_F and r^F_F are United States and foreign rates of return expected *by the foreigner*. Because United States consumers and foreigners are not treated identically in the tax system, r^{US} generally differs from r^{US}_F, and r^F from r^F_F.

A two-stage procedure similar to that in subsection 10.3.4 applies here. First, we determine the foreigner's investment behavior abroad, with remaining expenditures allocated in a Cobb-Douglas fashion. In our central case analysis, we take Z_2 to equal 50,000 and Z_3 to equal 0.5. In this specification, our dynamic sequencing of equilibria takes account of previous investments abroad in determining capital service endowments in each country in each period. Investments abroad in a given period imply international capital service flows in subsequent periods.

In the following section, we investigate how the model's findings are affected by the four formulations we have just described.

10.4   Policy Analyses under Alternative External Sector Formulations

In this section we examine results from a number of policy analyses, using the various formulations of external sector behavior presented in the preceding section. We consider the introduction of an 80% savings deduction in the United States income tax (as considered by Fullerton, Shoven, and Whalley 1982). We also consider corporate tax integration in the United States (as considered by Fullerton, King, Shoven, and Whalley 1981), and the introduction of alternative forms of value-added tax in the United States.

We use the same dynamic sequence of equilibria approach used in the earlier papers by Fullerton et al. and compute sequences of equilibria linked through household savings decisions, as described earlier. In the base case, the economy is assumed to lie on a balance growth path. Under different policies, the economy is initially displaced from balanced

growth and asymptotically returns to a new balanced growth path with a different ratio of capital service to labor endowment in each period. Our welfare analysis of gain or loss to the economy involves a calculation of the Hicksian compensating variation in each period for each household group. We first discount into present value terms, using the real net of return to capital as the discount rate, and then we sum over households.

Our analyses involve the same numerical specification used by Fullerton et al. We analyze six periods, each of ten years' duration, using the same values for all parameters which do not deal with the external sector. The various external sector formulations are incorporated as separate model extensions.

We refer to the four formulations as follows:

1. CONS ELAS NO ARM   Foreigners' behavior involves con-
                       stant-elasticity demand functions (con-
                       stant-elasticity offer curve in two-good
                       case); no Armington product heter-
                       ogeneity enters; no capital service or
                       capital good flows are considered.
2. CONS ELAS WITH ARM As in (1) except that we also consider
                       Armington product heterogeneity for
                       certain imported inputs.
3. CAP SERV FLOW   Flows of capital services take place be-
                       tween the United States and the rest of
                       the world.
4. CAP GOOD FLOW   Flows of capital goods take place be-
                       tween the United States and the rest of
                       the world.

These formulations were described above in subsections 10.3.2, 10.3.3, 10.3.4, and 10.3.5, respectively.

These formulations are listed in table 10.1 along with the values we have specified for the more critical parameters. In the case of the first formulation, the parameters μ and η imply an export price elasticity which the United States faces. We use an export price elasticity for the foreigner's demands of -1.4. This is approximately the central case value reported in the recent compendium of Stern, Francis, and Schumacher (1977). We use values for μ of 0.465 and η of -10. These jointly imply the -1.4 export price elasticity; the implied elasticity of the foreigner's import supply function is approximately 0.4.

For sensitivity analyses in this case, we consider μ and η set first at 10 and -10 and then at 1 and -1. For the 10, -10 case the export price elasticity is approximately -5. In the two-good case, as η and μ both become large (in absolute value), the elasticity of the offer curve approaches unity and this specification for the foreigner's behavior would imply that the United States is a small, open, price-taking economy. For

Table 10.1   **Characteristics of Alternative External Sector Specifications**

Specification	CONS ELAS NO ARM	CONS ELAS WITH ARM	CAP SERV FLOW	CAP GOOD FLOW
Section where described	10.3.2	10.3.3	10.3.4	10.3.5
Brief description	Constant-elasticity excess demands, no product heterogeneity, no capital flows, gross trade flows	Constant-elasticity excess demands, product heterogeneity for intermediate imports, no capital flows, gross trade flows	Capital service flows, no product heterogeneity, Cobb-Douglas commodity demands, gross trade flows	Capital good flows, no product heterogeneity, Cobb-Douglas commodity demands, gross trade flows
Critical parameters	μ, η	μ, η, σ^R_{VA}	E_K, RATIO*	Z_1, Z_2, Z_3, RATIO*
Values in central case	$\mu = .465$ $\eta = -10$ (jointly imply U.S. faces export price elasticity of -1.4)	$\mu = .465$ $\eta = -10$ $\sigma^R_{VA} = 1.7$	$E_K = -1$ RATIO $= 5$	$Z_1 = 250$ $Z_2 = 50,000$ $Z_3 = 0.5$ RATIO $= 5$
Sensitivity cases	$\mu = 10$, $\eta = -10$ $\mu = 1$, $\eta = -1$ Net rather than gross trade flows used	$\sigma^R_{VA} = 0.5, 1.0, 3.0$	$E_K = 0, -0.1, -10.0$ RATIO $= 2, 10$ Gross-of-tax rather than net-of-tax return to capital used	$Z_1 = 1,000, 100, 10$ $Z_2 = 100,000$ $Z_3 = .25, 1.0$ RATIO $= 2, 10$

*RATIO represents the ratio of the foreigner's benchmark endowments of capital services, input commodities, and export commodities to the United States benchmark endowments of capital services, level of imports, and level of exports, respectively.

the case of 1, -1 the export price elasticity is -1, and in the two-good case the elasticity of the offer curve is ∞. We also consider cases where net trade flows rather than the gross flows enter the benchmark calculation.

For the second formulation, the critical parameters are μ, η, and σ_{VA}^R. We take the same μ and η values as for the central case in our first formulation. σ_{VA}^R is set at 1.7. In our sensitivity runs, σ_{VA}^R is set at 0.5, 1.0, and 3.0.

For the capital service flow formulation, a critical parameter is E_K, which expresses the sensitivity of the foreigner's behavior to differences between the rental rates on capital employed in the United States and abroad. In our central case under this formulation, we set E_K at -1.0; in sensitivity runs we consider values of 0, -0.1, and -10.0 for E_K.

Another key parameter in this formulation is RATIO, the ratio of the foreigner's benchmark endowments of capital services, import commodities, and export commodities to the United States endowment of capital services, level of imports, and level of exports in the benchmark. RATIO is a rough indicator of the "size" of the rest of the world relative to the United States. In our central case, we set RATIO equal to 5; in sensitivity runs, we consider values of 2 and 10 for RATIO.

A final and important sensitivity analysis in this case involves the return to capital. In the central case, when foreigners rent to the United States, they receive P_K, the real net-of-tax rental price of, or return to, capital. P_{KF} is paid to the United States when Americans rent to foreigners. Because of the tax system in the United States, a differential exists between the marginal product of capital (the gross of tax price) and the net-of-tax return to capital. Thus the United States gains if it rents capital services from abroad, since the United States collects the marginal product of capital but pays the net-of-tax return to capital. Conversely, if the United States rents capital to the foreigner, the United States suffers a loss for the same reason. To correct for this, we calculate a tax rate which applies to international capital service transactions and use this new rate in one of our sensitivity cases.

For the capital good formulation, the critical parameters are Z_1, Z_2, and Z_3. These parameters determine the sensitivity of domestic households and of the foreigner to differences between domestic and foreign rates of return. We use values of 250 for Z_1, 50,000 for Z_2, and 0.5 for Z_3 in our central case. In sensitivity cases we consider values of 1,000, 100, and 10 for Z_1, 100,000 for Z_2, and 0.25 and 1.0 for Z_3.

10.4.1 Savings Deduction

In table 10.2 we show model results for a single tax policy—an 80% savings deduction—under the different external sector formulations. This policy, described in detail in Fullerton, Shoven, and Whalley (1982), represents a move from the current income tax system toward an expend-

Table 10.2   **Further Analysis of 80% Savings Deduction in United States Income Tax (dynamic welfare effects in present value of compensating variations over time)**

	Welfare Effect*
1. Original Fullerton-Shoven-Whalley type of formulation	538 (1.10)
2. CONS ELAS NO ARM (central case)	511 (1.04)
3. CONS ELAS WITH ARM (central case)	479 (0.98)
4. CAP SERV FLOW (central case)	−476 (− .97)
5. CAP GOOD FLOW (central case)	−33 (− .07)

Note: All results are from runs including six equilibria spaced ten years apart. An "additive" method of tax replacement (see subsection 10.4.1) was employed in every case.

*In billions of 1973 dollars. The numbers in parentheses represent the welfare gain or loss as a percentage of the present discounted value of consumption plus leisure in the base sequence ($49 trillion).

iture or consumption tax system. The deduction is only 80% since roughly 20% of savings is used for new housing construction, which does not incur the "double" taxation of the income tax system. Thus an 80% deduction would closely approximate a full consumption tax system. We "additively" adjust marginal income tax rates (increasing or decreasing all rates by a certain number of percentage points) so that the total revenue raised by the government is not altered in any period by the policy change. We consider six equilibria spaced ten years apart.

The original analysis suggests a present value gain to the United States of $538 billion (1973 prices) from the tax change. It is useful to compare this number with the discounted present value of consumption plus leisure in the base sequence of $49 trillion (1973 prices). The gain thus amounts to 1.10% of this discounted present value of the economy. Put another way, after allowing for the change in the timing of consumption, and spreading the gain involved over a number of years, an 80% savings deduction increases total consumer welfare by 1.10% per year.

The first two external sector formulations do not change this broad picture very much. In the constant-elasticity case with no Armington good, the gain falls to $511 billion. With the Armington good, the gain falls further, to $479 billion. This result indicates that the terms of trade effects of the tax change are weak, a finding which contrasts with the papers by Boadway and Treddenick (1978) and Whalley (1980); these studies find significant terms of trade effects associated with changes in factor taxes. These two papers both incorporate a complete Armington specification which leads to stronger terms of trade effects. In addition, in the present formulation there are not substantial differences in factor intensities of export and import competing industries; as a consequence, the offer surfaces for the United States have only limited bowness.

The major changes in results occur with the capital service and capital good flow formulations. In the service flow case, the $538 billion gain changes to a $476 billion loss. The main reason for this has already been indicated above: the United States incurs substantial capital service outflows as a result of the policy change so that the United States foregoes the gross-of-tax return to capital (capital's marginal product), but only receives the net-of-tax return. In effect, the foreign tax authority gains at the expense of the United States Treasury, as a United States tax credit is given for foreign taxes paid. The cumulative capital service outflow in this case over fifty years is approximately $1.7 trillion. In the sensitivity analysis, we note that the efficiency loss is reduced and even reversed as the E_K parameter is reduced toward zero. An interesting policy prescription from this case is that the United States should either have additional taxes on capital income received from abroad or revoke the foreign tax credit. The additional tax rates, if used, should equal United States capital factor tax rates. This prescription ignores possible retaliatory consequences of such action. The capital good flow case reveals a similar result, although the effect is quantitatively weaker.

10.4.2   Sensitivity Analysis

In table 10.3 we report our sensitivity analyses for our two constant-elasticity formulations. Given that the central case results of these two forms do not differ significantly from each other or from those of the original specification, it may not be surprising that a similar conclusion applies for sensitivity cases. The choice of the μ and η combination, or whether gross or net trade flows are specified, makes very little difference in the cases with no Armington good. In the Armington cases, the results

Table 10.3	Sensitivity Analysis of 80% Savings Deduction in United States Income Tax for Constant-Elasticity Formulations (dynamic welfare effects in present value of compensating variations over time)

	Welfare Effect*
1. Original formulation (table 10.2, case 1)	538
2. CONS ELAS NO ARM	
Central case (μ = .465, η = − 10)	511
μ = 10, η = − 10	502
μ = 1, η = − 1	538
Net rather than gross trade flows	529
3. CONS ELAS WITH ARM	
Central case (μ = .465, η = − 10, σ^R_{VA} 1.7)	479
σ^R_{VA} = .5	446
σ^R_{VA} = 1.0	467
σ^R_{VA} = 3.0	487

*In billions of 1973 dollars.

are relatively robust with respect to changes in σ_{VA}^R. Gains fall from \$487 billion to \$446 billion as σ_{VA}^R is lowered from 3.0 to 0.5.

In table 10.4 we report our sensitivity analysis of the 80% savings deduction cases from table 10.2 for our capital service and capital good flow formulations. For the capital service flow formulation, a most dramatic result appears when the gross-of-tax rental price is employed instead of the net-of-tax price in international capital service transactions. In this case the large loss of \$476 billion in the central case changes to a gain of \$562 billion. This gain is even larger than in the cases without capital flows. The reason is that with a closed capital market the additional saving caused by the adoption of a consumption tax depresses the marginal product of capital more than with an international capital market. This demonstrates clearly the significance in the model of the United States instituting a compensatory tax on capital income received from abroad.

Sensitivity analysis for the capital service flow formulation also included changing E_K from -1.0 to 0.0, -0.1, and -10.0 and varying RATIO, the goods and service endowment ratio, between 2 and 10. As expected, the welfare loss is larger for higher absolute values of E_K. With $E_K = 0$, we get results essentially equivalent to the formulations without capital flows.

Table 10.4   **Sensitivity Analysis of 80% Savings Deduction in United States Income Tax for Capital Service and Capital Good Flow Formulations (dynamic welfare effects in present value of compensating variations over time)**

	Welfare Effect*
A. Capital service flow formulation	
1. Central case (table 10.2, case 4)	-476
2. Gross of tax rental price used in place of net tax price	562
3. $E_K = .0$ (changed from -1)	525
4. $E_K = -.1$ (changed from -1)	192
5. $E_K = -10.0$ (changed from -1)	-730
6. RATIO = 2 (changed from 5)	-221
7. RATIO = 10 (changed from 5)	-601
B. Capital good flow formulation	
1. Central case (table 10.2, case 5)	-33
2. $Z_1 = 1,000$ (changed from 250)	-337
3. $Z_1 = 100$ (changed from 250)	122
4. $Z_1 = 10$ (changed from 250)	441
5. RATIO = 2 (changed from 5)	-38
6. RATIO = 10 (changed from 5)	-26

*In billions of 1973 dollars.

Table 10.5   **Further Analysis of United States Corporate and Personal Tax Integration (dynamic welfare effects in present value of compensating variations over time)**

	Welfare Effect*
1. Original formulation	265 (.54)
2. CONS ELAS NO ARM (central case)	287 (.59)
3. CONS ELAS WITH ARM (central case)	321 (.66)
4. CAP SERV FLOW (central case)	1,031 (2.10)
5. CAP GOOD FLOW (central case)	497 (1.01)
6. CAP GOOD FLOW (central cases)	
$Z_2 = 100,000$ (changed from 50,000)	666 (1.36)
$Z_3 = .25$ (changed from .5)	927 (1.89)
$Z_3 = 1.0$ (changed from .5)	326 (.67)

Note: All results are from runs involving six equilibria spaced ten years apart. An "additive" method of tax replacement (see subsection 10.4.1) was employed in every case.

*In billions of 1973 dollars. The numbers in parentheses represent the welfare gain or loss as a percentage of the present discounted value of consumption plus leisure in the base sequence ($49 trillion).

For our capital good formulation we only report sensitivity on Z_1 and the endowment ratio in table 10.4, because with an 80% savings case the United States saves abroad with no foreign savings in the United States.[12] Z_2 and Z_3 are immaterial in this case but have an effect in the integration cases reported below, where the capital good flow is in the opposite direction. We thus report Z_2 and Z_3 sensitivity later. Table 10.4 reveals significant sensitivity to Z_1 values; there is relatively little sensitivity to the values for RATIO.

10.4.3 Tax Integration

In table 10.5 we present further analyses of corporate and personal tax integration in the United States using the alternative external sector formulations presented earlier. Here we evaluate a policy of "full integration" as described in Fullerton, King, Shoven, and Whalley (1981). Such a policy involves the elimination of the corporate income tax accompanied by increases in personal taxes on capital income. The corporate income tax is eliminated for both domestic- and foreign-owned firms situated in the United States. Individuals are taxed on the basis of their total capital income, whether that income is realized (as dividends, rents, etc.) or accrues (e.g. as retained earnings).

As with table 10.2, the two constant-elasticity formulations do not make very much difference to results although gains increase rather than

12. For domestic consumers and more importantly for foreigners, this policy change lowers the United States rate of return relative to the foreign rate. Under these circumstances foreigners do not save in the United States (see subsection 10.3.5).

fall in comparison to the original. The capital service and capital good flow formulations, however, yield gains which are significantly higher than those under the original formulation. In these cases the gains are $1,031 and $497 billion, respectively. Tax integration induces a reallocation of capital from noncorporate to corporate sectors, since the latter experience a larger tax reduction from a policy of tax integration. This leads to an increase in the net-of-tax rental price of capital in the United States; the rental price and rate of return to capital rise in the United States relative to the rest of the world. Under the capital service flow formulation, this induces foreigners to rent their capital to the United States, while in the capital good flow formulation, this leads to foreign saving in the United States. In both cases, the United States experiences a substantial efficiency gain since it pays the net-of-tax return as its marginal product. We report sensitivity analyses on Z_2 and Z_3 for the capital good flow case; they have an impact in this situation as the foreigner saves in the United States (unlike the 80% savings deduction case).

10.4.4   Value Added Tax

In table 10.6 we present results from our simulations of introducing four alternative forms of value added tax (VAT) in the United States. Much of the recent discussion of value added taxation in the United States has been prompted by the VAT systems introduced in Europe over the last fifteen to twenty years. The destination-based VAT in Europe is seen in some quarters in the United States as a trade-restricting measure since exports leave Europe tax-free but imports are taxed as they enter. While this view is criticized by many academic economists who stress the

Table 10.6	Welfare Impacts of Introducing 10% VAT of Differing Types (dynamic welfare effects in present value of compensating variations over time)			
	Income-Type VAT		Consumption-Type VAT	
	Origin Basis	Destination Basis	Origin Basis	Destination Basis
1. Original formulation	−42	−47	265	261
2. CONS ELAS NO ARM	−39	−39	256	256
3. CONS ELAS WITH ARM	−47	−47	213	213
4. CAP SERV FLOW	261	236	91	106
5. CAP GOOD FLOW	−529	−467	128	127

Note: All results are central case results for runs involving six equilibria spaced ten years apart. An "additive" method of tax replacement (see subsection 10.4.1) was employed in every case. Welfare effects are measured in billions of 1973 dollars.

neutrality of either tax base for a broadly based tax, it has nonetheless been influential in policy debate.

We model an origin-based VAT as an equal rate factor tax on both primary factors and a destination-based tax as an equal rate final sales tax on expenditures in the United States. Under the income-type VAT all goods are taxed; under the consumption-type only current consumption goods are taxed. We model the latter feature through a savings deduction for the origin-based VAT of the consumption type. We impose equal yield through an additive replacement in the income tax; income tax collections fall through a linear income tax reduction applied to all household income tax rates. These tax changes are thus regressive.

The VAT is constructed to be a nondistorting tax save for impacts on labor supply and savings. The introduction of this tax alternative therefore implies a scaling down of existing distorting taxes, which produces welfare gains. Consumption-type VAT gains are due primarily to the reduction in the intertemporal distortion of the income tax. In the consumption-type runs the VAT compounds multiplicatively with other taxes, and neutrality between origin and destination bases holds exactly for the Armington and capital service flow cases and nearly so for the other cases.

The welfare gains in the income-type VAT runs are generally smaller than in the corresponding consumption-type VAT runs. The gains are smaller because the income-type VAT inefficiently distorts individuals' consumption-saving decisions more than the consumption-type VAT, since the former tax applies to investment goods (as well as consumption goods) and in effect taxes savings. There is one exception to this general result: in the capital service flow case, the gains under an income-type VAT are larger than under the consumption-type VAT. The domestic rental price of capital eventually rises (relative to the foreign rental price) under the income-type VAT but falls (relative to the foreign price) under the consumption-type VAT. As a result, capital is rented to the United States under the former tax and from the United States under the latter, in the capital service flow formulation. Since, as discussed earlier, those offering capital overseas receive only the net-of-tax price of capital as compensation, the direction of the capital service flow is favorable to the United States under the income-type VAT and unfavorable to the United States under the consumption-type VAT. The favorable effect under the income-type tax more than compensates for any adverse impact related to the tax's distortion of consumption-saving decisions.

The policy prescriptions from these runs are that foreign trade concerns regarding destination- versus origin-based taxes do not provide a legitimate reason for the United States to introduce a VAT, but a broadly based VAT which replaces existing distorting taxes may be an efficiency-gaining tax change.

10.5   Conclusion

In this paper we have described four alternative external sector formulations which can be used to represent external sector behavior in the Fullerton-Shoven-Whalley tax model for the United States. Our motivations are twofold: to assess the impact of alternative formulations on model findings, and to provide an enhanced capability for the analysis of tax policies (such as a VAT) which connect closely with foreign trade issues. We consider two formulations of merchandise trade behavior using constant-elasticity excess demand functions for foreigners' behavior. We also consider internationally mobile capital services and capital goods.

Under these different formulations, we reinvestigate two policy alternatives considered earlier by Fullerton, King, Shoven, and Whalley (1981) and Fullerton, Shoven, and Whalley (1982): an 80% savings deduction in the income tax, and personal and corporate tax integration. We also examine the effects of introducing a 10% value added tax, of the income type or consumption type, on either an origin or a destination basis.

Results indicate that the different external sector formulations can substantially affect the model's findings. The allowance for capital service flows can either greatly increase the efficiency gain of a tax policy (as in the case of corporate tax integration) or turn a significant gain into a large loss (as in moving to a consumption tax). Each of the policies we investigated appears to have the potential to generate substantial capital service flows between the United States and abroad. When the net flow is from the United States to foreigners, the United States is adversely affected since those offering capital receive only the net-of-tax rental price. The specification of merchandise and service trade appears to affect our results far less than the capital flow modeling.

This paper indicates that the evaluation of domestic tax policy is very sensitive to the functioning of international capital markets. Therefore further research which reveals more precisely the operation of these markets would be most useful for future analyses.

References

Armington, P. S. 1969. A theory of demand for products distinguished by place of production. *I.M.F. Staff Papers*, pp. 159–76.

Boadway, R., and J. M. Treddenick. 1978. A general equilibrium computation of the effects of the Canadian tariff structure. *Canadian Journal of Economics*, August, pp. 424–46.

Boskin, M. J. 1978. Taxation, saving, and the rate of interest. *Journal of Political Economy*, vol. 68, no. 2, part 2.

Caddy, V. 1976. Empirical estimation of the elasticity of substitution: A review. Preliminary Working Paper OP-09, IMPACT Project, Industrial Assistance Commission, Melbourne, Australia, November.

Deardoff, A., and R. M. Stern. 1979. An economic analysis of the effects of the Tokyo round of Multilateral Trade Negotiations on the United States and the other major industrialized countries. MTN Studies no. 5, prepared for Subcommittee on International Trade, Committee on Finance, United States Senate, 96th Congress, Washington.

Feldstein, M., and C. Horioka. 1980. Domestic savings and international capital flows. Forthcoming in *Economic Journal*.

Fullerton, D. 1980. Transition losses of partially mobile industry specific capital. NBER Working Paper no. 520.

Fullerton, D.; A. T. King; J. B. Shoven; and J. Whalley. 1981. Corporate tax integration in the U.S.: A general equilibrium approach. *American Economic Review* 71: 677–91.

Fullerton, D.; J. B. Shoven; and J. Whalley. 1978. General equilibrium analysis of U.S. taxation policy. *1978 Compendium of Tax Research*. Washington: Office of Tax Analysis, United States Treasury Department.

——. 1982. Replacing the U.S. income tax with a progressive consumption tax: A sequenced general equilibrium approach. NBER Working Paper no. 892, May. Forthcoming in *Journal of Public Economics*.

Gorman, W. M. 1957. Tariffs, retaliation, and the elasticity of demand for imports. *Review of Economic Studies* 25: 133–62.

Grubel, H. C., and P. J. Lloyd. 1975. *The theory and measurement of international trade in differentiated products*. New York: Wiley, Halsted Press.

Harberger, A. C. 1980. Vignettes on the world capital market. *American Economic Review*, May.

Johnson, H. G. 1953. Optimum tariffs and retaliation. *Review of Economic Studies* 21: 142–53. Reprinted with amendments in H. G. Johnson, *International trade and economic growth*. George Allen & Unwin, 1961.

Merrill, O. H. 1971. Applications and extensions of an algorithm that computes fixed points of certain upper semi-continuous mappings. Ph.D. thesis, University of Michigan.

Scarf, H. E., with the collaboration of T. Hansen. 1973. *The computation of economic equilibria*. New Haven: Yale University Press.

Stern, R. M.; J. Francis; and B. Schumacher. 1977. *Price elasticities in international trade: An annotated bibliography*. Macmillan Publishers for the Trade Policy Research Center.

Whalley, J. 1980. Discriminatory features of domestic factor tax systems in a goods mobile, factors immobile trade model: An empirical general equilibrium approach. *Journal of Political Economy*, December.

Whalley, J., and B. Yeung. 1980. External sector "closing" rules in applied general equilibrium models. Mimeo, University of Western Ontario, April.

Comment   David G. Hartman

The analysis of domestic saving or investment incentives has nearly always ignored the role of international trade and investment. Because of the increasing importance of international transactions, this paper, which "opens" the economy previously modeled by Fullerton, Shoven, and Whalley, is particularly welcome.

The main contributions of the paper are in the warnings it gives to users of general equilibrium models which do not include a sophisticated foreign sector. Its lessons should include not only the potential importance of foreign influences for domestic policy analysis but also the unfortunate nonneutrality of the simple "model closure" conditions usually used to describe the foreign sector.

In particular, previous versions of the Fullerton, Shoven, and Whalley model had a very simple foreign sector in which the value of net imports for each imported good was taken as constant, as was the value of net exports for each exported good. The authors assert here that the previous specification was unfortunate since foreigners were assumed to respond "perversely" to price changes, i.e. with their export supply having a price elasticity of -1.

In fact, since only relative prices matter, a negative foreign supply elasticity, at least locally, is not as perverse as is alleged. Such an elasticity is indicative only of an inelastic foreign demand for United States export goods. That is, there is no reason why the foreign offer curve could not be as shown in figure 10.1 over some range. What is important is that far from the previous trade specification representing a neutral model closure condition, it guarantees that extreme terms of trade effects will result from United States policy changes. So, included in all of the "original formulation" results could be important welfare effects arising from the international trade sector. If not literally perverse, the implied foreign behavior is at least extreme. This fact not only casts doubt on the reliability of previous results but also explains some apparent anomalies

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in the conclusions one reaches when comparing the authors' new results to the original formulation.

The new trade sector specification developed in this paper is carefully done and attractive in allowing for a range of possible foreign responses to United States policy changes. Unfortunately, the industry detail of the original model is lost at this point, presumably because of the lack of reliable estimates of foreign demand and supply elasticities for individual goods. Since the trade balance condition links aggregate foreign export supply and import demand, only one parameter is required to completely describe foreign behavior: it is determined by the authors' choices of μ and η, as shown in equation (3.14). With the qualification that one cannot tell how sensitive the analysis is to this aggregation, the results are striking and quite reassuring, in that the welfare effects of domestic tax policies are not sensitive to the foreign elasticities. That domestic policies directed toward savings and investment would not produce major terms of trade effects should not be surprising in light of the international trade literature, which provides contradictory evidence on whether United States import or export goods are relatively more capital intensive.

In fact, the results in this paper are weakly supportive of the notion that United States imports are relatively capital intensive (the Leontief paradox). For example, a savings deduction provides greater welfare gains when foreign demand for United States exports is highly inelastic ($\mu = 1$ and $\eta = -1$) than when the United States is virtually a price-taker ($\mu = 10$ and $\eta = -10$). That is, increased investment results in the expansion of United States production of its import good. Similarly, the "original formulation" estimate of the welfare gain, which was implicitly based on highly inelastic foreign demand, was an overestimate if the "central case" is taken as the most plausible. Fortunately, the results in general show that the welfare effects of these domestic policy changes do not depend significantly on the values of unknown foreign parameters.

This standard welfare analysis neglects both the costs of short-run dislocations and the changes in distribution which accompany policy change. One lesson of simple trade models is that massive changes in production patterns, and hence relatively major adjustment costs, could result from changes in factor proportions in an open economy. Also, a sizable effect on the distribution of income among factors of production can be produced by smaller changes in the terms of trade. Thus, along with the increased openness of the United States economy comes the greater importance to policymakers of factors other than aggregate equilibrium welfare changes. While these issues are not explored in this paper, the authors' methodology would allow them to be considered in a sophisticated fashion.

While the aggregate welfare effects of policy are found to be insensitive to the traded goods sector specification, a more disturbing result emerges

with respect to international capital flows. The conclusion that the usual analysis can be quite misleading in a world of highly elastic capital flows provides an important warning to researchers.

That capital flows could play a crucial role in determining the welfare effects of a policy to increase savings or investment should come as no surprise in the light of the arguments advanced by Peggy Musgrave (1969). Musgrave argued that United States investors will view foreign investment as attractive when after-tax returns abroad exceed those available at home. However, since a portion of the taxes paid on the foreign investment income accrue to the foreign government, the United States would earn a greater total return on its capital stock if foreign investment took place only when the after-foreign-tax return exceeded the gross return available at home. Allowing only a deduction for foreign tax payments, rather than the existing tax credit, would induce firms to follow a decision rule consistent with maximization of the total capital return, as the authors note here.

The qualitative results of this paper follow directly. Any change in domestic policy which stimulates saving produces a reduction in the domestic capital return, a capital outflow, and hence a tendency toward a loss in welfare. A simulus to investment, on the other hand, produces a capital inflow and a tendency toward a welfare gain, as the United States government collects a portion of the return to the foreign-owned capital.

Whether these welfare effects are sufficiently important to change the evaluation of a given policy depends on the elasticity of international capital flows. Since the size of this elasticity is highly controversial, the range of alternative results is crucial.

The range of results produced by different elasticity assumptions is very wide, but it is important to note that all the alternatives considered here are extreme by most standards. For example, under the central case of E_K equal to -1.0 (see table 10.4), only a 10% decline in the United States rental price of capital is required to cause half the United States capital stock to move overseas. The smallest alternative value of E_K considered is -0.1, which still implies a movement abroad of 5% of the United States capital stock in response to such a change in the capital return. This criticism should not detract from the clear thrust of the paper, which is methodological; but one should not be misled into believing that the broad range of results reported in this paper are produced by comparing the situation of no capital flows to cases of modest elasticity.

A further caution is that domestic policy measures which are straightforward to describe in a closed economy can become quite complex in a world of mobile capital. The very simple type of corporate and personal tax integration considered here represents only one of a wide variety of possible methods, which are discussed by McLure (1979). For example, foreigners could be denied relief from the tax, producing a reduction rather than an increase in foreign investment in the United States.

Obviously, very different outcomes could be expected from the various treatments of international investment under integration, so caution must be exercised in applying the authors' results.

This example also highlights the need to recognize the considerable stock of the United States capital currently invested abroad. While United States investment would not become more attractive to foreigners, it would become more attractive to United States investors under an integration scheme such as that just described. The welfare gain from inducing United States investors to repatriate capital, which is neglected here, is the subject of Griffin's (1974) analysis of integration. Even under the form of integration considered by Fullerton, Shoven, and Whalley, any welfare gains from capital repatriation should exceed those arising from foreigners' investment in the United States of the same amount, by the Musgrave argument. Thus the assumption that the original situation is one of no United States capital abroad tends to bias the results.

Finally, capital flows are assumed in the model to have no impact on the foreign demand and supply relations for goods. That assumption is, of course, not theoretically justified (see Jones 1967), but is very attractive compared to constructing a complete model of the rest of the world. This simplification would seem quite reasonable, except that direct investment, which is of particular concern in this paper, tends to be highly sector-specific. Foreign investment therefore can produce very direct terms of trade effects, the nature of which depend on such controversial factors as whether production abroad is a substitute for or complement to United States exports. Given the lack of evidence on these issues, the authors' specification seems sensible. Even more important, the basic domestic model, with its sectoral detail, does hold the potential for incorporating a more sophisticated description of foreign investment.

In general, the results reported here serve as a graphic reminder of how carefully tax policy must be conducted in a world of highly mobile capital. Unfortunately, it is with respect to capital flows that the least evidence is available. The authors have developed a powerful tool which requires much more information before its potential will be realized.

References

Griffin, J. A. 1974. The effect on U.S. foreign direct investment of the integration of the corporate and personal income taxes. Office of Tax Analysis Paper 22, United States Treasury Department.

Jones, R. W. 1967. International capital movements and the theory of tariffs and trade. *Quarterly Journal of Economics* 81: 1–38.

McLure, C. E. 1979. *Must corporate income be taxed twice?* Washington: Brookings Institution.

Musgrave, P. 1969. *United States taxation of foreign investment income.* Cambridge: Harvard Law School International Tax Program.

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