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Authors

Goulder, Lawrence H.
Eichengreen, Barry

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UNIVERSITY OF CALIFORNIA, BERKELEY

Department of Economics

Berkeley, California 94720

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Trade Liberalization in General Equilibrium: Intertemporal and Inter-Industry Effects

Lawrence H. Goulder
Harvard University and NBER

and

Barry Eichengreen
UC Berkeley and NBER

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Abstract

This paper uses a dynamic computable general equilibrium model to simulate the effects of unilateral reductions by the U.S. in tariffs and "voluntary" export restraints (VER's). We consider 50 percent cuts in tariffs and in *ad valorem* VER equivalents, separately and in combination. The model features intertemporal optimization by households and firms, explicit adjustment dynamics, an integrated treatment of the current and capital accounts of the balance of payments, and industry disaggregation. Central findings include: (1) VER's are considerably more significant than tariffs in terms of the magnitude of the macroeconomic effects induced by their reduction; (2) while VER reductions enhance domestic welfare, unilateral tariff cuts reduce domestic welfare (as a consequence of U.S. monopsony power and associated adverse terms of trade effects); (3) international capital movements critically regulate the responses of the U.S. and foreign economies to these trade initiatives and produce significant differences between short- and long-run effects; and (4) effects differ substantially across industries. Together, these findings indicate that simulation analyses that disregard international capital movements, adjustment dynamics, and industry differences may generate seriously misleading results.

Lawrence Goulder

Department of Economics
Harvard University
Cambridge, MA 02138

Barry Eichengreen

Department of Economics
University of California at Berkeley
Berkeley, CA 94720

I. INTRODUCTION

Over the last decade, economists and policy analysts have used increasingly sophisticated simulation models to assess major trade initiatives, including changes in tariffs and in nontariff barriers. Computable general equilibrium (CGE) models, in particular, have served as a workhorse for such policy investigations. The weight attached to CGE calculations by the policy community is reflected in the fact that many of the leading models are used in-house by governmental agencies and international organizations.[1]

These models have a number of attractive features, including their rich industry detail and their ability to account consistently for interactions between product and factor markets and among industries. The models are able to consider costs and supply decisions of foreign as well as domestic producers; this allows for better assessments of terms of trade effects (given U.S. monopsony power) than partial equilibrium analyses which treat foreign supply prices exogenously. The models can consistently account for revenue effects of trade policy: for example, how tariff revenues or quota rents influence resource allocation and welfare through their effects on domestic and foreign incomes.

However, existing CGE trade models have some significant limitations. First, the models generally lack a rigorous treatment of investment behavior. Firms' investment decisions are rarely modeled explicitly; instead, the level of aggregate investment is determined by aggregate saving. In addition, the allocation of investment across industries usually is based on the assumption of perfectly mobile physical capital: that is, aggregate investment is allocated so that at each point in time, after-tax marginal products of capital are equal in all industries. A number of studies emphasize the importance to policy results of investment modeling and adjustment dynamics. Fischer and Frenkel (1972) and Smith (1977) analyze the significance of tariffs for domestic investment and the domestic capital stock. Bovenberg (1988) and Goulder and Summers (1989) demonstrate the importance of adjustment dynamics for examining how policy shocks may differently affect the profit rates and asset prices of different industries. Gavin (1988) and O'Rourke (1988) have shown that models with adjustment dynamics yield very different results for the effects of tariffs on the current account than do models in which capital can be allocated instantaneously across sectors.

Analogous difficulties arise in the treatment of household consumption and savings decisions. Typically, consumption is specified as a function of current income rather than as the outcome of an explicit intertemporal optimization problem in which future income streams (and policy actions) are considered. Such specifications cannot account for differences between temporary and permanent, or between anticipated and unanticipated, disturbances.

These models also tend to disregard international flows of financial capital, considering only international commodity flows.[2] There is no treatment of individual portfolio decisions — in particular, the choice between investing in domestic and foreign assets. In a survey of recent CGE trade models, Srinivasan and Whalley (1986, p. 26) note, "none of the models in the present volume adequately takes [international capital movements] into account, nor has other numerical trade policy work developed significantly in these directions." At the same time, analytical studies, beginning with Mundell (1957), emphasize the significance of international capital movements. Work by Brecher and Diaz-Alejandro (1977) reveals that in the presence of internationally mobile capital, restricting trade in commodities may generate capital inflows or outflows that offset the effects of trade restrictions, with perverse welfare effects. Subsequent studies (e.g., Boyer, 1977; Eichengreen, 1981; Smith, 1988) have shown that the nature and magnitude of the effects depend on the substitutability of domestic and foreign assets and on changes in asset prices brought about by international capital flows.

In this paper we present a dynamic CGE model that takes important steps toward transcending these limitations. We show how consideration of adjustment dynamics, intertemporal optimization on the part of households and firms, and an integrated treatment of the current and capital accounts of the balance of payments can be incorporated into an operational, disaggregated CGE model. Our approach parallels recent work in macroeconomics, in which the dynamic response of the economy is derived from intertemporal decision making on the part of households and firms (see Sachs, 1983, and McKibbin and Sachs, 1986). However, these macroeconomic models do not disaggregate the production side of the economy into distinct industries; hence they cannot analyze the impact of trade policy initiatives on the intersectoral allocation of resources, traditionally a central issue in trade policy analyses. Our model, in contrast, combines a rigorous consideration of intertemporal dynamics with a disaggregated treatment of industries.

We use the model to analyze the effects of 50 per cent unilateral reductions in tariffs and in "voluntary" export restraints (VER's). We examine both macroeconomic effects and effects on particular industries, exploring how effects change over time.

The rest of this paper is organized as follows. Section II presents the structure of the model, while Section III describes the sources of data and parameters. Section IV offers simulation results, and the final section presents conclusions.

II. THE MODEL

A. Overview

The model distinguishes ten U.S. sectors: agriculture and mining, crude petroleum and refining, construction, the textile and apparel complex, metals, machinery, motor vehicles, miscellaneous manufacturing, services, and housing. This disaggregation permits consideration of several issues central to current debates over trade policy in the U.S. and abroad: for example, effects of restrictions on agricultural trade; of barriers to imports of textiles, steel and automobiles; and of restrictions on trade in services. The model also distinguishes ten foreign outputs.

At each point in time, domestic and foreign producers combine cost-minimizing levels of labor and intermediate inputs with the existing capital stock. Industry capital stocks evolve over time as a result of firms' investment decisions. Intermediate inputs can be obtained both at home and abroad, and firms choose the mix of domestic and foreign inputs in accordance with cost-minimization. The model adopts the "Armington" assumption, treating domestic and foreign intermediate inputs as imperfect substitutes.

Managers of domestic and foreign firms pursue forward-looking investment strategies aimed at maximizing the value of the firm. In making investment decisions, managers consider not only current profitability but potential future profits as well. Optimal investment involves balancing the costs of new capital (both the acquisition costs and the adjustment costs associated with installation) against its benefits in terms of the higher future revenues made possible by a larger capital stock, as in Abel (1979) and Summers (1981).

Forward-looking domestic and foreign households make consumption and portfolio decisions in accordance with intertemporal utility maximization. Overall consumption at each point in time is a composite of specific consumption good types which in turn are composites of domestically-produced and foreign-made goods of each type. When relative prices change, households alter the proportions of domestic and foreign consumer goods making up each composite in accordance with utility maximization. As on the production side, domestic and foreign consumer goods are treated as imperfect substitutes. Households' portfolio decisions include choosing the shares of domestic and foreign assets in financial wealth. An increase in the relative rate of return offered by a given asset induces households to hold a larger fraction of their wealth in that asset. These changes in asset demands give rise to changes in capital account balances and precipitate the adjustments in asset prices and rates of return necessary to bring about equilibrium in asset markets. Thus, both current and capital account transactions are treated explicitly, with balance-of-payments equilibrium established through adjustments in exchange rates and rates of return.

Finally, the model incorporates a government sector in both the domestic and foreign economies. Each government collects taxes, distributes transfers, purchases goods and services, and faces a budget constraint according to which revenues and expenditures must balance in each year.

B. Production

1. U.S. Industries

a. Production technologies. Each of the ten domestic industries produces a single output using inputs of labor, capital, and intermediate goods. A multi-level structure governs the production of each industry output (see Table 1). Firms choose the quantity of labor that maximizes profits, given the capital stock. Labor and capital combine to produce a value-added composite (VA). This composite then combines with intermediate inputs ($\bar{x}_1$, $\bar{x}_{2,\ldots}$, $\bar{x}_N$) in fixed proportions to generate output (X).

Industry outputs serve both as intermediate inputs and as final goods for purchase by the government. These outputs also combine in fixed proportions to create 17 different consumer goods as well as the capital goods used in production.[3]

Intermediate inputs are composites of foreign- and domestically-supplied intermediate goods. Each composite intermediate input of type i is a CES aggregate of foreign- and domestically-supplied intermediate goods of that type. Firms alter the mix of domestic and foreign inputs that make up each composite in accordance with cost-minimization.[4]

b. Producer behavior. Managers choose levels of employment, intermediate inputs, and investment to maximize V, the equity value of the firm. The starting point for obtaining an expression for V is the arbitrage condition requiring risk-adjusted rates of return to be equal across domestic assets. The expected return from holding (risky) equities must be consistent with those from holding a "safe" asset such as corporate debt. The return on equity is the sum of capital gains and dividends net of tax. Thus, for every firm at each point in time:

$$(1-\kappa)\ (\dot{V}-VN)/V + (1-\theta)\ DIV/V = i(1-\theta) + \eta \tag{1}$$

where VN represents new share issues, DIV is the current dividend, κ is the capital gains tax rate, θ is the marginal income tax rate, i is the nominal interest rate on domestic corporate debt, and η is the equity risk premium. Imposing a transversality condition ruling out eternal speculative bubbles and integrating yields an expression equating the value of the firm with the discounted value of after-tax dividends net of share issues:

$$V_t = \int_t^{\infty} \left[(\frac{1-\theta}{1-\kappa})DIV_s - VN_s\right] \exp\left[\int_t^s \frac{-r_u}{1-\kappa}\, du\right] ds \tag{2}$$

where r is the risk-adjusted rate of return, equal to $i(1-\theta) + \eta$.[5]

Dividends and new share issues in each period are related through the cash-flow identity equating sources and uses of funds:

$$EARN + BN + VN = DIV + IEXP \tag{3}$$

where EARN represents earnings after taxes and interest payments, BN is the value of new debt issue, and IEXP is the value of investment expenditure. Earnings are given by:

$$EARN = [pF(K,L,M) - wL - P_M M - iDEBT](1 - \tau) + \tau D \tag{4}$$

where K and L are inputs of capital and labor, M is the vector of composite intermediate inputs, p is output price (net of output taxes), F is quantity of output (gross of adjustment costs), w is wage rate (gross of indirect taxes on labor), P_M is the vector of composite intermediate input prices (gross of tariffs and intermediate input taxes facing the industry), DEBT is nominal debt, τ is corporate tax rate, and D is value of currently allowable depreciation allowances. We assume that firms pay dividends equal to a constant fraction, a, of after-tax profits net of economic depreciation and issue new debt to maintain a constant debt-capital ratio, b. We also assume that new share issues represent the marginal source of finance: that is, they make up the difference between EARN + BN and DIV + IEXP in equation (5).[6]

Investment expenditure is the sum of the "direct" costs of the new capital (net of the investment tax credit) plus adjustment costs associated with its installation:

$$IEXP = (1 - ITC)p_K I + (1 - \tau)p\phi I \qquad (5)$$

where ITC represents the investment tax credit rate, P_K is the purchase price of new capital goods, I is the quantity of investment, and $\phi(I/K)$ is adjustment costs per unit of investment. We model adjustment costs as internal to the firm: to add capital, currently available resources (labor, existing capital, and intermediate goods) must be devoted to installation.[7] Output is separable between inputs and adjustment costs:

$$X = F(K,L,M) - \phi I \qquad (6)$$

Using the capital stock accumulation condition, $\dot{K} = I - \delta^R K$, one can derive an expression for the value of the firm in terms of I, L, M, prices, taxes, and the technology. Firms maximize this value subject to the capital accumulation condition. Optimal investment is given by

$$\frac{I}{K} = h(Q) = h\left[[\frac{V-B}{p_K K} - 1 + ITC + b + \omega Z] \; [\frac{p_K}{(1-\tau)p}] \right] \tag{7}$$

where $h(\cdot) = [\phi + (I/K)\phi']^{-1}$, B is the present value of depreciation allowances on existing capital, Z is the present value of depreciation allowances on a dollar of new investment, and $\omega = a(1-\theta)/(1-\kappa) - a + 1$. Q is in fact the shadow value of marginal capital, or tax-adjusted q. Since components of Q — namely, V, B, and Z — are defined in terms of discounted streams of dividends and depreciation allowances, they incorporate expectations about the future.

The adjustment cost function is:

$$\phi(I/K) = \frac{(\beta/2)(I/K - \xi)^2}{I/K} \tag{8}$$

implying that the relationship between the rate of investment and Q is simply $I/K = \xi + (1/\beta)Q$.

2. Foreign Industry

The structure of foreign production is identical to that of domestic production, except for aggregation. A representative foreign firm produces output using inputs of capital, labor, and domestic and foreign intermediate inputs. Input levels as well as levels of investment are chosen to maximize firm value. A constant elasticity of transformation (CET) production frontier is employed to allow the prices of foreign goods to change relative to one another in response to changes in demand.[8]

C. Household Behavior

Households are represented as forward-looking and possessing perfect foresight. The treatment of domestic and foreign households is symmetric.

1. Consumption and Asset Choices

In each country, a representative, infinitely-lived household solves a multilevel decision problem (Table 2). Each household chooses a path of consumption and a path of portfolio holdings. When domestic and foreign assets are imperfect substitutes and offer different expected returns, portfolio and consumption choices need to be coordinated, since the choice of portfolio affects the overall rate of return to the household. One approach to this problem would be to incorporate risk explicitly. But the integration of portfolio choice and consumption demands in the face of risk and uncertainty presents difficult, unresolved theoretical issues, particularly when there are many time periods and many consumption goods.[9] Moreover, risk may only partly explain the main empirical fact of interest: that households hold diversified portfolios despite sustained differences in rates of return.[10] We adopt an alternative approach. Our starting point is the observation that households exhibit strong home-country preference: assets from their own country often make up the bulk of their portfolios, even when rates of return on other-country assets are comparable or higher. In keeping with this observation, we posit a portfolio preference function which is consistent with observed home-country preference yet which can be embedded within a utility-maximizing framework that allows households to adjust asset shares in accordance with differences in rates of return.[11] For concreteness, we discuss the domestic household problem here (the structure of the foreign household's maximization problem is perfectly analogous). In each period t, the domestic household maximizes a utility function of the form:

$$U_t = \int_t^{\infty} e^{-\delta(s-t)} \frac{\sigma}{\sigma-1} (C_s^{\beta} A_s^{1-\beta})^{\frac{\sigma-1}{\sigma}} ds \tag{9}$$

where δ is the rate of time preference, σ is the intertemporal elasticity of substitution, C is an index of overall consumption at a given point in time, and A is a function of the household's asset holdings. We specialize A to a CES function of α and $1-\alpha$, the shares of the household's portfolio devoted to domestic and foreign assets.[12]

$$A = k[\alpha_o^{1-\rho}\alpha^{\rho} + (1-\alpha_o)^{1-\rho}(1-\alpha)^{\rho}]^{1/\rho} \tag{10}$$

The household maximizes utility subject to the wealth accumulation condition:

$$\dot{WK}_t = r_{DD,t}\alpha_t WK_t + r_{DF,t}(1-\alpha_t)WK_t + YL_t - \bar{P}_t C_t \tag{11}$$

where WK is the total nonhuman wealth owned by the household, r_{DD} and r_{DF} are the annual after-tax returns offered to the domestic household on its holdings of domestic and foreign assets, YL is labor income net of all taxes and transfers, and $\bar{p}$ is the price index for overall consumption.

A(•) summarizes the household's portfolio preferences: if $r_{DD} = r_{DF}$, households maximize utility by choosing the asset shares α_o and $1-\alpha_o$. When rates of return differ, however, maintaining the portfolio shares α_o and $1-\alpha_o$ has a cost in terms of a lower overall return than that which could be obtained if the household held more of the asset with the higher return. The household chooses the path of α that balances the rewards of approaching preferred shares against the costs in terms of a lower overall return on the portfolio.

The parameter ρ in the portfolio preference function is related to σ_A, the elasticity of substitution between asset shares ($\rho = 1 - 1/\sigma_A$). When $\sigma_A = 0$, households maintain shares α_o and $1-\alpha_o$ of domestic and foreign assets irrespective of differences in rates of return. As $\sigma_A \rightarrow \infty$, household behavior approaches the limiting case of perfect substitutability, where the slightest difference in return leads households to hold only the asset offering the higher return.[13]

As shown in the appendix, the household's decision problem can be solved using optimal control techniques. Current consumption and saving depend on full (human and non-human) wealth and the expected interest rates.[14] Higher future interest rates reduce wealth and thereby reduce consumption and raise savings. Changes in the relative returns offered by home and foreign assets induce households to raise the portfolio share of the asset whose relative return has increased.

2. Household Non-human Wealth

The domestic (foreign) household's total non-human wealth, WK (WK^*), is related to industry liabilities according to:

$$WK = \gamma TWK + (1-\gamma^*)TWK^*/e \tag{12}$$

$$WK^* = \gamma^* TWK^* + (1-\gamma)TWK \cdot e \tag{13}$$

where TWK and TWK^* represent total nonhuman wealth (the total value of firm debt and equity) located at home and abroad, γ and γ^* denote the proportions of domestic and foreign wealth owned by domestic and foreign residents, respectively, and e is the nominal exchange rate, expressed as units of foreign currency per dollar. Assets are denominated in the currency of the country of origin. The proportion of the household's portfolio held in domestic assets (α), can be expressed as $\gamma TWK/WK$. The proportion of the foreign household's portfolio held in foreign assets (α^*), can be expressed analogously. When rates of return change, households immediately alter the composition of their portfolios. Changes in asset holdings over time reflect both changes in portfolio composition and increases in portfolio size associated with household saving.

Each asset generally yields a different return to residents of different countries; this reflects anticipated exchange rate movements and features of tax systems that impose different rates according to the residence of the taxpayer. $\bar{r}$ and $\bar{r}^*$, the average returns on the portfolios of domestic and foreign residents, are given by:

$$\bar{r} = \alpha r_{DD} + (1-\alpha) r_{DF} \qquad (14)$$

$$\bar{r}^* = \alpha^* r_{FF} + (1-\alpha^*) r_{FD} \qquad (15)$$

The variables r_{FF} and r_{FD}, defined analogously to r_{DD} and r_{DF}, are the returns expected by foreign residents on assets located in the foreign country and in the U.S., respectively.[15]

3. Demands for Specific Consumer Goods

For domestic households, overall consumption (C) in each period is a Cobb-Douglas aggregate of 17 composite consumption goods ($\bar{c}_i$), implying that consumption spending is allocated across consumption goods in fixed expenditure shares. Imported consumer goods are incorporated by treating each good $\bar{c}_i$ as a CES composite of domestic and foreign goods of type i. Households select the optimal mix of domestic and foreign goods to minimize the cost per unit of composite. Thus, international goods trade stems from cost-minimizing producer behavior (which generates trade in intermediate goods) and utility maximizing consumer behavior (which generates trade in consumer goods).

D. Government Behavior, Tariffs, and Voluntary Export Restraints

The domestic government is the same as in Goulder and Summers (1989), to which the reader is referred for details. The model incorporates very specific elements of the U.S. tax system. Overall real government spending (transfers plus purchases) is exogenous and increases at the steady-state growth rate, g. The model is parameterized so that in the base case, government revenues equal expenditures in each period. In revised-case simulations, budget balance is maintained through lump-sum adjustments to personal income taxes.[16] The foreign government performs the same functions and has the same tax instruments as the domestic economy government.

We model tariffs on an *ad valorem* basis, considering tariffs on imports of both consumer goods and intermediate inputs. We treat voluntary export restraints (VER's) by imposing values for the *ad valorem* rents or markups associated with these restrictions. In the absence of a policy change, the same rents (per dollar of import) continue to apply over time.[17] Liberalized VER's are represented as reductions in the *ad valorem* markups. While tariff revenues accrue to the U.S. government, VER rents are enjoyed by foreign producers.

E. Equilibrium

The model is calibrated to exhibit steady-state growth in the base case (or benchmark) equilibrium. Following a policy shock, temporary equilibria (in the sense employed by Grandmont, 1977) with market-clearing are generated in every period. These temporary equilibria form a transition path on which the economy gradually approaches a new long-run, steady-state equilibrium.

The requirements of temporary equilibrium are that in each country and in each period: (1) the demand for labor equal its supply, (2) the demand for output from each industry equal its supply, (3) total external borrowing by firms equal total saving by residents of the given country plus the net capital inflow, and (4) government revenues equal government spending. Equilibrium is established by adjustments in the nominal exchange rate, in domestic and foreign output prices, and in lump-sum adjustments to domestic and foreign taxes.[18] To solve for the temporary equilibrium of each period, we employ the algorithm of Powell (1970), which is designed to solve systems of nonlinear equations.

In the short run, shocks give rise to divergences in marginal products of capital across industries and in average portfolio returns to domestic and foreign residents. Over time, long-run equilibrium is re-established as firms' investment decisions equalize marginal products of capital across industries (adjusted for taxes and risk) and households' portfolio decisions and savings behavior equalize overall portfolio returns (see Goulder and Eichengreen, 1989).

Since households and firms are forward-looking with perfect foresight, solution of the model requires that expectations conform to the actual future values. To derive perfect foresight expectations, we repeatedly solve the model forward, each time generating a path of equilibria under a given set of expectations. After each path of equilibria is obtained, we revise the expectations and solve for a new path. Using an approach similar to that of Fair and Taylor (1983), we obtain perfect foresight expectations and the consistent intertemporal equilibrium path.

III. DATA AND PARAMETERS

Here we sketch out the data sources and calibration procedures for the model. Details are provided in Goulder and Eichengreen (1989).

A. Stocks and Flows

We combine information from different sources to form a 1983 benchmark data set. Much of the benchmark data is drawn from the general equilibrium data set assembled by Scholz (1987). We supplemented Scholz's data on consumption and production with data on capital stocks and capital taxes as well as parameters governing firms' financial behavior (dividend-payout ratios, debt-capital ratios, etc.). Base case values for important variables are displayed in Table 3.

Since domestic firms distinguish between domestic and foreign intermediate goods in production, it is necessary to employ a domestic and foreign input-output matrix describing the use of domestic- and foreign-made inputs in each industry. Since there exists no readily-available foreign input-output matrix, we constructed one.[19] "Armington" elasticities of substitution in consumption and production were obtained by aggregating estimates from Shiells, Deardorff, and Stern (1986).

Finally, we calculated tariff rates based on information in TRADENET data tapes from the U.S. Department of Commerce. VER rates were obtained from Hufbauer et al. (1986), Hamilton (1988), Feenstra (1985), and Dinopoulos and Kreinin (1987). Tariffs are expressed as *ad valorem* equivalent rates, computed as the ratio of tariff revenues to import value. In most cases, the *ad valorem* equivalents of VER's for 1983 are import-weighted averages of estimates obtained for more detailed industry categories. Base case tariff rates, VER rates, and trade flows are displayed in Table 4. Interestingly, the VER rates on average are considerably higher than the tariff rates, a fact emphasized by de Melo and Tarr (1989).[20]

B. Parameters

Calibrating the model involves selecting certain parameters from outside sources and deriving the remainder from restrictions posed by two sorts of requirements. According to the replication requirement, the model must generate a base case equilibrium solution with values matching those of the benchmark data set. According to the balanced growth requirement, the model must generate a steady-state growth path in the base case.

We first specify the exogenous growth rate of effective labor (g), the exogenous growth rate of nominal wages (π_o), and the gross-of-tax nominal interest rate (i). These variables take the values .03, .06, and .075, respectively. g accounts for both population growth and Harrod-neutral technical change, and determines the steady-state real growth rate of the economy.[21] π_o determines the steady-state inflation rate.[22] We also employ a value of 0.5 for the intertemporal elasticity of substitution (σ).[23]

In the steady state, the rate of gross investment (I/K) in each industry must satisfy $I/K = g + \delta^R$ (suppressing subscripts for convenience). Values for K, g, and δ^R are contained in the benchmark data set, allowing the initial level of investment in each industry to be derived from this steady-state requirement for the investment rate. Combining these investment levels with data on firms' incomes and with the required dividend and interest payments implied by firms' dividend payout and debt-capital ratios, we calculate the level of external borrowing by firms necessary to meet investment needs.

On the household side, we calculate human and non-human wealth based on benchmark income flows, the benchmark interest rate, and the assumption of steady-state income growth. The solution of the household utility maximization problem yields an expression for steady-state consumption in terms of total wealth, the path of interest rates, and parameters (see appendix). Using the benchmark values for total wealth and the (steady-state) interest rate, along with a posited value for time preference (δ), we calculate initial consumption; this is subtracted from initial income to obtain the initial value of household savings. In the benchmark equilibrium, we require a zero capital account balance. This implies that in each country the value of aggregate household savings must equal total external borrowing by firms. This requirement is applied to identify δ. The value of δ that satisfies this requirement is .025.

This procedure yields a fully parameterized benchmark data set. By the replication restriction, the values for flows in this data set correspond to the values generated by the model in the base case.

IV. SIMULATION RESULTS

Here we examine permanent, unilateral, fifty percent across-the-board reductions by the U.S. of different trade barriers. We consider reductions in tariffs and in VER's, examining the two changes separately and in combination.[24] In all policy experiments, the paths of real government spending at home and abroad are the same as in the base case equilibrium; lump-sum adjustments to personal income taxes are applied to assure budget balance in each country at each point in time.

A. Aggregate Effects

Table 5 summarizes the aggregate effects. Consider first the tariff reductions alone. Tariff cuts reduce the wedge between gross- and net-of-tariff import prices by 50 percent, or by .021 1983 dollars on average.[25]

However, the average gross-of-tariff import price falls by much less than this amount because of the increase in average net-of-tariff prices. The rise in net-of-tariff prices — by 1 percent on impact and 1.2 percent in the steady state — offsets approximately half of the reduction in the tariff wedge. This reflects U.S. monopsony power in international markets — specifically, the impact on world prices of the rise in import demands occasioned by the tariff reductions.

From the U.S. viewpoint, the costs in terms of higher net-of-tariff import prices and reduced tariff revenues are larger than the gross efficiency benefits from reduced tariffs. The U.S. forfeits the standard terms-of-trade gain accruing to a large country from a tariff (absent retaliation). Since actual rates in the base case are below optimal tariff rates, cutting these rates causes domestic wealth and consumption to fall (relative to the base case paths).[26] In contrast, higher net-of-tariff prices benefit foreign producers as well as foreign households, who own over 95 percent of foreign productive assets. Hence foreign consumption and wealth rise.

Table 5 reveals significant changes over time. The adverse terms of trade effects become larger as the U.S. adjusts its capital stock to concentrate more on imports (which, although rising in price, are still less expensive gross of tariffs than in the base case).[27] As a consequence of the deterioration in the terms of trade, U.S. household consumption and wealth continue to fall and foreign household consumption and wealth continue to rise following the impact effect. In the short run, U.S. saving falls short of domestic investment (while foreign saving exceeds foreign investment); hence the U.S. runs a capital account surplus and a current account deficit.[28] As these current account deficits persist, Americans accumulate debt to foreigners. A larger fraction of U.S. output (largely owned by U.S. households) must therefore be transferred to foreigners in the form of interest payments. After 13 years, the trade balance swings from deficit to surplus to enable the U.S. to finance the net interest payments stemming from the debt to foreigners accumulated in the interim.

Cuts in VER's, also shown in Table 5, generally produce larger macroeconomic effects, in keeping with the fact that in the benchmark data VER's (measured in terms of their *ad valorem* equivalents) are larger than tariffs. Although the policy change reduces the average VER markup by .031 (one-half the benchmark average), import prices again fall by only about half this amount because of U.S. monopsony power. But in contrast to the tariff case, U.S. producers and households benefit from the VER reductions despite the terms-of-trade effect. This is a familiar result attributable to the differences in the disposition of the tariff and VER rents. Tariff reductions lower the "rents" (tariff revenues) that are enjoyed by U.S. taxpayers, since such revenues enable the U.S. government to maintain the same public expenditures with lower domestic taxes; in contrast, VER reductions lower the rents that accrue to foreign producers and that largely benefit foreign households (the principal owners of foreign firms). Thus, as the table indicates, the VER reductions lead to reductions in foreign wealth and consumption, but increases in U.S. wealth and consumption.

Although this policy change improves the terms of trade, the improvement diminishes over time. Accordingly, U.S. wealth and consumption are somewhat higher (relative to the base case) in the short run than in the long run, although the changes over time are not as pronounced as under the tariff reduction. Although the VER reduction boosts both domestic saving and investment, the investment response is larger, and thus the U.S. initially runs a current account deficit. After 10 years, the U.S. trade balance moves into surplus to enable the nation to meet the net interest obligations associated with previous foreign borrowing.

We also consider the reduction of tariffs and VER's in combination. Table 5 indicates relatively little interaction: the percentage changes produced by the combined policy are approximately equal to the sum of the changes from the component policies.

B. <u>The Significance of International Capital Mobility</u>

To explore further the significance of international capital flows, we simulated the same tariff and VER cuts under the assumption of no international capital mobility.[29] Differences are displayed in Figure 1. The consumption paths indicate that international capital flows enable U.S. households to enjoy more consumption in the short term. On impact, both tariff cuts and VER reductions tend to raise domestic investment relative to saving. This is compatible with equilibrium in the loanable funds market only if there is a net inflow of foreign capital. In the absence of capital mobility, domestic interest rates must rise to eliminate the savings-investment imbalance, and thus domestic consumption is lowered. In the long run, however, domestic consumption is higher absent capital mobility, since U.S. households do not accumulate debt to foreigners and thereby avoid the need to service increased liabilities to foreigners through increased exports.

The paths in Figure 1 indicate that consideration of international capital flows is important for ascertaining the effects of these policy changes. Under the tariff cut, the signs of the short-term effects on consumption and investment are reversed once the capital account is considered.

C. Welfare Effects

Table 6 shows the effects of these initiatives on the welfare of U.S. and foreign households. The welfare measure is a dynamic equivalent variation, expressed as a percentage of base case non-human wealth.[30] EV represents the change in welfare inclusive of changes along the transition path; EV_{ss} indicates the change in steady-state welfare, disregarding the transition.

The effects on U.S. households of the tariff and VER reductions are of opposite sign, as expected, and the VER effects are much larger in magnitude. The negative welfare impact of the tariff attests to monopsony power effects and the significance of the optimal tariff considerations mentioned earlier.[31]

The results also underscore the importance for welfare of international capital mobility. For U.S. households, the (inclusive-of-transition) EV's are higher in the presence of internationally mobile capital than in its absence. Mobility enables such households to enjoy more consumption in the short and medium term. Although long-run consumption is lower in the mobility case than in the no-mobility case, the higher EV's under mobility indicate that the nearer-term consumption gains more than compensate for the longer-term sacrifice. As indicated by the figures in the EV_{ss} column for U.S. households, steady-state welfare is higher in the absence of international capital mobility, since long-run consumption is higher.

D. Industry Effects

Table 7 reveals considerable variation across industries. The textiles, apparel, and leather complex is affected most profoundly by loss of protection. This is in keeping with the fact that this industry enjoyed the most generous levels of tariff and non-tariff protection in the base case, so that halving the effective rates significantly reduces industry output. The motor vehicles industry is similarly affected (particularly by the reduction of the generous VER levels from which it benefits in the base case).

Some industries benefit from liberalized trade. For these industries, positive cost-side effects (in terms of reduced prices of foreign intermediate inputs) are larger than the negative demand-side effects (in terms of lost producer or consumer demand associated with the cheaper prices of competing imports). The industries which especially benefit — miscellaneous manufacturing and machinery — are those in which foreign inputs represent a significant share of costs (Table 3), in which initial levels of protection are relatively low (Table 4), and in which export volumes are significant.

Short- and long-run responses differ widely at the industry level. In the petroleum refining industry, only a third of the long-run output response shows up in the short run. In contrast, in the services industry nearly 90 percent of the long-run output response is evident in the short run.

E. Sensitivity Analysis

Table 8 presents results under alternative parameter values. Higher U.S. "Armington" elasticities, or lower foreign ones, imply larger terms-of-trade effects (larger increases in net-of-tariff prices) when tariffs or VER's are reduced. Hence the U.S. welfare losses from tariff cuts are greater, and the

U.S. welfare gains from liberalized VER's are smaller. The reverse is the case when the elasticities are changed in the other direction. Welfare effects are relatively sensitive to changes in the Armington elasticities; since the values of these parameters are not known with precision, one cannot make definitive statements about the magnitude of the aggregate welfare effects.

Lower adjustment costs imply a more elastic response of investment to policy shocks. Similarly, a higher intertemporal consumption elasticity implies a more elastic savings response. In both cases adjustment proceeds more rapidly, and the terms of trade worsen more quickly. Thus the welfare losses from the tariff cut are larger under low adjustment costs and high intertemporal consumption elasticities than in the central case. However, lower adjustment costs and higher intertemporal elasticities yield higher welfare under the VER cut. Efficiency gains from VER reductions are larger in these more elastic cases. The results suggest that the larger efficiency gains more than compensate for the costs associated with a faster deterioration of the terms of trade. Finally, the "Keynesian Consumption" simulation specifies savings in each period as a function of current income and current interest rates rather than as stemming from intertemporal optimization. In the short term, the decline in domestic saving is smaller under this specification than in the central case. Hence U.S. interest rates are lower, and domestic investment higher, in the short run. The gap between domestic saving and investment is smaller under this specification; hence the capital account surplus (trade balance) is smaller. Differences in the long run are not dramatic.

V. CONCLUSIONS

In this paper we have investigated important trade initiatives using a disaggregated model that incorporates a rigorous intertemporal treatment of household and firm decisionmaking, adjustment dynamics, and attention to international capital movements.

We find that the VER's are considerably more significant than tariffs in terms of the magnitude of the potential welfare changes from their removal. Reducing VER's by fifty percent (on an *ad valorem* equivalent basis) generates welfare gains valued at between two and four percent of current non-human wealth. Halving tariffs produces much smaller welfare effects.

Simulations indicate that the U.S. wields significant monopsony power, as world prices increase considerably when trade barriers are removed and U.S. import demands increase. Such price increases attenuate the potential gains from the removal of VER's and account for the welfare losses under tariff reductions.

International capital movements critically regulate the ways the U.S. and foreign economies respond to these trade initiatives. Trade liberalization leads to significant inflows of foreign capital that tend to depress U.S. interest rates and induce more short-term domestic consumption than would arise in the absence of capital mobility. Disregarding international capital movements leads to significantly different results; indeed, the sign of the consumption response may be reversed. These results underscore the importance of considering international capital movements in analyzing major trade initiatives.

Footnotes

1. The recent debate over the prospective U.S.-Canada free trade agreement has given new impetus to this research. See, for example, Brown and Stern (1987) and Wigle (1988).

2. An exception is provided by Brown and Stern (1987), who consider international capital flows in a model of U.S.-Canadian trade.

3. All capital goods are assumed to be produced with the same technology.

4. We calibrate the model using econometric estimates of elasticities of substitution between domestic and foreign intermediates; these elasticities regulate the magnitude of terms-of-trade effects by influencing the extent to which demands for imported inputs are responsive to changes in relative prices.

5. Poterba and Summers (1985) explicitly derive this expression for V.

6. This specification conforms to the "traditional" view of dividend behavior. Empirical support for this view is presented in Poterba and Summers (1985) and Shoven (1986).

7. See Mussa (1978) for a discussion of alternative approaches to modeling adjustment costs.

8. De Melo and Robinson (1986) have shown how CET frontiers can be used to endogenize (in a given currency) the relative prices of goods supplied by a given industry to the home market and the export market. Our CET frontier endogenizes the relative prices (in foreign currency) of foreign goods. This appears to be the simplest way to make these prices responsive to changes in demand without explicitly introducing separate production functions for each foreign good.

9. The consumption-based capital asset pricing model (see, for example, Duffie and Zame, 1987) offers a potential approach to this problem, although the difficulties of empirical implementation are formidable.

10. Adler and Dumas (1983), for example, argue that exchange rate risk provides only part of the explanation as to why households maintain internationally diversified portfolios.

11. The model is agnostic as regards the specific bases for households' portfolio preferences. One explanation might invoke risk considerations. Another might refer to different liquidity services offered by domestic and foreign assets. Poterba and Rotemberg (1983) refer to such services to justify including money in individual utility function.

12. An alternative formulation would define A in terms of asset levels rather than shares. But since asset stocks are used to finance future consumption, adding levels of asset holdings to the utility function would introduce an element of double-counting.

13. Thus the value of σ critically influences the extent to which policy shocks or other exogenous changes will generate international capital flows.

14. Human wealth is the present value of the infinite stream of after-tax earnings and transfers; non-human wealth is the present value of the stream of after-tax dividends (net of new share issues) and interest payments.

15. The rate r_{DD} is a weighted average of the after-tax rates of return (inclusive of risk premium) offered to the domestic household from its ownership of domestic equities and debt. Similarly for r_{DF}, r_{FF}, and r_{FD}. The returns r_{DF} and r_{FD} incorporate the capital gains from exchange rate movements.

16. This facilitates welfare evaluations, since household utility functions do not incorporate welfare derived from government-provided goods and services.

17. In the model's base case equilibrium, a quota that increases at the steady-state growth rate of the economy is equivalent either to a tariff or to a VER depending on whether the quota rents accrue to the U.S. government (tariff) or to foreign producers (VER). The disposition of the quota rents depends on whether quotas are auctioned competitively.

18. The number of equilibrating "prices" is one less than the number of equilibrium conditions, reflecting the fact that one of the equilibrium conditions is redundant from Walras's Law. Both domestic and foreign nominal wages are fixed in their respective currencies. The exchange rate variable permits the relative prices of domestic and foreign labor to vary. It may be noted that balance of payments equilibrium does not require an additional equilibrium condition: Walras' Law assures that this equilibrium is established when the other markets clear.

19. This involved categorizing imports according to their end use (intermediate use, consumption, or investment.) This information was obtained from the End-Use Import Tables of the Bureau of the Census Highlights of U.S. Export and Import Trade (1983) for merchandise trade, and from McCulloch (1988) for trade in services.

20. Since the 1983 benchmark year, VER rates have continued to rise, both absolutely and relative to tariff rates. See de Melo and Tarr. Compared to other sources, the Hufbauer et al. estimates of VER *ad valorem* equivalents are large, a fact that should be borne in mind when interpreting the simulation results. We employ the Hufbauer et al. estimates because they are the only consistent ones of which we are aware that are available for a wide range of commodities. We follow de Melo

and Tarr in substituting Hamilton's estimates for textiles and Feenstra's and Dinopoulos-Kreinin's for autos, however, since these authors have made more extensive efforts to control for quality change (trading up).

21. The model is indifferent as to the relative contributions of population growth and Harrod-neutral technical change to the overall growth of effective labor.

22. Many computable general equilibrium models are homogeneous of degree zero in all prices, so that the price level has no significance. This model incorporates the fact that in the U.S., nominal capital gains are taxed and depreciation deductions are based on the nominal acquisition cost. Hence the price level (and thus the rate of inflation) affects real tax obligations.

23. Econometric estimates of σ vary considerably. We consider a range of values spanning most of the low estimates from time-series analyses and higher ones from cross-sectional studies. See Hall (1985) for a general discussion and recent estimates.

24. We simulate the VER reductions by halving the *ad valorem* tariff equivalent rates. The increase in imports associated with these liberalizations is therefore endogenous. We assume that tariffs and VER's apply to different specific types of goods within each of our 10 industry or 17 consumer good categories. For this reason, when we simulate tariff reductions we do not raise the VER markups to maintain the same import levels.

25. Average import prices are expressed relative to the U.S. producer price index; the weights used in their computation are benchmark import shares.

26. Domestic wealth and consumption rise slightly in the first few periods. In the short term, significant inflows of foreign capital depress U.S. interest rates; this raises domestic wealth, which in turn stimulates higher consumption.

27. The time profile of the terms of trade depends on supply as well as demand considerations. Under different parameter specifications (with more elastic capital stock responses, for example), the terms of trade could improve, rather than worsen, over time. This is the case because trade liberalization ultimately raises the foreign capital stock relative to the U.S. stock of capital. By increasing the supply of foreign goods (relative to U.S. goods), this exerts a positive influence on the U.S. terms of trade. Under our central case parameter assumptions, however, this supply-side effect is more than offset by demand-side effects.

28. The capital account surplus arises as follows. The tariff cut raises demands for foreign goods and stimulates investment demands abroad, which pull up foreign interest rates. Increased purchases of imports also raise foreign incomes. Because foreign interest rates rise, foreign wealth falls slightly, despite increased foreign incomes (current and future). Foreign household consumption (a function of wealth) rises only

slightly. Hence foreign income rises considerably more than consumption, and foreign saving increases by more than the increase in foreign investment. For example, in the first period, foreign saving rises by .68 percent, while foreign investment increases by only .01 percent. The excess of foreign saving over investment is the net capital inflow to the U.S.

29. In this alternative specification, we assume that all capital located domestically (abroad) is owned by U.S. (foreign) residents. Hence the base case equilibrium involves no international capital flows or international interest payments. In all other respects the base case equilibrium path is identical to that under capital mobility. In the no-mobility case, portfolio shares do not enter household utility functions.

30. The dynamic equivalent variation is the change in initial wealth at base case prices necessary to yield the same lifetime utility as enjoyed in the policy change case. Thus a positive EV implies that the policy change is welfare-improving.

31. We have simulated increases in tariffs to locate the "optimal" tariff. We find that, under our central case parameter assumptions, U.S. welfare reaches a maximum when tariff rates are approximately 6 times the benchmark rates. We only considered raising all tariffs in the same proportion; further welfare increases would be possible with non-uniform increases. Since welfare effects are quite sensitive to parameters whose values are not known with precision (see sensitivity analysis subsection), these optimal tariff results should only be regarded as suggestive.

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Table 1

Industry Production Structure

Production Relationship	Functional Form
$X = X(VA, \bar{x}_1, \bar{x}_2, \ldots, \bar{x}_N)$	Leontief
$VA = VA(L, \bar{K})$	CES
$\bar{x}_i = \bar{x}_i(x_i, x_i^*) \quad (i = i, N)$	CES

Key:

X = gross output (exclusive of adjustment costs).

VA = value added.

L = labor input.

$\bar{K}$ = capital input (fixed in the current period of time).

$\bar{x}_i$ = composite intermediate input $(i = 1, \ldots, N)$.

x_i = intermediate domestically-produced input $(i = 1, \ldots, N)$.

x_i^* = intermediate foreign-produced input $(i = 1, \ldots, N)$.

Table 2

Household Consumption Structure

Consumption Relationship	Functional Form
$U = U(\bar{C}_t, \bar{C}_{t+1}, \ldots)$	constant intertemporal elasticity of substitution
$\bar{C}_s = \bar{C}_s(C_s, A_s)$	Cobb-Douglas
$C_s = C_s(\bar{c}_{1,s'}, \bar{c}_{2,s'}, \ldots, \bar{c}_{m,s})$	Cobb-Douglas
$A_s = A_s(\alpha_s, 1-\alpha_s)$	CES
$\bar{c}_{i,s} = \bar{c}(c_{i,s}, c_{i,s}^*)$	CES

Key:

U = intertemporal utility.

C_s = overall consumption at time s.

A_s = portfolio preference index at time s.

$\bar{c}_{i,s}$ = consumption of composite consumer good i at time s.

$c_{i,s}$ = consumption of domestically-made consumer good i at time s.

$c_{i,s}^*$ = consumption of foreign-made consumer good i at time s.

α_s = share of portfolio devoted to domestically-located assets.

Table 3

Base Case Production Values[1]

	Gross Output	Capital	Labor	Intermediate Inputs Domestic	Intermediate Inputs Foreign	Foreign Input Cost Share [(5)/((4)+(5))]
	(1)	(2)	(3)	(4)	(5)	(6)
DOMESTIC INDUSTRY						
1. Agriculture	249.8	178.0	31.0	193.7	3.5	.018
2. Petr. Refining	279.7	287.7	25.6	207.9	88.5	.299
3. Construction	367.1	14.6	112.1	74.9	0.0	.000
4. Textiles	138.6	23.6	28.0	52.9	1.7	.031
5. Metals	296.5	97.0	85.9	144.5	47.8	.249
6. Machinery	296.7	85.6	79.7	159.6	4.9	.030
7. Motor Vehicles	133.5	27.7	25.1	34.8	2.9	.077
8. Misc. Manufacturing	930.9	261.3	199.2	458.9	12.5	.027
9. Services	2160.7	1656.5	971.5	1036.3	10.4	.010
10. Housing	439.2	1890.4	11.0	0.0	0.0	.000
Total	5292.7	4522.4	1568.1	2363.6	172.2	.073
FOREIGN INDUSTRY	12,602.4	12,597.9	4297.3	5232.4	282.6	.054

[1] All values in billions of 1983 dollars.

Table 4

Base Case Trade Flows and Parameters[1]

	Tariff Rate (%)	Tariff Revenue	VER Rate (%)	VER Rents	Import Value[2]	Subst. Elast.[3]	Export Value
Intermediate good:							
1. Agriculture	5.1	.18	7.9	.26	3.49	1.14	33.90
2. Petr. Refining	0.4	.34	3.4	2.93	88.50	2.36	17.58
3. Construction	0.0	.00	0.0	.00	.00	1.00	.14
4. Textiles	22.2	.37	43.4	0.51	1.68	6.19	2.87
5. Metals	4.5	2.13	6.9	3.07	47.80	2.80	6.21
6. Machinery	4.8	.24	3.4	.16	4.94	4.79	43.77
7. Motor Vehicles	3.8	.11	26.4	.61	2.91	1.00	6.32
8. Misc. Manufacturing	5.9	.74	5.4	.64	12.53	1.64	91.80
9. Services	3.9	.41	3.4	.34	10.38	1.00	80.00
10. Housing	0.0	.00	0.0	.00	.00	1.00	.00
All Intermediate Goods:	2.6	4.53	5.2	8.53	172.23	2.40	282.60
All Consumer Goods:	8.3	8.32	11.7	10.46	99.96	2.66	43.05
Total - All Goods:	3.9	12.85	6.2	18.99	325.65	2.49	325.65

[1] All values in billions of 1983 dollars. Rates in last three rows are weighted averages.

[2] Net of tariffs but gross of VER rents.

[3] Elasticity of substitution between corresponding domestic and imported goods. Central case substitution elasticities for the foreign economy are twice the values in the table. The larger values are included to account for the foreign economy's larger size (2.33 times that of U.S.), which implies greater opportunities for intra-industry substitution.

Table 5

Aggregate Affects of Reduced Trade Barriers[1]

	Reduced Tariffs			Reduced VER's			Combined Reductions		
Period:	1	5	∞	1	5	∞	1	5	∞
Avg. Import Price[2]									
Gross of tariffs (base case value = 1.104)	1.093	1.094	1.095	1.086	1.088	1.089	1.078	1.080	1.082
Net of tariffs (base case value = 1.062)	1.072	1.073	1.074	1.046	1.047	1.048	1.057	1.060	1.061
Terms of Trade[3]	.991	.990	.989	1.022	1.021	1.019	1.012	1.009	1.006
U.S. Economy									
Consumption	.04	−.02	−.12	.58	.53	.51	.62	.50	.36
Investment	.05	.02	−.12	.14	.14	.14	.19	.14	−.01
GDP	.01	.03	−.01	.00	.04	.09	.00	.06	.07
Household Wealth	.12	.03	−.12	.60	.52	.50	.75	.55	.35
Foreign Economy									
Consumption	.04	.07	.16	−.02	.00	−.04	.02	.07	.12
Investment	.01	.04	.18	−.16	−.15	−.24	−.15	−.11	−.07
GDP	.00	.00	.06	.00	−.02	−.08	.00	−.02	−.02
Household Wealth	−.02	.03	.15	−.02	−.01	−.04	−.05	.05	.13
Value of Imports									
Gross-of-Tariff Value	2.76	2.70	2.60	7.14	7.10	7.16	10.69	10.58	10.56
Tariff Revenue	−44.38	−44.45	−44.46	17.55	17.44	17.69	−33.76	−33.90	−33.70
Net-of-Tariff Value	4.62	4.56	4.46	6.73	6.70	6.74	12.44	12.33	12.30
VER Rent	10.51	10.25	10.19	−30.38	−30.54	−30.39	−21.56	−21.93	−21.68
Value of Exports	3.75	4.20	4.58	5.74	6.36	6.87	10.41	11.60	12.56
Balance of Payments[4]									
Trade Balance	−2.9	−1.2	.4	−3.2	−1.1	.4	−6.6	−2.4	.8
Net Interest Income	.8	.0	−.6	.7	−.2	−.6	1.6	−.1	−1.2
Capital Account	2.1	1.1	.2	2.6	1.3	.2	5.1	2.5	.3

[1] All figures express percentage changes from the base case path, except for items under average import price and balance of payments headings.

[2] Weighted-average nominal dollar price of imports, divided by U.S. producer price index. Weights are base case import shares.

[3] Terms of trade defined as ratio of Laspeyres export price index to Laspeyres net-of-tariff import price index. Base case ratio is 1.

[4] Figures under this heading are in billions of real U.S. dollars. All figures are normalized to adjust for steady-state growth trend.

Figure 1

U.S. Consumption Dynamics under Alternative Mobility Assumptions

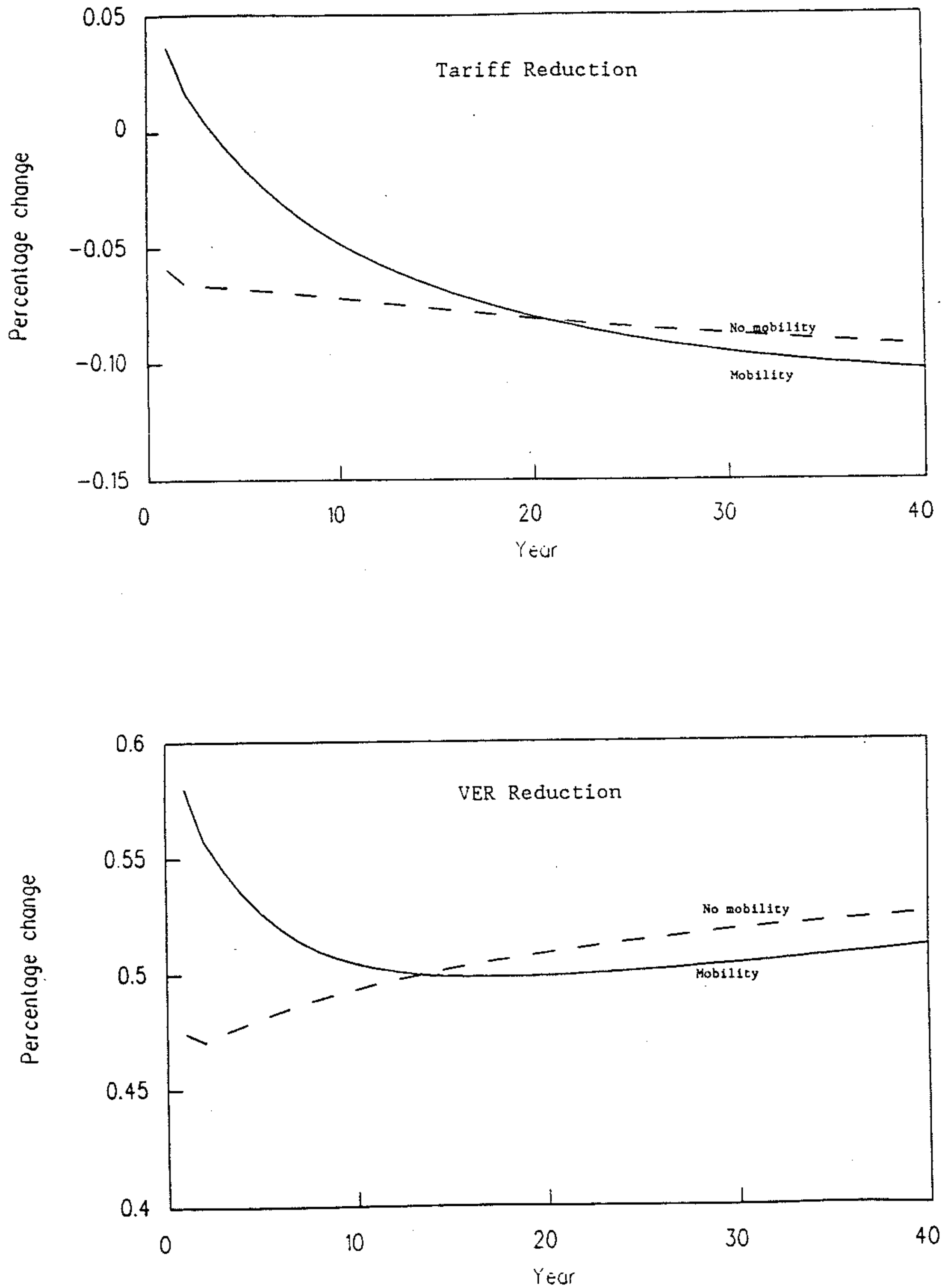

Table 6

Welfare Effects

	U.S. Households		Foreign Households	
	EV	EV_{SS}	EV	EV_{SS}
Reduced Tariffs				
mobile capital	-.39	-.89	.72	1.12
immobile capital	-.56	-.72	.78	1.06
Reduced VER's				
mobile capital	3.58	3.56	-.07	-.30
immobile capital	3.46	3.71	-.01	-.36
Combined Reductions				
mobile capital	3.11	2.52	.69	.89
immobile capital	2.82	2.85	.82	.76

Table 7
Industry Effects

		Reduced Tariffs		Reduced VER's		Combined Reductions	
		SR	LR	SR	SR	SR	LR
1. Agriculture	Output	.19	.46	.38	.88	.61	1.44
	Earnings	1.03	.50	2.02	.97	3.27	1.56
	Investment	.57	.45	1.04	.87	1.69	1.41
2. Petr. Ref.	Output	.32	.85	.30	.84	.67	1.83
	Earnings	1.04	.90	.95	.94	2.17	1.98
	Investment	.99	.82	.95	.82	2.06	1.77
3. Construction	Output	.03	−.08	.10	.10	.12	.00
	Earnings	−.01	−.08	.01	.15	−.03	.04
	Investment	.09	−.10	.14	.10	.21	−.05
4. Textiles	Output	−2.59	−2.77	−7.99	−8.62	−11.89	−12.94
	Earnings	−3.26	−2.77	−10.08	−8.59	−14.82	−12.93
	Investment	−2.08	−2.77	−6.59	−8.59	−9.81	−12.91
5. Metals	Output	−.14	−.09	−.25	−.10	−.28	−.07
	Earnings	−.13	−.09	−.28	−.05	−.28	−.02
	Investment	−.03	−.13	−.12	−.13	−.06	−.15
6. Machinery	Output	1.18	1.60	1.88	2.55	3.38	4.64
	Earnings	1.68	1.60	2.63	2.61	4.78	4.40
	Investment	1.26	1.57	1.94	2.53	3.53	4.58
7. Vehicles	Output	.05	.02	−1.19	−1.23	−1.09	−1.16
	Earnings	.05	.02	−1.43	−1.19	−1.33	−1.13
	Investment	.12	.00	−.89	−1.19	−.74	−1.16
8. Misc. Manufacturing	Output	.15	.24	.52	.71	.73	1.03
	Earnings	.19	.24	.63	.77	.89	1.09
	Investment	.23	.20	.56	.68	.85	.94
9. Services	Output	−.08	−.10	−.07	−.07	−.18	−.21
	Earnings	−.03	−.10	−.04	−.01	−.10	−.16
	Investment	−.03	−.15	−.06	−.12	−.12	−.33
10. Housing	Output	.04	−.32	−.03	.14	.02	−.26
	Earnings	−.16	−.26	.53	.25	.33	−.04
	Investment	−.08	−.32	.08	.13	−.03	−.26
Total Domestic	Output	.02	.05	−.05	.08	−.04	.13
	Earnings	.05	−.06	.49	.28	.54	.20
	Investment	.05	−.12	.14	.14	.19	−.01
Foreign	Output	.00	.06	.01	−.08	.01	−.02
	Earnings	.06	.18	−.23	−.25	−.23	−.08
	Investment	.01	.18	−.16	−.24	−.15	−.07

NOTE: "SR" and "LR" refer to effects in first period and new steady state.

Table 8

Sensitivity Analysis

	Avg. Import Price (net of tariffs)		Trade Balance		U.S. Consumption		U.S. Investment		U.S. Household Welfare		Foreign Household Welfare	
	SR	LR	SR	LR	SR	LR	SR	LR	EV	EV_{SS}	EV	EV_{SS}
A. <u>Tariff Reduction</u>												
1. Central Case	1.072	1.074	−2.9	0.4	0.04	−0.12	0.05	−0.12	−0.39	−0.89	−0.72	1.12
2. "Armington" Elasticities												
a. U.S. values halved	1.068	1.069	−1.6	0.2	0.04	−0.04	0.03	−0.03	−0.06	−0.29	0.42	0.66
b. U.S. values doubled	1.078	1.080	−4.8	0.6	0.04	−0.21	−0.10	−0.20	−0.78	−1.56	1.15	1.80
c. Foreign values halved	1.078	1.082	−4.1	0.6	−0.03	−0.34	0.09	−0.29	−1.38	−2.50	0.95	1.48
d. Foreign values doubled	1.068	1.068	−2.0	0.2	0.09	0.01	0.03	−0.01	0.24	0.10	0.56	0.89
3. Adjustment Costs												
a. Low	1.072	1.074	−3.0	0.3	0.04	−0.12	0.07	−0.11	−0.41	−0.93	0.78	1.20
b. High	1.072	1.074	−2.8	0.5	0.03	−0.13	0.05	−0.12	−0.38	−0.86	0.67	1.06
4. Intertemporal Consumption Elasticities												
a. Low	1.072	1.074	−2.6	0.4	0.01	−0.12	0.08	−0.11	−0.34	−0.88	0.66	1.11
b. High	1.072	1.074	−3.3	0.3	0.08	−0.12	0.02	−0.11	−0.48	−0.93	0.81	1.20
5. "Keynesian" Consumption	1.073	1.074	−1.4	0.3	−0.26	−0.12	0.32	−0.11	NA	NA	NA	NA
B. <u>VER Reduction</u>												
1. Central Case	1.046	1.048	−3.2	0.4	0.58	0.51	0.14	0.14	3.58	3.56	−0.07	−0.30
2. "Armington" Elasticities												
a. U.S. values halved	1.036	1.037	−0.6	0.1	0.57	0.65	0.06	0.29	3.99	4.48	−0.79	−1.43
b. U.S. values doubled	1.060	1.065	−7.7	1.0	0.65	0.39	0.27	0.03	3.27	2.75	1.11	1.60
c. Foreign values halved	1.054	1.061	−5.1	0.8	0.48	0.17	0.19	−0.13	2.12	1.22	0.31	0.31
d. Foreign values doubled	1.039	1.040	−1.9	0.2	0.67	0.74	0.10	0.32	4.52	5.02	−0.34	−0.69
3. Adjustment Costs												
a. Low	1.045	1.048	−3.7	0.3	0.60	0.53	0.21	0.15	4.03	3.97	−0.07	−0.30
b. High	1.046	1.048	−3.2	0.5	0.58	0.50	0.10	0.14	3.27	3.26	−0.07	−0.28
4. Intertemporal Consumption Elasticities												
a. Low	1.046	1.048	−3.3	0.4	0.58	0.51	0.15	0.13	3.58	3.52	−0.07	−0.29
b. High	1.046	1.048	−3.4	0.4	0.60	0.52	0.12	0.16	3.62	3.59	0.00	−0.29
5. "Keynesian" Consumption	1.047	1.048	−1.5	0.3	0.19	0.55	0.56	0.28	NA	NA	NA	NA

Notes:

Figures in import price and trade balance columns are levels; figures in other columns are percentage changes from the base case. "SR" and "LR" refer to effects in first period and new steady state. The low and high adjustment cost simulations halve and double the parameter β of the adjustment cost function $\phi(I/K) = [(\beta/2)(I/K - \xi)^2](I/K)^{-1}$ with compensating changes in ξ that leave the value of ϕ unchanged at the benchmark value for I/K. Central case values for β and ξ are 19.607 and 0.076. Central case value for intertemporal consumption elasticity is 0.5. Low and high intertemporal elasticities are 0.25 and 1.0. In the "Keynesian" consumption formulation, S, the value of saving of the domestic household, is given by

$$S = kY\bar{r}^{\epsilon}$$

where Y is after-tax income, $\epsilon = 0.4$, and $k = .1274$. Consumption is determined as a residual (Y − S). The same function and parameters apply to the foreign household. Welfare values do not apply to this case since behavior is not derived from utility maximization.

APPENDIX

Solution to the Household's Maximization Problem

Here we provide the solution to the domestic household maximization problem. The foreign household problem is perfectly analogous.

The domestic household maximizes a utility function of the form:

$$U = \int_0^\infty e^{-\delta t} \frac{\sigma}{\sigma-1} (C_t^\beta A_t^{1-\beta})^{\frac{\sigma-1}{\sigma}} dt \tag{A1}$$

subject to the budget and transversality constraints:

$$\dot{WK}_t = r_{DD,t}\alpha_t WK_t + r_{DF,t}(1-\alpha_t)WK_t^* + YL_t - \bar{p}_t C_t \tag{A2}$$

$$\lim_{t\to\infty} WK_t \geq 0$$

The Hamiltonian is:

$$H = e^{-\delta t}\left\{\frac{\sigma}{\sigma-1}(C_t^\beta A_t^{1-\beta})^{\frac{\sigma-1}{\sigma}} + \lambda_t[(r_{DF,t}-v_t\alpha_t)KW_t + YL_t - \bar{p}_t C_t]\right\} \tag{A3}$$

where $v_t = r_{DF,t} - r_{DD,t}$.

Differentiating with respect to the control variables C_t and α_t yields the first-order conditions:

$$\beta(C_t^\beta A_t^{1-\beta})^{-1/\sigma} C_t^{\beta-1} A_t^{1-\beta} = \lambda_t \bar{p}_t \tag{A5}$$

$$(1-\beta)(C_t^{\beta}A_t^{1-\beta})^{-1/\sigma}C_t^{\beta}A_t^{-\beta}A_t' = \lambda_t v_t WK_t \qquad \text{(A6)}$$

Once λ, the marginal utility of wealth, is known, α and C can be identified from these first-order conditions. Differentiating the Hamiltonian with respect to the state variable WK yields the equation of motion for λ:

$$\frac{\dot{\lambda}_t}{\lambda_t} = \delta - \bar{r}_t \qquad \text{(A7)}$$

where $\bar{r}_t$ is the average portfolio return, equal to $\alpha_t r_{DD,t} + (1-\alpha_t)r_{DF,t}$. The model is calibrated with $\bar{r} > \delta$; hence λ declines over time. Higher values for $\bar{r}$ imply that λ declines at a faster rate, which from (A5) implies a steeper consumption profile (higher saving). Using (A5) to substitute for C in (A6) yields an expression indicating that for a given λ, α is a decreasing function of V: that is, the home asset share declines with increases in r_{DF} relative to r_{DD}.

In the steady state, $\lambda_t = \bar{\lambda}e^{(\delta-\bar{r}_{ss})t}$, where $\bar{\lambda}$ is a constant and $\bar{r}_{ss}$ is the steady-state value for $\bar{r}$. We obtain the path of λ by first identifying $\bar{\lambda}$ and then recursively applying (A7) for transition years. This yields the unique λ path consistent with (A7) and the required steady-state λ values.

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