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ABSTRACT

This paper investigates the long-run incidence of the corporate income tax in an open-economy model calibrated with two economies: the United States and a larger mirror economy representing the rest of the world. Imperfect substitutability of domestic and foreign products plays a key role in limiting—often eliminating—the incidence borne by domestic labor. We reach two novel conclusions. First, contrary to conventional wisdom, our analysis reveals that most of the long-run incidence of the corporate income tax is not borne by domestic labor. Nor is much of it borne by landowners. This finding is usually true even at an implausibly large portfolio substitution elasticity. The incidence is typically borne by domestic capital, as in the original Harberger (1962) closed-economy model. Second, for those parameter values in which the incidence is not borne mostly by domestic capital, interestingly, most of the incidence is *exported*. The exportation of the incidence of the corporate income tax, which has received little or no attention in the previous literature, might motivate tax coordination between countries. These results are robust to a range of parameter values and model assumptions. Our model is also compatible with several empirical rigidities.

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I. Introduction

The incidence of the corporate tax is one of the most controversial issues in tax policy analysis. The incidence is crucial to assigning the distributional effects of the tax since lower income individuals tend to have smaller relative amounts of savings. This relationship is true whether viewed from a single year or a lifetime perspective. The more the burden falls on capital, the more the corporate tax contributes to overall progressivity of the tax system. Moreover, if the corporate tax fell largely on labor, it would be more efficient to impose the tax directly on labor, since the shift of the tax burden is accompanied by welfare losses due to a sectoral misallocation of capital and labor.

The controversial nature of the incidence of the tax was especially evident during the last major tax reform, the Tax Reform Act of 1986 (TRA86), which cut the individual tax and raised the corporate tax. The Joint Committee on Taxation (JCT), which is responsible for distributional analysis of proposed legislation for the Congress, avoided the incidence controversy altogether by ignoring the corporate tax in its distributional analysis of TRA86. Their failure was criticized by Feldstein (1988) who prepared a distributional analysis of the 1986 legislation that allocated the corporate tax to capital. Bradford (1995) also criticized JCT's work as being incomplete. (The JCT still does not allocate the corporate income tax in its distributional analysis.) At one time, the Congressional Budget Office (CBO) prepared two distributional estimates: one assigned all the incidence to labor and the other assigned all the incidence to capital. Later, the CBO simplified their analysis, and avoided some political pressure, by dividing the incidence evenly between capital and labor.[1] The Treasury Department's Office of Tax Analysis (OTA) takes a more traditional view and

[1] Citing this paper, the CBO recently announced it will now allocate the full incidence to capital.

allocates the full incidence to capital. Interestingly, the political "conservatives" inside the Washington Beltway sometimes prefer assigning the full incidence to *capital*, thereby allowing them to claim that the tax code is sufficiently progressive.

Among academics, Harberger's (1962) closed-economy model dominated the understanding of the incidence of a corporate tax for several years. That paper argued that the corporate income tax tends to fall completely on capital. The model's incidence results have largely withstood modifications in modeling the corporate sector (Gravelle and Kotlikoff, 1989). It is this view that guided OTA's decision to allocate the full incidence of the corporate tax to capital.

By the mid 1970s, Harberger's 1962 incidence result, however, was drawn into question in several studies when the closed-economy assumption was relaxed. Indeed, every major study that we are aware of argues that immobile factors (labor and/or land) bear most, if not all, of the long-run incidence of the corporate tax in the open economy due to capital flows across borders. Some notable studies include Bradford (1978), Kotlikoff and Summers (1987), Mutti and Grubert (1985), and, interestingly, Harberger (1995). Harberger (1995) argues that, in fact, *labor* bears *more than* 100 percent of a corporate tax burden once open economy considerations are taken into account. Moreover, most related textbooks suggest that domestic labor bears the capital income tax, especially in a small open economy.

Indeed, while there is little debate among economists that capital, being immobile in the short run, bears the burden of the corporate income tax in the short run, most economists today seem to accept the idea that capital escapes most of the burden in the long run. Fuchs, Krueger, and Poterba (1997) report that economists at the top 40 universities estimate, on average, that capital bears only 40 percent of the tax. The authors suggest that these views reflect uncertainties about the degree of openness of world capital markets and the interest elasticity of savings. Slemrod (1995b) surveying members of the National Tax Association, reports that among academic economists, over half believe that non-capital factors (labor and consumers) largely bear the tax. Auerbach and Slemrod (1997, p. 621) refer to an assumption that 100 percent of the tax falls on capital as "extreme," even though such an assumption would have been a central tendency in Harberger's model, where some reasonable assumptions about elasticities could have caused capital to bear *more than* 100 percent of the tax. It is safe to conclude, therefore, that the original Harberger (1962) argument that the incidence is born mainly by capital is now dead among academics.

This paper reconsiders the incidence of the capital income tax in the open economy. We report our findings using a multi-sector general equilibrium open-economy model that allows for imperfect substitution between domestic and foreign products as well as imperfect substitution between domestic and foreign capital. Our model has two countries—the domestic economy and the rest of the world—and four sectors in each country: the traded corporate sector, the traded non-corporate sector, the non-traded corporate sector, and the non-traded non-corporate sector.

We reach two surprising conclusions. First, our analysis reveals that most of the long-run incidence of the corporate income tax is *not* borne by domestic labor. Nor is much of it borne by landowners. For plausible parameter values, the incidence is typically borne by domestic capital—as in the original Harberger (1962) closed-economy model. This is true even for an implausibly large portfolio substitution elasticity. Second, for those parameter values in which the incidence is not borne mostly by domestic capital, interestingly, most of the incidence is *exported* instead of being borne by labor. The exportation of the incidence of the corporate income tax has received little or no attention in the previous literature. This surprising result might motivate tax coordination between countries. These results are robust to a range of parameter values and model assumptions.

While our analysis focuses primarily on the incidence question, our model is also consistent with several rigidities which could be explored in more detail in future work. Feldstein and Horioka (1980) have demonstrated empirically that the net flow of capital is fairly small in many countries and suggested that capital may be relatively immobile. Although their result is now widely accepted as one of the key stylized facts in international economics, their proposition has generated considerable controversy as to its theoretical cause. Our analysis presents a potential reason—imperfect product substitutability—for the apparent limits on the mobility of capital across countries. Our model is also consistent with other empirical rigidities as well. For example, the factor price equalization theorem will hold in our benchmark (Cobb-Douglas) case only if we eliminate non-traded sectors as well as the imperfect substitutability inside of traded sectors. Similarly, goods prices will equalize in the presence of nontraded goods only if products are perfectly substitutable and capital is perfectly mobile.

We consider a fixed worldwide capital stock for two reasons. First, a fixed capital stock allows the consideration of the open economy assumption in isolation from an assumption about the savings response. Secondly, neither theory nor empirical evidence at present provides a good guide to the appropriate savings response. A fixed capital stock is, however, consistent with a lifecycle model in which the steady-state income and substitution effects exactly cancel. Near exact cancellation was the central tendency in the lifecycle model of Auerbach and Kotlikoff (1987). Thus our assumption is reasonable, as well as convenient, for focusing on open economy effects. (Note that the well-known "degeneracy problem" prevents modeling both countries as intertemporal infinite-horizon consumers: either the most patient country will eventually accumulate all of the capital stock or, if both consumers have equal patience, the division of the world's capital stock will be indeterminate.) Most open-economy tax models in the literature, therefore, consider a fixed capital stock as well. One exception is Mutti and Grubert (1985) who augment their model with a reduced-form saving elasticity equation. But they show that even a large saving elasticity plays little role in driving their conclusion that the capital income tax does *not* fall on capital: almost all of the incidence in their central case is driven by capital flows.[2]

Our model, like most other corporate tax models, reflects the long run steady state after all capital has been re-allocated. In the short run, the corporate capital owners will bear the tax, with the burden gradually shifting as the capital stock is reallocated. After developing this basic model, however, we also discuss certain elements of the adjustment process and test for the effects of assuming steady state growth with produced capital goods (as in the case of Gravelle and Kotlikoff, 1995). Section II of the paper explains the intuition behind our results using a simplified single-good model. Section III outlines the more complicated multiple-good model that we use. Section IV reports simulation results. Section V shows that our key conclusion—that labor bears little of the corporate tax—is robust to numerous model and parameter assumptions. Section VI concludes.

II. Background Intuition for Our Results: A Simplified Model

The factors that affect the incidence of a capital income tax can be illuminated by examining the price relationships in a simple single-good economy. The relationship between changes in output and factor prices is:

$$\hat{p} = \mu\hat{w} + (1 - \mu)(\hat{r} + \hat{\tau}) \tag{1}$$

where p is the output price, μ is the labor income share, w is the wage rate, r is the after-tax rate of return to capital, τ is the tax on the rate of return, and the ^ symbol refers to small percentage changes (in the case of τ to the percent change with respect to r).

[2] In their central case, they find that increasing the interest saving elasticity from zero (a fixed worldwide capital stock) to 0.4 (the relatively high value estimated by Boskin [1978]) plays a relatively small role, decreasing their incidence on capital from 22 percent to 12 percent.

The Closed Economy

In a closed economy with fixed capital, the entire burden will fall on capital. To see this, consider a closed economy, beginning with no tax, with fixed capital and labor, and with *p* as the numeraire so that the left hand side of (1) is equal to zero. The tax is imposed on capital employed in the domestic economy. Because the ratio of capital to labor is fixed, the ratio of the wage and pre-tax rate of return must also remain fixed in order to satisfy the first order conditions of profit maximization. Since the tax increases the pre-tax return relative to the after-tax return, the latter must fall by the amount of the tax, so as to maintain the original pre-tax return and restore the original factor price ratio.

The Small Open Economy with Perfect Product and Perfect International Capital Markets

At the other extreme is a small open economy with a single worldwide commodity and perfectly mobile capital where only labor can bear the tax (see Bradford 1978) . This incidence occurs because the world-wide price and rate of return are fixed. In this case, only *w* can change and labor bears the full burden of capital, with capital flowing out to the rest of the world until the ratio of capital and labor will be consistent with the new ratio of marginal products. The exact magnitude of the capital flow will depend on the substitutability of factors in production; for a small change in the tax rate, the percentage change in capital will be $-\sigma/\mu$ times the percentage change in the tax rate, where σ is the factor substitution elasticity. From the first order conditions of the profit maximization problem, the percentage change in the capital-labor ratio is equal to the percentage change in the relative factor prices, or, denoting labor and capital by *l* and *k*:

$$\hat{k} - \hat{l} = \sigma(\hat{w} - \hat{r} - \hat{\tau}) \qquad (2)$$

Since l, r and p are is fixed, $\hat{w} = -(1-\mu)\hat{\tau}/\mu$ (from equation (1)) and $\hat{k} = -\sigma\hat{\tau}/\mu$. This outcome occurs even if the imported product is not perfectly substitutable with the domestic product. Only if capital is imperfectly mobile so that the domestic rate of return falls, can some of the burden be shifted back to capital income.

The Large Open Economy with Imperfect Product and Capital Markets

The more complicated intermediate cases result in the burden being shared by capital and labor. Three modifications that are particularly important are: (i) allowing the U.S. to be a *large* open economy, (ii) imperfect substitution between imports and domestic goods and (iii) imperfect capital flows. As explained in this section, each of these modifications tend to shift the burden away from labor and toward capital. (Essentially, just as perfect product substitution allows the equivalent of capital flows (factor price equalization) when direct capital flows cannot occur, imperfect product substitution effectively acts to make capital less mobile even when direct capital flows can occur).

Suppose initially that the domestic country is large, but imports and domestic goods are perfect substitutes, capital is perfectly mobile, and countries have the same technology of production (and, hence, equal capital/labor ratios). We can still retain p as the numeraire. The flow of capital abroad will drive down the rate of return around the world. It can be shown (see Kotlikoff and Summers, 1987) that, for a small tax change, domestic capital bears the share of the tax that is equal to the share of total output produced by the country, while labor bears the remainder. For example, if the country produces 30 percent of output, then capital will bear 30 percent of the tax and labor will bear 70 percent. Foreign capital will bear 70 percent of the tax, and the same amount will be gained by foreign labor. This relationship arises from the fixed world capital stock assumption. Denoting the domestic (rest of world) economy with subscript 1 (2),

(3) $$dk_1 + dk_2 = 0$$

which, via equation (2), gives

(4) $$k_1\sigma(\hat{w}_1 - \hat{r} - \hat{\tau}) + k_2\sigma(\hat{w}_2 - \hat{r}) = 0$$

From the price equation (1), where $\hat{p} = 0$, we get $\hat{w}_1 = -(\hat{r} + \hat{\tau})(1-\mu)/\mu$ and $\hat{w}_2 = -\hat{r}(1 - \mu)/\mu$. If the domestic economy is responsible for the share ϕ of the worldwide output and capital stock, we find that $\hat{r} = -\phi\hat{\tau}$ and that the percentage change in capital equals $-\sigma(1-\phi)\hat{\tau}/\mu$. As a country becomes very large (ϕ approaches 1) the capital stock will not change and the tax burden will fall on capital—the closed economy results; as the country becomes very small (ϕ approaches zero), we obtain the small country results.

Suppose now domestic and foreign capital are imperfect substitutes, so that after-tax rates of return can diverge. More of the burden can now shift to capital since the domestic rate of return can fall further than in the perfect substitutes case.

And once we are considering a large or small country with some non-traded sectors, or if the traded products are not perfect substitutes, the price of domestic output can rise relative to foreign output, making it possible for the wage rate to fall less or even rise. Even when foreign and domestic capital are perfect substitutes, more of the burden falls on capital through a reduction in purchasing power when the domestic economy is large. Gravelle (1994) showed that in a simple two-country model, either low product substitution elasticities or low substitutability between foreign and domestic capital holdings can lead to most of the tax being borne by capital.

Whether the predictions from an intermediate model are closer to those of the simplistic closed-economy model or the simplistic open-economy discussed above requires using a detailed computable general-equilibrium model that incorporates factors (i), (ii) and (iii) noted above. This type of model is developed in the next section. The subsequent section considers additional model enhancements and experiments.

III. The Basic Model

Most analysis of a uniform capital income tax in an open economy have used a single good model. As noted above, Bradford (1978) demonstrated that a capital income tax imposed in a local jurisdiction with perfectly mobile capital and homogenous products falls on capital in every location, and also burdens the local immobile factors and benefits immobile factors in other jurisdictions. Kotlikoff and Summers (1987), among others, showed that the share falling on immobile factors under perfect capital mobility is proportional to the size of the economy relative to the rest of the world: as the economy gets larger, less of the tax falls on immobile factors. Slemrod (1988) explored many aspects of taxation in an open economy, including the degree of capital mobility and the differences between source-based and residence-based taxes. Sibert (1990) examines incidence in a single-good open-economy growth model; she also reviews previous modeling of this type. Gravelle (1994), described above, also used a single good model.

There is been relatively little analysis of a partial factor tax, such as the corporate income tax, which falls only on some sectors. Goulder, Shoven, and Whalley (1983) incorporated foreign supplies and demands of goods and capital in their model, but did not address tax incidence or develop a complete model. A later version (Goulder and Eichengreen, 1989) also addressed efficiency, but not incidence. Mutti and Grubert (1985) used a three- sector, two-country linearized model, and found that allowing for an open economy could dramatically reduce the share of a territorial tax that falls on capital. They focused exclusively on the incidence on capital and did not report the incidence on domestic labor or the burden exported. Finally, Harberger (1995) used a partial factor tax model to argue, as noted earlier, that *labor* bears more than 100 percent of a corporate tax burden. He, however, did not develop a full general equilibrium model and only considered the case of infinite elasticities. Moreover, he used the corporate good price as the numeraire and did not account for the lower prices of noncorporate and imported commodities in measuring the real incidence on wages, thus overstating that incidence on labor income.

The model used herein allows for partial factor taxes and has four sectors. Harberger (1962) showed that the incidence of the tax is affected by elasticities, and particularly by differential factor substitution elasticities between the corporate and non-corporate sector. Hence, we need four sectors to test for the importance of elasticities depending jointly on whether the sector is taxed and whether its goods are traded. Sector 1 is the traded corporate sector consisting mainly of manufacturing. Sector 2 is the traded non-corporate sector consisting mainly of agriculture. Sector 3 is the non-traded corporate sector consisting mainly of services and utilities. Sector 4 is the non-traded non-corporate sector consisting mainly of trade and services. A mirror foreign economy calibrated to the rest of the world is created to allow trade and the flow of capital and a general equilibrium solution. Foreign consumers are assumed to have the same utility functions and the same technology of production; foreign production shares are altered to calibrate to observed trade flows. Only the corporate sectors 1 and 3 face the corporate tax in our benchmark simulations, although we consider variations.

Each sector employs capital and labor as factors of production. The traded non-corporate sector 2 (agriculture) also employs land as an input. As in the case of Harberger (1995), including land allows for perfect substitutability in nontraded agricultural products even when we consider perfect substitutability in traded corporate products; without an additional factor of production, such an assumption would produce a corner solution. Since perfect product substitution in the traded corporate good in sector 1 will imply a unique relationship between the wage rates and rates of return, the land rent can adjust to allow consistency between that relationship and perfect substitutability of agricultural products.

The corporate tax is assumed to be imposed on the basis of location (a territorial tax) rather than ownership of capital (a residence-based tax). This assumption will tend to slightly bias our results against our main conclusion that capital tends to bear the burden of the corporate tax. With a residence-based tax, the tax is imposed regardless of the location of capital, and the tax tends to fall more heavily on domestic capital. While some countries impose corporate taxes solely on a territorial basis, the U.S. nominally taxes capital located abroad, but allows a credit against tax for foreign taxes paid. However, there are many ways for corporations to avoid or reduce this tax on capital invested abroad. Firms are able to avoid or reduce this tax by reinvesting profits abroad and by averaging foreign tax credits across high and low tax jurisdictions. And while it is not currently commonplace, individual investors could also invest their funds directly in foreign corporations. In practice, only negligible amounts of corporate tax are imposed on foreign earnings of U.S. owned capital. Hence, the exploration of the effects of a pure territorial tax are highly relevant to the incidence of the U.S. corporate income tax, as well as to taxes imposed on a territorial basis by other countries. The assumption of residence-based taxation (even in part) would merely tend to shift the tax burden more towards capital than it might otherwise be in a territorial system. Taxes imposed at the individual level, not considered here, are largely residence based.

The model also ignores the effect of the corporate tax on debt-financed capital. This assumption also tends to bias our results against our central conclusion that capital bears the corporate tax, an issue that will be returned to in the conclusion.

Consumers

Consumers maximize a nested CES utility function:

$$(5)\quad U_i = \left\{ b_1 \left[\left[a_i c_{i,1}^{[1-1/\gamma]} + (1-a_i) x_{-i,1}^{[1-1/\gamma]} \right]^{\frac{1}{1-1/\gamma}} \right]^{1-1/\varepsilon} + b_2 c_{i,2}^{1-1/\varepsilon} + b_3 c_{i,3}^{1-1/\varepsilon} + b_4 c_{i,4}^{1-1/\varepsilon} \right\}^{\frac{1}{1-1/\varepsilon}}$$

$$\sum_{j=1}^{4} b_j = 1$$

subject to a budget constraint:

$$(6)\qquad \sum_{j=1}^{4} p_{i,j} \cdot c_{i,j} + p_{-i,1} \cdot x_{-i,1} = \sum_{j=1}^{4} p_{i,j} \cdot q_{i,j} - r_i \tilde{K}_{-i} + r_{-i} \tilde{K}_i$$

γ is the product substitution elasticity between home and import consumption of good 1 and ε is the product substitution elasticity between the four basic goods. c is domestic consumption, x is exports, p is price, q is output, r is the after-tax rate of return and $\tilde{K}_i$ is capital exports. $i \in \{1,2\}$ is the country index, where 1 is the United States and 2 is the "rest-of-the-world" country. The notation "-*i*" stands for the country that is not *i*. $j \in \{1,2,3,4\}$ is the sector index for the sectors described earlier. Notice that while sector-1 traded corporate goods may be imperfectly substitutable, traded non-corporate sector-2 goods (agriculture) are assumed to be perfectly substitutable. First-order conditions are given in Table 1*a*. A variable list is given in Table 1*b* and parameter definitions and values are given in Table 1*c*. Since the entire economy is represented by a single utility function, tax revenues are spent in the same manner as private incomes. With fixed labor and owned capital, this assumption is equivalent, for purposes of determining prices and quantities, to rebating revenues on a lump sum basis, since a dollar in private hands will be spent the same way as a dollar in public hands.

Firms

Firms in sectors 1, 3, and 4 maximize profits, Π:

(7) $$\Pi_{i,j} = p_{i,j}\, q_{i,j} - w_i l_{i,j} - \frac{r_i k_{i,j}}{(1-\tau_{i,j})} \qquad j \in \{1,3,4\}$$

subject to a technology constraint (a CES production function):

(8) $$q_{i,j} = A_j \left[m_j l_{i,j}^{1-1/\sigma_j} + (1-m_j) k_{i,j}^{1-1/\sigma_j} \right]^{\frac{1}{1-1/\sigma_j}} \qquad j \in \{1,3,4\}$$

where w is the wage rate, τ is the tax rate, l is labor, k is capital, and σ is the factor substitution elasticity.

Firms in sector 2 also maximize profits:

(9) $$\Pi_{i,2} = p_{i,2}\, q_{i,2} - w_i l_{i,2} - \frac{r_i k_{i,2}}{(1-\tau_{i,2})} - \Re_i \bar{F}_i$$

subject to:

(10) $$q_{i,2} = A_2 \left[n_1 l_{i,2}^{1-1/\sigma_2} + n_2 k_{i,2}^{1-1/\sigma_2} + (1-n_1-n_2) \bar{F}^{1-1/\sigma_2} \right]^{\frac{1}{1-1/\sigma_2}}$$

where $\Re_i$ is land rent and $\bar{F}$ is the fixed amount of land available.

Portfolios

To allow for imperfect mobility of capital, the model incorporates a portfolio allocation function. Investors allocate a fixed amount of capital between domestic use and export, according to a portfolio allocation function:

(11) $$\frac{\bar{K}_i - \tilde{K}_i}{\tilde{K}_i} = d_i \left(\frac{r_i}{r_{-i}} \right)^{\theta}$$

where $\bar{K}_i$ is the capital stock owned by country *i*. θ is the portfolio substitution elasticity, which is the percentage change in the ratio of domestic to foreign holdings divided by the percentage change in the ratio of domestic to foreign rates of return. Equation (11) corresponds closely to empirical specifications of estimates of θ reported below.

While this function is not derived from a utility function, it is consistent with the presumption of risk-adverse investors who desire mixed portfolios. We do not explicitly model this utility function, which would introduce extensive complexity into the model, particularly with a tax system that employs imperfect loss offset. Such an explicit model is not required to assess the burden that falls on labor income (assuming labor income is not risky); to the extent that the burden falls on capital income, the tax burden may be considered to be lightened in general by the sharing of risk with the government. Feldstein and Horioka (1980) and others have also argued that the imperfect substitutability of domestic and foreign capital, as evidenced by the substantial home bias of domestic capital ownership, can be traced to legal, accounting, language and cultural differences between countries. Investors seem to prefer companies that they easily understand and have easy legal recourse in case of fraud. Moreover, interestingly, even the value of θ is typically unimportant since our conclusion that capital bears most of the incidence of a corporate tax holds even if we dropped equation (11) and instead assumed perfect substitutability ($\theta = \infty$). Our results are primarily driven by imperfect *product* substitution.

Prices

The price in sector 2 is equal in both countries due to perfect substitutability. We take the sector-2 price as the numeraire:

(12) $$p_{1,2} = p_{2,2} = 1$$

When estimating incidence, the new factor prices are divided by a Laspeyres consumption-weighted price index in order to estimate real values. Thus the incidence measure indicates the share of the burden that reduces the purchasing power of each type of factor income. (A Paasche index produces similar results). The values in $\overline{(\cdot)}$ represent the initial calibrated weights.

(13)
$$\bar{P}_i = p_{-i,1}\overline{\left(\frac{x_{-i,1}}{C_i}\right)} + \sum_{j=1}^{4} p_{i,j}\overline{\left(\frac{c_{i,j}}{C_i}\right)}$$

<u>Aggregation</u>

Finally, there are a number of market clearing conditions. In the goods market:

(14)
$$c_{i,1} + x_{i,1} = q_{i,1}$$

(15)
$$p_{1,2}\,q_{1,2} + p_{2,2}\,q_{2,2} = p_{1,2}\,c_{1,2} + p_{2,2}\,c_{2,2}$$

(16)
$$c_{i,j} = q_{i,j} \qquad j \in \{3,4\}$$

These equations set domestic consumption and exports of the traded good 1 equal to output, worldwide production of the traded good 2 equal to worldwide consumption, and consumption equal to output in the nontraded goods.

There are also factor constraint equations:

(17)
$$L_i \equiv \sum_{j=1}^{4} l_{i,j}$$

(18)
$$K_i \equiv \sum_{j=1}^{4} k_{i,j} = \bar{K}_i - \tilde{K}_i + \tilde{K}_{-i}$$

These equations sum total labor used in the four industries in each country to a fixed labor supply and set total capital used in the four industries in each country to the fixed amount of capital owned minus capital exported plus capital imported.

First-Order Conditions

In addition to these equations, there are several equations that are derived from the utility and production functions, listed in Table 1*a*. Equations (T-1) - (T-3) are consumption demand equations that are derived from the first-order conditions of the utility function and the budget constraint. Equations (T-4) and (T-5) are the first-order conditions of the profit maximization for sectors 1, 3 and 4; equation (T-6) relates output and factor prices and is derived by substituting these first-order conditions into the production function. Equations (T-7) through (T-10) are similar equations for sector 4, and equation (T-11) relates land rent in sector 2 to the other factor prices given the equality of prices in sector 2 and the price equations.

The entire problem includes about 70 non-linear equations which are solved simultaneously using Gauss-Seidel as described in the Appendix. Values of the calibration parameters (Table 1*c*) are derived so that each simulation starts with the exact same initial observable economy (Table 1*d*) when the choices for various elasticities are varied from their benchmark setting. The U.S. accounts for 30 percent of output and capital. Data on the allocation of output and factor incomes are derived from Gravelle and Kotlikoff (1995) and data on imports and exports and capital flows are taken from Gravelle (1994), with import and export shares across sectors taken from the national income accounts. Additional characteristics of the initial economy are shown in Table 1*d*.

Table 1*a* Additional Equations From First-Order Conditions

First-Order Conditions of the Utility Maximization Problem

(T-1)
$$c_{i,1} = \frac{a_i^{\gamma} b_1^{\varepsilon} p_{i,1}^{-\gamma} \left[a_i^{\gamma} p_{i,1}^{1-\gamma} + (1-a)^{\gamma} p_{-i,1}^{1-\gamma} \right]^{\frac{\varepsilon-\gamma}{\gamma-1}}}{\Lambda_i} \cdot C_i$$

(T-2)
$$x_{-i,1} = \frac{(1-a_i)^{\gamma} b_1^{\varepsilon} p_{-i,1}^{-\gamma} \left[a_i^{\gamma} p_{i,1}^{1-\gamma} + (1-a)^{\gamma} p_{-i,1}^{1-\gamma} \right]^{\frac{\varepsilon-\gamma}{\gamma-1}}}{\Lambda_i} \cdot C_i$$

(T-3)
$$c_{i,j} = \frac{b_j^{\varepsilon} p_{i,j}^{-\varepsilon}}{\Lambda_i} \cdot C_i \qquad 2 \le j \le 4$$

$$\Lambda_i = \left[a^{\gamma} p_{i,1}^{(1-\gamma)} + (1-a_i)^{\gamma} p_{-i,1}^{(1-\gamma)} \right]^{\frac{\varepsilon-\gamma}{\gamma-1}+1} + b_2^{\varepsilon} p_{i,2}^{1-\varepsilon} + b_3^{\varepsilon} p_{i,3}^{1-\varepsilon} + b_4^{\varepsilon} p_{i,4}^{1-\varepsilon}$$

$$C_i = \sum_{j=1}^{4} p_{i,j} \cdot c_{i,j} + p_{-i,1} \cdot x_{-i,1}$$

First-Order Conditions of Profit Maximization in Sectors 1, 3 and 4

(T-4)
$$\frac{l_{i,j}}{q_{i,j}} = m_j^{\sigma_j} A_j^{\sigma_j - 1} \left(\frac{w_i}{p_{i,j}} \right)^{-\sigma_j} \qquad j \in \{1,3,4\}$$

(T-5)
$$\frac{k_{i,j}}{q_{i,j}} = (1-m_j)^{\sigma_j} A_j^{\sigma_j - 1} \left(\frac{r_i}{p_{i,j}(1-\tau_{i,j})} \right)^{-\sigma_j} \qquad j \in \{1,3,4\}$$

(T-6)
$$p_{i,j} = \frac{1}{A_j} \left[m_j^{\sigma_j} w_i^{1-\sigma_j} + (1-m_j)^{\sigma_j} \left(\frac{r_i}{(1-\tau_{i,j})} \right)^{1-\sigma_j} \right]^{\frac{1}{1-\sigma_j}} \qquad j \in \{1,3,4\}$$

(table continued)

First-Order Conditions of Profit Maximization in Sector 2

(T-7)
$$\frac{l_{i,2}}{q_{i,2}} = n_1^{\sigma_2} A_2^{\sigma_2 - 1} \left(\frac{w_i}{p_{i,2}} \right)^{-\sigma_2}$$

(T-8)
$$\frac{k_{i,2}}{q_{i,2}} = n_2^{\sigma_2} A_2^{\sigma_2 - 1} \left(\frac{r_i}{p_{i,2}(1 - \tau_{i,2})} \right)^{-\sigma_2}$$

(T-9)
$$\frac{\bar{F}_i}{q_{i,2}} = (1 - n_1 - n_2)^{\sigma_2} A_2^{\sigma_2 - 1} \left(\frac{\Re_i}{p_{i,2}} \right)^{-\sigma_2}$$

(T-10)
$$p_{i,2} = \frac{1}{A_2} \left[n_1^{\sigma_2} w_i^{1-\sigma_2} + n_2^{\sigma_2} \left(\frac{r_i}{(1 - \tau_{i,2})} \right)^{1-\sigma_2} + (1 - n_1 - n_2)^{\sigma_2} \Re_i^{1-\sigma_2} \right]^{\frac{1}{1-\sigma_2}}$$

(T-11)
$$\Re_2 = \left[\left(\frac{n_1}{1 - n_1 - n_2} \right)^{\sigma_2} \left(w_1^{1-\sigma_2} - w_2^{1-s\sigma_2} \right) + \left(\frac{n_2}{1 - n_1 - n_2} \right)^{s} \sigma_2 \left(\frac{r_1^{1-\sigma_2}}{(1 - \tau_{1,2})} - \frac{r_2^{1-s\sigma_2}}{(1 - \tau_{2,2})} \right) + \Re_1^{1-s\sigma_2} \right]^{\frac{1}{1-s\sigma_2}}$$

Table 1*b* Variable Definitions

Variable	Definition
$c_{i,j}$	Consumption of good *j* in country *i* (and net exports for *j* = 2)
C_i	Total consumption expenditures in country *i*
$\bar{F}_i$	Fixed factor (land) in country *i*
$k_{i,j}$	Capital stock in sector producing good *j* in country *i*
K_i	Total capital stock in country *i*
$\tilde{K}_i$	Capital stock export by country *i*
$\bar{K}_i$	Capital stock owned by country *i*
$l_{i,j}$	Labor supply in sector producing good *j* in country *i*
$\bar{L}_i$	Total labor supply of country *i*
nx_2	Net exports of good 2 by country 1
$p_{i,j}$	Price of good *j* produced in country *i*
$\tilde{P}_i$	Price of capital produced goods faced by country *i*
$\bar{P}_i$	Aggregate price level in country *i*
$q_{i,j}$	Quantity of good *j* produced in country *i*
Q_i	Output of country *i*
Q	World output
r_i	After-tax rate of return to capital in country *i*
$\Re_i$	Rental rate of fixed factor in country *i*
w_i	Wage rate in country *i*
x_i	Exports of good 1 by country *i*

Table 1c Parameter Descriptions		
Parameter	Description	Benchmark Value
a_i	Preference weight placed on country i's own sector-1 good	— [1]
A_i	Technology (efficiency) parameter in sector producing good j	—
b_j	Preference weight placed on good $j \in \{1,2,3,4\}$	—
d_i	Preference weight on ratio of domestic to foreign portfolio shares	—
ε	Substitution elasticity between basic goods	1.0
γ	Substitution elasticity between domestic and foreign sector-1 goods	1.0
m_j	Technology weight placed on labor in sectors 1,3 and 4	—
$\mu_{i,j}$	Capital share in sector j in country i	[2]
n_1	Technology weight placed on labor in sector 2	—
n_2	Technology weight placed on capital in sector 2	—
ν_i	Fixed-factor share in sector 2 in country i	[2]
ω	Trade-adjusted size of country 2's consumption as a multiple of country 1's consumption, $1 \Big/ \left[C_2 + (C_1 - Q_1)\right]$	[2]
$\psi_{i,j}$	Output share in sector j in country i, $q_{i,j} \Big/ Q_i$	[2]
σ_j	Factor substitution elasticity in sector j	1.0
θ	Capital substitution elasticity	3.0

Notes: [1] Calibrated parameters: these parameters are computed endogenously as a part of calibration.
[2] Values of these variables for the initial economy are shown in Table 1d. Values for these variables might change in the new economy after the policy change.

Table 1d Initial Economy Calibration	
Variable	Value
$\widetilde{K}_1$	$0.022 / r_1$
$\widetilde{K}_2$	$0.019 / r_2$
$\mu_{i,1}$	0.18
$\mu_{i,2}$	0.17
$\mu_{i,3}$	0.24
$\mu_{i,4}$	0.53
nx_2	$0.007 \cdot Q_{12}$
ω	3 / 7
ν_i	0.34
$\psi_{i,1}$	0.28
$\psi_{i,2}$	0.03
$\psi_{i,3}$	0.45
$\psi_{i,4}$	0.24
Q_1	1.0
r_i	0.07
$\Re_i$	1.0
w_i	1.0
x_1	$0.088 \cdot Q_{12}$
x_2	$0.098 \cdot Q_{12}$

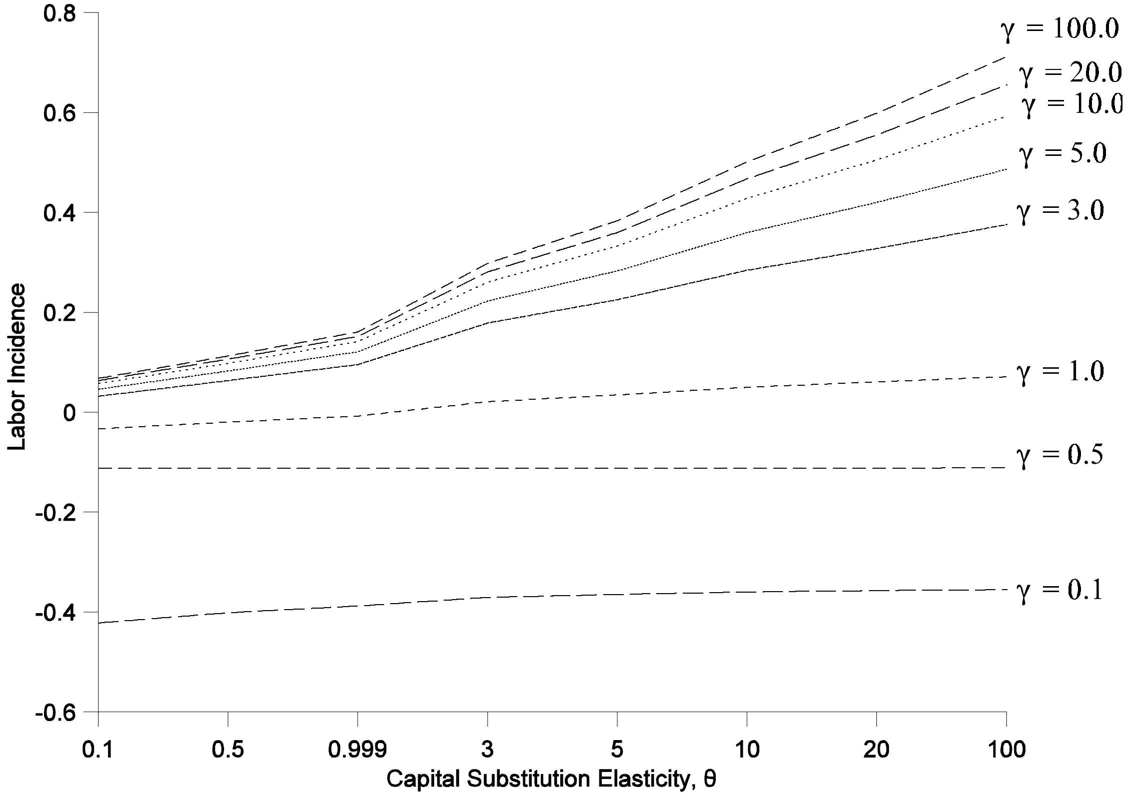
Sources: Gravelle and Kotlikoff (1995), Gravelle (1994).

IV. Incidence in the Basic Model

The results depend on four elasticities: the product substitution elasticity between the traded corporate domestic and foreign good (γ); the portfolio substitution elasticity (θ); the factor substitution elasticity (σ); and the elasticity between the four basic types of products (ε). In the domestic Harberger (1962) model, setting the factor substitution elasticity (σ) and the general product substitution elasticity (ε) to the same value results in the burden falling only on capital, and this result holds for large tax changes when these elasticities are unitary. We, however, are modeling the U.S. as a large open economy in a world with imperfect product and capital markets. Figure 1 shows the fraction of the tax that falls on labor, with these unitary elasticities, as the product substitution elasticity between foreign and domestic traded goods (γ) and the portfolio substitution (θ) vary.

Our model also indicates that a non-trivial share of the burden falls on foreign factors of production, with foreign labor gaining while foreign capital losing. These results are shown for selected values of γ and θ in Table 2. (Note that the sum of the burden is over 100 percent due to the excess burden introduced by the tax distortion.) In the simple textbook case with both elasticities set at infinity (approximated with 100), domestically-owned capital bears 36 percent of the tax, foreign capital bears 66 percent of the burden, and foreign labor gains 67 percent of the tax. Because of the smallness of the agricultural sector, land rents gain or lose only a fraction of the tax. The burden borne by domestic capital is less than 100 percent because the US is a large open economy. The shares borne by domestic capital and labor are roughly consistent with the US share of world output, a result shown by Kotlikoff and Summers (1987). (The burden is measured with respect to domestically owned capital—not domestically located capital—which affects the results slightly; also, the tax change is not arbitrarily small.)

Figure 1
The Incidence on Labor of Increasing the Corporate Income Tax by 10 Percentage Points as a Function of the Substitution Elasticity Between Domestic and Foreign Products (γ) and Between Domestic and Foreign Capital (θ)
(Percent)



Note: Assumes factor substitution elasticities ($\sigma_{i,j}$) and the general product substitution elasticity (ε) are unitary.

More realistic values for the product substitution elasticity or the factor substitution elasticity will shift most of the burden to domestic capital and away from domestic labor. What values for the product and portfolio elasticities are likely to be relevant? This is an empirical issue.

Consider the traded product substitution elasticity (γ). Goulder, Shoven and Whalley (1993) and Ballard Fullerton, Shoven and Whalley (1985) used a central import substitution elasticity of 1.7; Goulder reported sensitivity results, with a range between 0.5 and 3. Mutti and Grubert (1985) used a product substitution elasticity of 3, at the high end of this range. In their extensive empirical examination, Shiells and Reinert (1993) used maximum likelihood estimation with budget share equations based on the CES functional form. Their product elasticities are typically below 1.0.

Evidence on capital mobility for equity capital or for total capital does not generally suggest large elasticities either. We have already noted the Feldstein and Horioka (1980) results suggesting the limits on capital mobility based on the relationship between savings and investment across countries. A related literature has examined the "international diversification puzzle" which focuses on the home bias of security holdings. Another literature has explored the flow of physical investment by multinational corporations. Altshuler, Grubert and Newlon (1997) find elasticities of between 2 and 3, depending on model specification; these numbers were higher than earlier findings by Grubert and Mutti (1991) of an elasticity around 1. The values calculated by Altshuler, Grubert and Newlon are similar to those of Hines and Rice (1994) for U. S. investment in foreign tax havens. There is also a literature on the responsiveness of foreign direct investment in the U.S. to the U.S. tax rate which generally found imperfect substitution (see Slemrod (1990) for a survey). Slemrod's (1990) own work reported an elasticity for foreign direct investment in the U.S. of the same general magnitude as the recent estimates of outbound investment (of 2). Auerbach and Hassett (1993) report no shift in the U.S. share or composition of outbound investment following the Tax Reform

Act of 1986.

These previous empirical results suggest that we should be considering elasticities below 3 for both γ and θ, with a value of the product substitution elasticity closer to 1. With both elasticities set equal to 3, Table 2 shows that domestic labor bears 18 percent of the tax. With both elasticities set at 1, labor bears none of the tax and, in fact, gains 1 percent. Notice that even with a portfolio substitution elasticity of 100, domestic labor still bears only 7 percent of the burden with a realistic product substitution elasticity of 1. Thus, labor bears little or none of the tax burden. Similarly, labor is likely to be relatively unaffected by foreign taxes on capital income, which will primarily affect returns to foreign capital and, to a lesser extent, domestic capital income. These results illustrate that the traded product elasticity (γ) and the portfolio substitution elasticity (θ), separately or in combination, exert a powerful effect on the incidence results.

Table 3 shows, for the same sets of elasticities as Table 2, the share of the burden exported, and the excess burden due to the production distortions induced by the tax. The exported burden is highly sensitive to the product substitution elasticity and is greatest when capital mobility is high and product substitution is low. The export of some of the tax, although receiving little or no attention in the literature, is not surprising since there are downward sloping demand curves for the domestic product; i.e., the corporate tax can be passed on in part to consumers, some of whom are foreign consumers (just as an optimal tariff can export tax burdens through the market power of demand).

Table 2
Burdens Across Different Factors
For Selected Domestic-Foreign Product Substitution Elasticities (γ) and Portfolio Elasticities (θ)
(Percent)

γ/θ	Domestic Labor	Domestic Capital	Domestic Land Rent	Foreign Labor	Foreign Capital	Foreign Land Rent
1/0.1	-3	91	0	6	10	0
1/3	2	81	2	0	21	-1
1/100	7	71	3	-5	32	-3
3/0.1	3	92	-1	-1	9	1
3/3	18	76	0	-16	26	0
3/100	38	55	1	-35	48	-1
100/0.1	7	92	-2	-4	9	2
100/3	30	72	-2	-27	29	2
100/100	71	36	-1	-67	66	1

Note: Assumes factor substitution elasticities ($\sigma_{i,j}$) and the general product substitution elasticity (ε) are unitary.

Table 3
Burden Exported, Excess Burden and Effect on Domestic capital Stock, for Selected Values of the Domestic-Foreign Product Substitution Elasticity (γ) and the Portfolio Elasticity (θ)
(Percent)

γ/θ	Burden Exported	Excess Burden	Percentage Change in Capital Stock (Percent)
1/0.1	16	3	-0.6
1/3	20	3	-0.9
1/100	26	4	-1.6
3/0.1	9	3	-0.8
3/3	10	3	-1.3
3/100	12	4	-3.0
100/0.1	7	3	-0.8
100/3	4	3	-1.4
100/100	1	5	-4.4

Notes: 1. Assumes factor substitution elasticities ($\sigma_{i,j}$) and the general product substitution elasticity (ε) are unitary.
2. Excess burden independently and exactly calculated by dividing the total equivalent variation (home and foreign) of the tax change by the tax revenue. For the basic model, measuring excess burden as the sum of burdens less the tax generates slightly larger values for the Laspeyres price index and slightly smaller values for the Paasche index.

V. Sensitivity to Alternative Specifications and Elasticities

Despite its complexity, the basic model in the previous section nonetheless abstracted from several aspects of reality. This section examines what we believe are the most important model extensions. We find that these model enhancements do not overturn our basic conclusion that domestic labor bears little, if any, of the corporate tax. Rather interestingly, we find that domestic labor bears little of the tax even when the burden falls less on domestic capital: the tax burden is typically exported in these cases. This section also considers additional parameter sensitivity analysis, including moving away from a Cobb-Douglas economy, as well as the importance of general versus partial factor taxation. Finally, we examine the effects of allowing for positive economic growth.

Produced Capital Goods

Many models do not account for the production costs of capital goods; two exceptions are Auerbach (1989) and Gravelle and Kotlikoff (1995). One of the several important contributions of Mutti and Grubert (1985) was their inclusion of produced capital goods in an open-economy tax incidence model. Their study focused, in large part, on showing the differential effects of a territorial versus a residence-based tax, and how the substitutability of investments between foreign and domestic use and the savings elasticity affected the burden of a tax on capital. But their results also demonstrate the importance of how allowing for produced capital goods could limit the incidence falling on domestic capital. Since they, however, focused only on the incidence on domestic capital, it was not clear exactly where the burden of the tax fell, although it would be conventional to believe that it fell on labor. Our own results confirm the importance of incorporating produced capital goods. But we find that labor bears little of the tax. Interestingly, most of the decrease in the burden falling on capital coming from incorporating produced capital goods is *exported*.

Accordingly, we developed a version of the model that incorporates capital goods prices. Our initial exploration begins with the assumption that capital goods and their components are not traded and thus, that the price index used is an index of domestic production. Thus, we use a domestic output price index which is slightly different from Mutti and Grubert's assumption of a domestic consumption price index. We consider alternative price indices below including using the domestic consumption price index as well as the world price level.

Initially, we consider a steady state model without growth (or one where growth is negligible), where these produced capital goods prices affect only the value of the flows of capital income in the steady state. This assumption of no steady-state investment will be modified subsequently (and shown not to be important, at growth rates typical of mature economies).

These modifications required revision to a few equations in the model. First, the rate of return is modified in each place that it appears, except the portfolio equation, by multiplying it by the price of capital goods, or $r_i \Rightarrow \tilde{P}_i r_i$. The portfolio equation is also modified to reflect the allocation of asset values:

(19) $$\frac{\tilde{P}_i \bar{K}_i - \tilde{P}_{-i} \tilde{K}_i}{\tilde{P}_{-i} \tilde{K}_i} = d_i \left(\frac{r_i}{r_{-i}} \right)^{\theta}$$

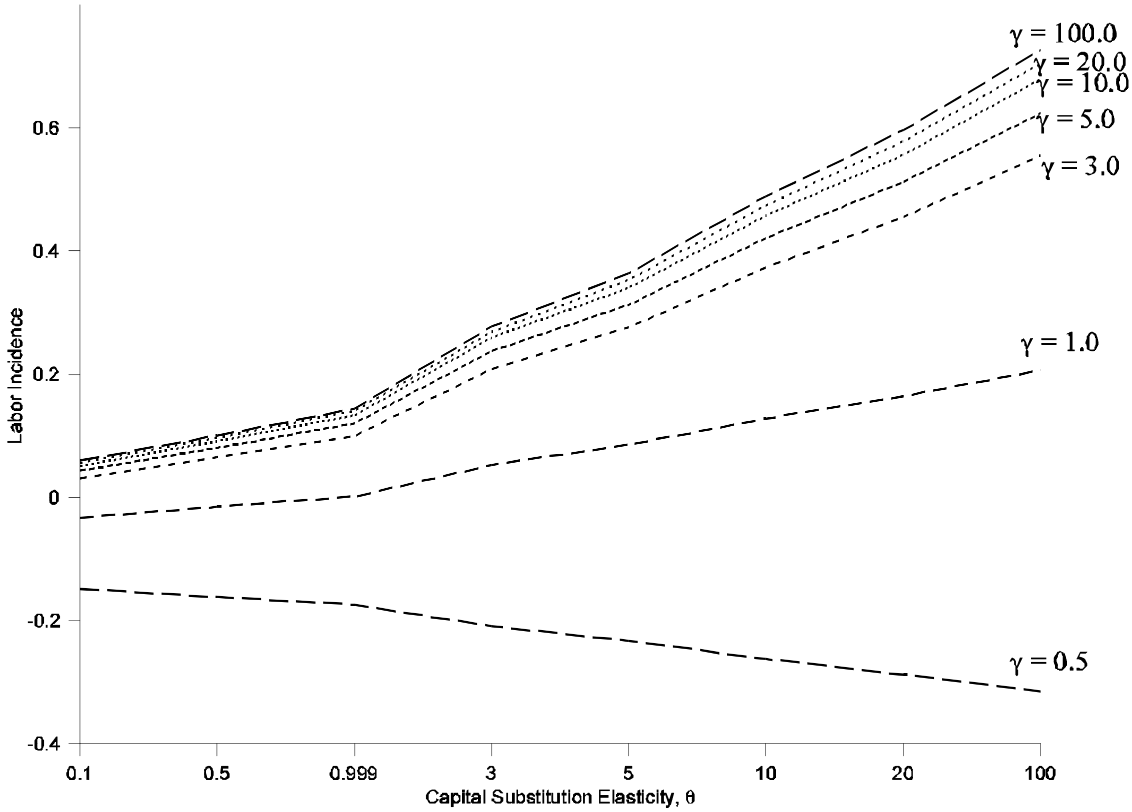
Finally, the capital goods price is defined to be equal to the domestic price level:

(20) $$\tilde{P}_i = \sum_{i=1}^{2} \sum_{j=1}^{4} p_{i,j} \overline{\left(\frac{q_{i,j}}{Q_i} \right)} \qquad , \qquad Q_i \equiv \sum_{j=1}^{4} q_{i,j}$$

Allowing for produced capital goods did change the estimated incidence on labor and capital, although it did not significantly alter our conclusion that labor bears little, if any, of the incidence. Figure 2 shows the burden on labor with produced capital goods, at different values of γ and θ, again assuming that the factor substitution elasticities ($\sigma_{i,j}$) and the substitution elasticity between products (ε) produced by the four sectors is unitary. This graph shows a somewhat different picture of the role of the different elasticities on labor burden. In particular, the role of the traded product substitution elasticity (γ) is somewhat less important at higher values. Nevertheless this analysis also clearly demonstrates the importance of product substitution elasticities in determining the tax burden on labor and suggests that labor bears little of the corporate tax. For example, when both elasticities are set at 3, labor bears 21 percent of the tax; when both elasticities are set at one, labor bears none of the tax. Finally, with a portfolio elasticity of one, labor bears only 7 percent of the tax even with a portfolio elasticity equal to 100.

Use of produced capital goods can, however, significantly alter the burden on capital income when capital is mobile but traded product substitution is imperfect. Table 4 shows the allocation of the burden across all of the factors of production. It indicates that while the traded product substitution elasticity has a pronounced effect on the incidence on labor—this is particularly true when capital is very mobile—it does not have much effect on the incidence on capital income, which is driven largely by the portfolio substitution elasticity. Results are similar to the case with no produced capital goods when the portfolio substitution elasticity is small, regardless of the size of the traded product substitution elasticity, and when the traded product substitution elasticity is large, regardless of the portfolio substitution elasticity. It is in cases with very mobile capital, but low traded product substitution elasticities that the burden on capital is significantly lower than in the case with no produced capital. Note, however, that the burden on land rent increases in this case.

Figure 2
The Incidence on Domestic Labor of Increasing the Corporate Income Tax by 10 Percentage Points as a Function of the Substitution Elasticity Between Domestic and Foreign Capital (θ):
Domestically Produced Capital Goods



Note: Assumes factor substitution elasticities ($\sigma_{i,j}$) and the general product substitution elasticity (ε) are unitary.

Table 4
Allocation Across Different Factors, Selected Domestic-Foreign Product Substitution Elasticities (γ) and Portfolio Elasticities (θ), Domestically Produced Capital Goods
(Percent)

γ/θ	Domestic Labor	Domestic Capital	Domestic Land Rent	Foreign Labor	Foreign Capital	Foreign Land Rent
1/0.1	-3	90	0	5	11	0
1/3	5	70	4	-4	35	-3
1/100	21	38	9	-23	81	-9
3/0.1	3	92	-1	-1	9	1
3/3	21	72	0	-19	30	0
3/100	55	36	2	-54	71	-2
100/0.1	6	93	-2	-3	8	2
100/3	28	73	-2	-25	27	2
100/100	73	35	-1	-69	67	1

Note: Assumes factor substitution elasticities ($\sigma_{i,j}$) and the general product substitution elasticity (ε) are unitary.

The reduction in the burden on capital with produced capital is accompanied, in part, by an increase in the amount of the tax that is exported, as shown in Table 5. There is also an increase in production distortions, which accounts for part of the increased burden on foreign and domestic goods.

Some insight into the importance of the role of produced capital goods might be gained by thinking back to a one-good economy. In this case, the price relationship is:

$$\hat{p} = \mu \hat{w} + (1-\mu)(\hat{r} + \hat{\tau} + \hat{p}) \tag{21}$$

As in the basic model without produced capital goods, a rise in the price permits some of the burden to be shifted away from labor. At the same time, a rise in the price of products also increases the earnings from domestic capital because capital goods have higher prices, increasing the flow of income from these goods. These effects cancel each other out, so that the price rise does not permit the burden to be shifted to capital income. At the same time, there is no fall in the price of foreign production which would permit foreign owners of capital to recoup their burden, as in the basic model. Comparing the incidence tables, the main change that takes place is a shift in the burden from domestic capital to foreign capital. This shift occurs in large part because the introduction of produced capital goods prevents the increase in burden on domestic capital income that operates through a loss in purchasing power: in a model with capital goods prices, the value of capital rises with the domestic price and offsets this sources-side tax incidence. Similarly, the decrease in burden for foreign capital, through gains in purchasing power as foreign consumption prices fall, is offset by a similar fall in the value of capital.

The introduction of produced capital goods influences other relationships in the model. For example, the demand for capital from the first-order conditions of the production function is no longer influenced directly by the product price. That is, in the case where capital goods are not produced,

$$\hat{k} = \sigma(\hat{p} - \hat{r} - \hat{\tau})/\mu \qquad (22)$$

but when capital goods are produced,

$$\hat{k} = -\sigma(\hat{r} + \hat{\tau})/\mu \qquad (23)$$

In the first case, a rise in product prices offsets the effect of the tax increase in reducing the demand for capital in the domestic economy; in the second case it does not. This effect is shown in Table 5, which also shows the share of the tax that is exported. And, consistent with the intuition from equations (21) and (22), the product substitution elasticity does not play much of a role in influencing the capital flows.

Factor Elasticities ($\sigma_{i,j}$) and the General Product Elasticity (ε)

Table 6 explores the sensitivity of the results in our model with produced capital goods to some of these other elasticities and to the structure of industries. Notice that both the lower factor substitution elasticity and the higher product substitution elasticity contribute to smaller burdens on capital. Whereas our produced goods case found a burden on capital equal to 72 percent when both γ and θ were three, the burden fell to 52 percent when we set σ equal to 0.5 and ε equal to 1.25. (The burden on labor rose from 21 percent to 44 percent). With θ equal to 100, the burden on capital was 29 percent (rather than our base case value of 35 percent). In this case, the labor share rose from 55 percent in our base case to 68 percent in the case with the lower factor substitution elasticity and higher value of ε.

Table 5
Burden Exported, Excess Burden and Effect on Capital Stock, for Selected Domestic-Foreign Product Substitution Elasticities(γ) and the Portfolio Elasticity (θ): Domestically Produced Capital Goods
(Percent)

γ/θ	Burden Exported	Excess Burden	Percentage Change in Capital Stock (Percent)
1/0.1	16	2	-0.2
1/3	28	2	-1.7
1/100	51	1	-4.3
3/0.1	9	3	-0.1
3/3	11	3	-1.6
3/100	15	3	-4.4
100/0.1	7	3	-0.0
100/3	3	3	-1.5
100/100	0	5	-4.5

Notes:
1. Assumes factor substitution elasticities ($\sigma_{i,j}$) and the general product substitution elasticity (ε) are unitary.
2. Excess burden independently and exactly calculated by dividing the total equivalent variation (home and foreign) of the tax change by the tax revenue. For the model with produced capital goods, measuring the excess burden as the sum of burdens less the tax typically generates slightly larger values for the Laspeyres price index and slightly smaller values for the Paasche index. For the case of perfect product substitution (θ = 100), the Laspeyres measure, however, is noticeably larger: it is 17 for (γ,θ) = (1,100), 8.5 for (γ,θ) = (3,100) and 5.5 for (γ,θ) = (3,100).

Capital Intensity

Table 6 also reports our examination of the effects of capital intensity when we set all of the capital shares equal. Recall that the traded corporate sector 1 is less capital intensive than the non-traded corporate sector 3, and both are less intensive than the non-traded noncorporate sector 4 (which includes housing); see Table 1*d*. Table 6 shows that making all sectors equally capital intensive has little impact on the results. In our benchmark case, γ=3 and θ=3, the burden falling on capital actually increases slightly. But in all cases, the burden continues to fall largely on capital at moderate and lower elasticities.

Partial Versus General Factor Tax

Finally, Table 6 shows that the effects are influenced slightly by which sectors bear the tax. When the tax is imposed only on traded corporate goods (sector 1), the burden on capital tends to be a little smaller. For example, at γ=3 and θ=3, the burden falling on capital drops from 72 to 68 percent. Taxing only the non-traded corporate sector 3 or the non-traded non-corporate sector 4 has little impact on the results. Imposing the tax on all sectors has little impact either. For example, at γ=3 and θ=3, the burden falling on capital stays at 72 percent. These calculations do suggest that models with different structures can produce slightly different results. Nevertheless, the results for a general tax and for partial taxes are similar.

Table 6
Share of Tax Borne by Domestic Labor (Domestic Capital)
and
Sensitivity of Results
to
Factor Substitution Elasticity (σ), General Product Substitution Elasticity (ε),
Capital Share Differences and Sectoral Tax Differences,
For
Selected Foreign-Domestic Product Substitution Elasticities (γ) and the Portfolio Elasticity (θ):
Produced Capital Goods Case
(Percent)

γ/θ	Base Case (Table 4)	Low σ 0.8	High σ 1.2	Low ε 0.8	High ε 1.2	Equal Capital Share	Tax on only Sector 1	Tax on only Sector 3	Tax on only Sector 4	Tax on All Sectors
1/0.1	-3(90)	1(86)	-7(93)	-6(92)	0(88)	-5(90)	-17(84)	5(93)	5(93)	-2(91)
1/3	5(70)	13(64)	0(75)	2(71)	8(69)	0(72)	-9(63)	13(73)	13(73)	7(72)
1/100	21(38)	30(34)	12(42)	17(39)	24(37)	11(43)	5(27)	28(39)	29(40)	23(46)
3/0.1	3(92)	7(88)	0(95)	0(94)	6(89)	2(92)	1(89)	5(93)	5(93)	1(92)
3/3	21(72)	27(67)	16(78)	19(74)	23(71)	17(85)	19(68)	22(74)	23(75)	19(72)
3/100	55(36)	60(33)	51(38)	54(37)	57(35)	53(36)	55(28)	55(38)	57(39)	55(39)
100/0.1	6(93)	10(89)	3(95)	3(95)	9(90)	5(93)	9(92)	6(94)	6(94)	3(92)
100/3	28(73)	33(68)	23(78)	26(75)	30(72)	25(75)	32(71)	26(75)	27(75)	25(73)
100/100	73(35)	74(33)	72(37)	72(36)	74(34)	74(34)	80(29)	69(38)	70(38)	71(36)

Price Index for Capital Goods

The results are obviously affected by the choice of price index for capital goods, which in turn reflects the ability to trade in these goods. As shown in Table 7, when an index that is weighted by domestic consumption rather than domestic output is used, so that $\tilde{P}_i = \bar{P}_i$, the burden on capital rises somewhat. Using a domestic output price index is appropriate when capital goods are not traded; using a consumption weighted index presumes that capital goods are imported and exported in the same shares as consumption goods. For example, in the case of a portfolio substitution elasticity of 0.1 and a product substitution elasticity of 100, the burden on capital rises from 38 percent to 46 percent. In general, this case is not significantly different from the case where capital goods are produced domestically. Another alternative is to use the worldwide price of capital goods, which would imply a much greater ability to trade capital goods:

(24)
$$\tilde{P}_i = \sum_{i=1}^{2} \sum_{j=1}^{4} p_{i,j} \overline{\left(\frac{q_{i,j}}{Q} \right)}$$

$$Q \equiv \sum_{i=1}^{2} \sum_{j=1}^{4} q_{i,j}$$

This version produces results almost identical to the results in our basic model with no capital goods prices, and it also causes the product substitution elasticity to have a pronounced effect on capital flows. It follows that while including produced capital goods is potentially important in reducing the incidence falling on capital, allowing for this market to be more global reduces—possibly eliminates—the importance of this feature.

Table 7
Burden on Labor (Capital), Alternative Capital Goods Price Indices, Selected Foreign-Domestic Product Substitution Elasticities (γ) and the Portfolio Elasticity (θ)
(Percent)

γ/θ	No Capital Goods Prices	Domestic Output Weighted Price	Domestic Consump-tion Weighted Price	World Consump-tion Weighted Price	More Trade and Capital Flows*	2% Growth Rate**	7% Growth Rate**
1/0.1	-3(91)	-3(90)	-3(90)	-3(91)	-8(81)	-3(92)	-2(98)
1/3	2(81)	5(70)	5(72)	2(81)	3(60)	9(72)	23(78)
1/100	7(71)	21(38)	17(46)	7(71)	13(43)	33(34)	86(38)
3/0.1	3(92)	3(92)	3(92)	3(92)	2(82)	2(93)	-1(98)
3/3	18(76)	21(72)	20(73)	18(76)	25(60)	21(75)	22(78)
3/100	38(55)	55(36)	52(39)	38(55)	49(37)	61(33)	81(36)
100/0.1	7(92)	6(93)	6(93)	7(92)	7(84)	4(94)	0(98)
100/3	30(72)	28(73)	27(73)	30(72)	38(60)	26(75)	22(73)
100/100	71(36)	73(35)	72(35)	71(36)	74(33)	74(33)	79(35)

*Uses domestic consumption weighted price index for capital goods.
**Uses domestic output weighted price index for capital goods.
Note: Assumes factor substitution elasticities ($\sigma_{i,j}$) and the general product substitution elasticity (ε) are unitary.

Trade and Capital Flows

The 6th column of Table 7 explores the effect of changing the initial level of trade and capital flow involvement with the rest of the world, a setting that would be more appropriate to some other countries. A capital goods price index weighted by consumption is used. Comparing it to the 4th column, we find that the burden on capital falls somewhat (in part because more investments are located abroad) and that, at a low traded product substitution elasticity (γ), more of the burden is exported and less of the burden falls on labor. This reflects a greater ability to export the tax because more of the product is used to satisfy foreign demand.

Growth

Up to this point, the prices of capital goods are incorporated in a model that has no steady state investment (or negligible investment) so that prices of produced capital goods only affect the value of capital income flows. In order to allow a more realistic treatment of capital, the version of the model with the domestic-output price index for capital-produced goods was modified to include a positive rate of economic growth. This was done by assuming that each sector contributes to the production of capital goods in proportion to their domestic output weight. (The modifications to the formulae and calibration are available from the authors.) A steady-state growth rate of two percent and, for the purpose of sensitivity analysis, seven percent were simulated. Seven percent was chosen since this is equal to the initial marginal product of capital. As shown in the 7th and 8th columns of Table 7, in most cases, this modification did not have much effect. In some cases, growth caused slightly more of the burden to fall on labor, and in some cases slightly less. In our benchmark case, γ=3 and θ=3, the burden falling on capital increased slightly from 72 percent to 75 percent with 2 percent growth and 78 percent with 7 percent growth. However, in some cases where the product substitution elasticity was much smaller than the portfolio elasticity, there was a significant increase in the burden on domestic labor (and a corresponding increase in benefit for foreign labor).

In the case of the very high growth rate equal to 7 percent, the traded product substitution elasticity (γ) had little effect on the burden on labor and, in fact, caused the burden to increase slightly as γ fell. This reversal of the pattern of incidence arises from the change in relative supply. Normally, with perfect product substitution, the supply of the domestic good contracts and the foreign good expands when capital moves abroad as the result of the tax; but when these goods are imperfect substitutes, the rise in price allows the tax to be exported abroad and relieves the burden on domestic labor. When the growth rate equals the marginal product of capital, all returns to capital are diverted to investment. This causes the amount of output available for consumption to actually contract abroad (as the marginal product of foreign capital falls below the growth rate) and rise in the domestic economy (where the marginal product is above the growth rate). With imperfect substitution, the domestic economy bears more than 100 percent of the tax and foreigners have a net gain (through a gain by foreign labor). High growth rates can reduce, or at the extreme, reverse the export of the tax.

These experiments suggest that the growth rate will matter to tax incidence, but at the same time, growth rates more typical of today's developed country do not have a significant effect. And, in the range of empirical estimates, the burden on labor is still small or negligible: labor bears 2 percent of the tax at a growth rate of 2 percent and 7 percent at a growth rate of 7 percent, when both the traded product and portfolio elasticities are one. When both elasticities are three, labor bears around twenty percent.

Finally, it is important to recognize that the effects of changing relative product prices, which allows substantial export of taxes in the steady state under some assumptions, will be reversed during the transition when investments are being reduced in the country imposing the tax and increased in foreign countries (assuming investment goods are not traded). These demand side shifts will cause a temporary fall in domestic prices and rise in foreign prices. However, the burden (benefit) of these changes will not fall on domestic (foreign) labor; rather, during the adjustment period, they will impose windfall gains and losses on capital income, just as in the case of a closed economy model in the short run, since firms cannot immediately alter their capital stock. Indeed, in an open economy, more than 100 percent of the burden of a tax would fall on owners of capital in the short run.

VI. Conclusion

The analysis in this paper not only helps to address the question of the incidence of the U.S. corporate income tax, but also identifies some of the important features and behavioral parameters that influence that incidence in general.

The findings of this paper reverse the basic conclusions drawn from the more simplistic models of an open economy (discussed in Section I) that predict the burden of a capital income tax, or a partial factor tax, falls on labor income as the immobile factor. This study suggests that the tax burden in the U.S., a large country with imperfect product and portfolio substitution, is much more like a closed economy. The corporate tax appears to fall largely on capital income, unless product and portfolio substitution elasticities are considerably higher than those measured empirically. Moreover, when the tax does not fall as heavily on capital, it is more likely to be exported rather than to fall on labor when traded products are not perfectly substitutable.

This analysis has been one fitted to U.S. values and focuses on a stylized territorial tax case with perfect competition and equity finance. Relaxing these assumptions would, however, tend to reinforce our general conclusion that the tax is borne by capital. The U.S. tax is legally residence based, not territorial, for its own multinationals, in that firms are liable for the tax if profits are repatriated and foreign taxes are lower. If firms have to undertake avoidance costs, this implicit tax will nevertheless discourage foreign investment and shift more of the burden on capital.

Monopoly power and excess profits, of course, also mean that some portion of the tax is not likely to be shifted at all, but to remain as a burden on owners of equity.

Debt finance introduces yet another reason to expect that the U.S. corporate tax is likely to fall on capital. Because interest is deductible, including the inflation portion of the interest rate, debt finance tends to be subsidized at the corporate level, and this subsidy rises with the tax rate (see Gravelle, 1994, pp. 58-59). Firms may respond, in part, by allocating more debt to the investment locations with higher tax rates. However, since tax authorities impose limits on the degree to which interest can be artificially allocated, a higher corporate tax makes real borrowing more attractive in the domestic economy. If investor's interest bearing assets are more mobile than equity finance, a higher corporate tax could attract capital to the U.S. rather than reducing the domestic capital stock. Certainly, vigorous enforcement of interest allocation rules could help to simultaneously maintain revenues and help ensure that the burden of the corporate income tax falls on capital.

This study has identified many factors that can influence the incidence of the U.S. corporate tax. First, and most importantly, the analysis underscores the importance of imperfect substitution in traded goods, which becomes important for a larger country or any country with many industries. Imperfect product substitution is very effective in limiting the tax burden that falls on labor. And this is true even when the tax burden falling on capital is limited.

Second, this study shows that there are some general similarities in the incidence of a partial and a general capital tax; in particular, the burden does not fall on domestic labor even with fairly high trade product or portfolio elasticities. This insight confirms that the crucial point of the original Harberger model—namely that a partial capital income tax imposed on a territorial basis (i.e. a business tax) tends to have the same burden as a general capital income tax—extends to an open economy with or without perfect traded product and capital substitution.

Third, the study suggests that how capital goods are produced and traded has a non-trivial impact on the degree to which the tax is exported versus falling on domestic capital. With produced capital goods, the incidence of the corporate tax falling on capital might be reduced. But the burden is not shifted much to labor. The tax is often exported to foreign factors of production. In particular, circumstances where investments are highly substitutable, but product substitution elasticities are low, can lead to substantial fractions of a tax being exported. Moreover, this export becomes larger the more trade a country engages in. This issue may be of greater importance to European countries where the traded sector is much larger than in the U.S. Slemrod (1995a) has discussed the potential importance of international capital taxation rules, including corporate tax harmonization, to achieve efficient worldwide production outcomes as national economies become more integrated. Our analysis underscores that potential importance of these rules for the distribution, and especially the exporting, of tax burdens as well.

Appendix: Calibration and Model Solution

The entire programming problem includes about 70 non-linear equations. The equations used in solving the model are the first-order conditions and price relationships in Table 1*a*, along with the portfolio equation in (11), the market clearing equations in (14) through (18), and the domestic budget constraint in equation (6) (the foreign budget constraint is redundant). Once the estimated factor returns are obtained, they are divided by the relevant consumption price index in equation (13) to obtain real purchasing power values.

The numerical calculations involve three stages: calibration, simulation, and verification.

In the *calibration stage*, values of the calibration parameters (Table 1*c*) are derived so that each simulation starts with the exact same initial observable economy (Table 1*d*) when the choices for various elasticities are varied from their benchmark setting. This is done by solving the set of equations shown above for a unique representation of the calibration parameters. The U.S. accounts for 30 percent of output and capital. Data on the allocation of output and factor incomes are derived from Gravelle and Kotlikoff (1995) and data on imports and exports and capital flows are taken from Gravelle (1994), with import and export shares across sectors taken from the national income accounts. Additional characteristics of the initial economy are shown in Table 1*d*.

The *simulation stage* solves for the new economy after the corporate tax is increased ten percent (the exact value of the tax increase is quantitatively unimportant). The model is solved via Gauss-Seidel iteration: an initial guess is made for two sets of factor prices (w_i and r_i), the rest of quantities and prices are derived from the restrictions shown above in the text and Table 1*a*, and the factor prices are updated from the market-clearing conditions; the process continues until the factor prices converge within a small threshold.

The *verification stage* involves three steps. First, by Walras Law, the complete set of market equations contains a redundant equation which can be used to check the solutions; but this check will not detect some types of programming mistakes. In our second step, one of the authors (not the main programmer) retyped all of the equations in a spreadsheet and checked to make sure that all of the equalities in the restrictions hold for given values of the deep parameters from the calibration stage and equilibrium values from the simulation stage. Third, the program is executed for cases in which the answer is known a priori on theoretical grounds (e.g., $\theta = \gamma = 100$).

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