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I. INTRODUCTION

Recent discussions of tax reform in the United States have focused on corporate income tax reform. The last fundamental reform of the income tax system, including the corporate income tax, was the much-celebrated Tax Reform Act of 1986 (TRA86), which followed the classic model of a base-broadening, rate-reducing (BBRR) reform that financed significant corporate and personal rate cuts with the elimination of a wide variety of tax preferences. In the interim, however, many countries around the globe have reformed their tax structures. This is especially true for corporate income taxes abroad, where many nations – at least partly in response to the inexorable forces of globalization and international tax competition (Zodrow, 2010) – have dramatically reduced statutory rates while enacting base broadening measures that have kept corporate tax revenues roughly constant as a share of GDP (Bilicka and Devereux, 2012). As a result, the United States, which was a relatively low tax country after TRA86, now has the highest statutory corporate tax rate in the industrialized world, and has also lost its advantage in marginal effective corporate tax rates (which take into account other features of a tax system, including accelerated deductions for depreciation and other investment allowances).

Proponents of corporate income tax reform argue that such high tax rates (1) discourage investment and capital accumulation and thus reduce productivity and economic growth, (2) discourage foreign direct investment in the United States while encouraging US multinational companies (MNCs) to invest abroad, and (3) encourage US – and foreign multinationals investing in the US – to engage in income shifting, using a variety of techniques to move revenues to low tax countries and deductions to the relatively high tax United States. In addition, the combination of a high statutory tax rate coupled with a wide variety of tax preferences distorts the allocation of investment across asset types and industries and reduces the productivity of the nation’s assets, while exacerbating the many inefficiencies of the corporate
income tax, including distortions of business decisions regarding the method of finance (debt vs. equity in the form of retained earnings or new share issues), organizational form (corporate vs. non-corporate), and the mix of retentions, dividends paid, and share repurchases (Gravelle, 1994; Nicodème, 2008).

A separate issue that has attracted a great deal of attention is the tax treatment of US and foreign MNCs under current law. Following recent reforms in the United Kingdom and Japan, the United States is now the only major industrialized country that operates a worldwide tax system under which the foreign-source income earned by US subsidiaries is subject to a residual US tax when repatriated to the US parent, subject to a credit for foreign taxes paid. By comparison, most other countries (e.g., 28 of the 34 OECD nations) operate a territorial system under which the active foreign-source income of their domestically headquartered MNCs is largely exempt from any residual domestic taxation. Proponents of a move toward a territorial tax system in the United States argue that it would improve the international competitiveness of US multinationals and end the current tax disincentive for the repatriation of foreign-source income that arises as firms defer repatriation to avoid paying residual US taxes.

These developments have by no means gone unnoticed in the United States. Numerous proposals for reform have emerged, all of which have generally followed the example of TRA86 and taken the form of traditional BBRR reforms. These include the reports of the President’s Advisory Panel on Federal Tax Reform (2005), the National Commission on Fiscal Responsibility and Reform (2010), and the Debt Reduction Task Force of the Bipartisan Policy Center (2010).

The most comprehensive recent proposal for reforming the corporate and individual income tax systems – and the focus of this paper – was put forth as a legislative discussion draft on February 26, 2014 by Representative Dave Camp (R-MI), Chairman of the House Ways and
Means Committee.¹ In this paper, we report the results of a numerical simulation of the macroeconomic effects of the corporate income tax reform proposals contained in the Camp discussion draft (i.e., we hold the personal income tax system constant), using the Diamond-Zodrow model, a dynamic overlapping generations, computable general equilibrium (CGE) model that is designed to analyze both the short-run and long-run macroeconomic effects of tax reforms.

The paper proceeds as follows. In the following section, we outline the corporate tax reform features of the Camp discussion draft that we simulate. The following sections describe the Diamond-Zodrow model. Section III provides a brief description of the domestic (closed economy) features of the model, which are described in detail in Zodrow and Diamond (2013). Sections IV–V provide a detailed description of the international features of the model that have been added to the model since the publication of Zodrow and Diamond (2013). The corporate tax reform simulation results are reported in Section VI. The final section concludes.

II. CORPORATE INCOME TAX PROVISIONS IN THE CAMP DISCUSSION DRAFT

The Camp discussion draft provides for a comprehensive base-broadening, rate-reducing (BBRR) revenue neutral reform of both the business and individual income taxes. In this paper, we focus on the effects of the corporate income tax provisions in this plan. The specific provisions of the discussion draft and the estimates of their revenue effects that we use in our analysis are provided in Joint Committee on Taxation (2014). The main features of the corporate income tax reform provisions in the discussion draft are as follows.

The Camp discussion draft would phase in over five years a reduction in the top corporate rate to 25 percent, financing this rate reduction with the elimination of a wide range of business tax preferences. It would also follow virtually all of our main trading partners by moving the United States to a participation exemption international tax system, under which the active foreign-source income of US multinationals is largely untaxed; foreign-source income from intangibles derived from sales to foreign markets, however, would be taxed in the year earned at a 15 percent rate, subject to credits for foreign taxes paid, while foreign-source income from intangibles derived from sales to the US market would be taxed in the year earned at a 25 percent rate. The corporate alternative minimum tax would also be eliminated.

The primary business tax base-broadeners would be (1) the replacement of accelerated depreciation (in 2017) with deductions taken over a longer period with partial inflation-indexing, (2) the replacement of half of expensing of expenditures on advertising with phased-in amortization over 10 years, (3) the replacement of expensing of research and development with phased-in amortization over five years, (4) a three-year (2015-2017) phase-out of the deduction for domestic production activities, (5) the repeal of LIFO inventory accounting, coupled with recapture of the existing LIFO reserve over 2019-2022, and (6) the introduction of a limitation on the deduction of net operating losses by C-corporations. In addition, all business tax credits would be eliminated with the exception of a reformed low-income housing tax credit and a permanent simplified 15 percent tax credit for research and development expenses.

On the international side, the discussion draft would move the United States to a participation exemption tax system, under which 95 percent of foreign-source dividends repatriated from controlled foreign corporations would be tax exempt; with a 25 percent corporate tax rate, such dividends would effectively be taxed at a rate of 1.25 percent. However, foreign-source income attributable to intangibles – defined as income in excess of a return of 10
percent on invested capital – would be taxed currently at a rate of 15 percent if derived from sales to foreign markets and at a rate of 25 percent if derived from sales to the US market, subject to credits for foreign taxes paid. To provide for tax neutrality with respect to decisions regarding the location of intangibles, income derived from intangibles on sales to foreign markets from the United States would also be taxed at a 15 percent rate. The discussion draft includes several other international tax reforms including a new thin capitalization rule, changes in foreign sales sourcing rules, temporary extension of the active finance exception, and a permanent CFC look-through rule. In addition, the discussion draft includes a one-time tax on the existing stock of unrepatriated profits, imposed at an 8.75 percent rate on cash and cash equivalents and a 3.5 percent rate on illiquid assets, subject to credits for foreign taxes paid.

III. OVERVIEW OF THE DOMESTIC COMPONENT OF THE DIAMOND-ZODROW MODEL

This section provides a short description of the domestic component of the Diamond-Zodrow (DZ) model used in this analysis, which is described in detail in Zodrow and Diamond (2013). The model combines various features from other broadly similar CGE models, including those constructed by Auerbach and Kotlikoff (1987), Goulder and Summers (1989), Goulder (1989), Keuschnigg (1990), Fullerton and Rogers (1993), Bettendorf, Devereux, van der Horst, Loretz, and de Mooij (2009), and de Mooij and Devereux (2011). Key parameter values used in the simulation are listed in the appendix; for discussion of some of these choices, see Gunning, Diamond, and Zodrow (2008). Versions of the model have been used in analyses of tax reforms by the U.S. Department of the Treasury (President’s Advisory Panel on Federal Tax Reform, 2005) and in a number of other recent tax policy studies (Diamond and Zodrow, 2007, 2008,
The domestic component of the DZ model includes both corporate and non-corporate composite consumption goods and owner-occupied and rental housing, with the corporate sector subject to the corporate income tax and subdivided into domestic and multinational firms as described below, and the non-corporate sector taxed on a pass-through basis at the individual level and subdivided into a “tax preferred good” that benefits from various subsidies provided through the income tax code and an unsubsidized “tax neutral” good. Firms combine labor and several different types of capital to produce their outputs at minimum after-tax costs. The time paths of investment are determined by profit-maximizing firm managers who take into account all business taxes (including all tax preferences) as well as the costs of adjusting their capital stocks, correctly anticipating the macroeconomic changes that will occur after a tax reform is enacted. Firms finance their investments with a mix of equity and debt, and choose an optimal debt-asset ratio to balance the costs and benefits of additional debt, including its tax advantages.

On the consumption side, household supplies of labor and saving for capital investment and demands for all housing and nonhousing goods are modeled using an overlapping generations structure in which a representative individual in each generation spends a fixed amount of time working and in retirement, makes consumption choices to maximize lifetime welfare subject to a lifetime budget constraint that includes personal income and other taxes, and makes a fixed “target” bequest.

The government purchases fixed amounts of the composite goods and makes transfer payments, which it finances with the corporate income tax, a progressive tax on wage income after deductions and exemptions, and constant average marginal tax rates applied to interest income, dividends, and capital gains. The modeling of corporate income tax revenues includes
explicit consideration of depreciation allowances for new and old assets, other production and investment incentives, and state and local income and property taxes. The government must balance its budget in each period, after taking into account enough borrowing to maintain a constant debt-to-GDP ratio. During the five-year phase-in of the reduction in the corporate tax rate under the Camp discussion draft, we assume that government transfers are adjusted to meet the government budget constraint; after the phase-in period, the corporate tax rate adjusts endogenously to balance the federal government budget, so that dynamic revenue increases are offset by further reductions in the corporate tax rate. State and local governments finance fixed levels of purchases of the composite goods with sales, property, and income taxes. Tax policy in the rest of the world is assumed to remain constant; that is, other countries do not respond to the corporate income tax rate reduction in the United States by reducing their own tax rates further.

All markets are assumed to be in equilibrium in all periods, and the economy must always begin and end in a steady-state equilibrium, with all of the key macroeconomic variables growing at the exogenous growth rate, which equals the sum of the population and productivity growth rates. The model does not include unemployment, so that any labor supply response that is observed reflects changes in labor supply in the context of a full employment economy.

IV. THE INTERNATIONAL COMPONENT OF THE DIAMOND-ZODROW MODEL

We now describe the international component of the model, which consists of multinational production sectors in the US and the rest-of-the-world (RW) and allows for international flows of goods and capital. These features allow for a much more complete modeling of tax reforms in today’s globalized economy, including especially corporate income tax (CIT) reforms such as changes in the taxation of the international operations of U.S. multinational corporations; examples would include the often-discussed move to a territorial tax
system from the current worldwide tax system with deferral and a foreign tax credit, or the elimination of deferral under the current worldwide system.

Specifically, the international component of the model includes a single foreign rest-of-the-world sector and two types of multinational corporations (MNCs), each of which owns a firm-specific factor that generates economic rents. The first is a US-based MNC (US-MNC) that consists of a representative parent firm that invests in the United States and a representative foreign subsidiary that invests abroad, and a foreign-based multinational (RW-MNC) that consists of a parent firm that invests in RW and its subsidiary that invests in the United States. To simplify the analysis, we model RW as consisting entirely of the foreign MNC sector (including both the US-MNC subsidiary and the RW-MNC parent); that is, we assume that the remainder of the rest of the world is unaffected by any reforms analyzed. In addition, to account for the greater international mobility of certain types of capital, stressed by Becker and Fuest (2011) among others, we include two types of capital in the model. The first is firm-specific capital \((FSK)\) that earns economic rents, is owned exclusively by the two MNCs, and is highly mobile across the US and RW. The second is a significantly less internationally mobile “ordinary” capital \((K)\) that is used by all firms and earns normal returns; to capture the effects of any differential tax treatment of different types of assets, this type of capital is disaggregated into equipment, structures, and inventories. Both the US and foreign-based MNCs trade intermediate goods between their affiliates, and the model includes international trade between the US and RW in the consumer goods produced by the MNC sectors in each country, which are assumed to be imperfect substitutes following the standard Armington (1969) assumption. (Trade is limited to the two multinational sectors to simplify the analysis.) Finally, we assume that both MNCs have variable debt-asset ratios that depend on the levels of statutory tax rates, and can engage in

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2 For a comparison of our model to that constructed by Becker and Fuest (2011), see Appendix section A.1.
the shifting of profits from high tax to low tax jurisdictions to reduce their overall tax liabilities.

A. Overview

When the model includes its international component, the US economy is assumed to have two corporate sectors — a standard perfectly competitive corporate sector (C) that produces a non-traded domestic good and is characterized by normal returns to “ordinary” capital \( (K) \), and a multinational corporate sector (M) that produces a good that is traded internationally, and is comprised of a US-MNC parent (denoted by the superscript USP) and a RW-MNC subsidiary (denoted by the superscript RWS) that utilize both ordinary capital \( (K) \) and firm-specific capital \( (FSK) \) that earns above-normal returns. The above-normal after-tax returns in this sector, which accrue to the firm-specific capital \( (FSK) \) invested in the M sector, are assumed to persist in the long run; in the steady state the total gross or before-tax returns to such firm-specific capital (which include all above-normal returns), denoted as \( \Pi^{USP} \) and \( \Pi^{RWS} \), equal total revenues net of the firm’s costs, including any taxes, of its purchases of (1) labor, (2) “ordinary” capital \( (K) \) that earns normal returns, and (3) intermediate goods that are purchased from the MNC’s affiliate in RW. The level of investment in firm-specific capital of the two multinationals is exogenous, as the amount of \( FSK \) is simply assumed to grow at the exogenous growth rate in the economy. The investment in \( FSK \) by the US-MNC is modeled as purchases of the C-sector good, which is the numeraire good. Production involving the stock of firm-specific capital is allocated across the M-sectors in the US and RW as described below.

Each MNC and thus its firm-specific capital \( FSK \) are assumed to be owned by domestic residents, who thus effectively own foreign capital through their ownership of a MNC that
invests some of its FSK and produces abroad. In addition, foreigners own some of the US ordinary capital stock, and US residents own some of the RW ordinary capital stock.3

With its international component, the DZ model thus has five production sectors, with a single tradable consumption good — the good produced by the M-sector. These five production sectors are: (1) a competitive corporate sector that produces a non-tradable good (C); (2) a multinational corporate sector (M), with total output of $X^{MT}$ which includes both goods produced in the US by the US-MNC parent firm ($X^{MUSP}$) and goods produced in the US by the RW-MNC foreign subsidiary ($X^{MRWS}$); (3) a competitive noncorporate business sector that produces a non-tradable good (N); and two non-tradable housing production sectors, that is, (4) a competitive owner-occupied housing sector (H); and (5) a competitive rental housing sector (R). Note that in the multinational corporate tradable goods sector (M), aggregate supply in the US is

$$X^{MT} = X^{MUSP} + X^{MRWS}.$$  

Aggregate demand in the M sector in the US is

$$M^{USDOM} + M^{USEXP} + M^{IGUSS} + M^{IGRW},$$

where the first term reflects domestic consumption of M-sector goods produced in the US, the second term reflects US exports of this consumption good to RW, and the third and fourth terms reflect exports of the intermediate good to the US-MNC’s foreign subsidiary and the RW-MNC’s parent firm. Both investment goods ($K$ and FSK) and government goods and services are assumed to be produced solely by the competitive corporate (C) sector. In parameterizing the model, we assume that FSK corresponds roughly to intangibles and, drawing on Gravelle (2012), assume that intangibles account for 26.5 percent of the capital stock.4 We set the production function parameters so that the share of above-normal

3 US residents are assumed to include their shares of the US-MNC’s FSK and their shares of both domestic and foreign ordinary capital in their bequests.

4 Estimates of the share of the capital stock accounted for by intangibles vary widely; for example, Hulten, Corrado and Sichel (2006) estimate the intangibles share as roughly 55 percent, while Dauchy (2013), using broadly similar techniques but assuming faster depreciation for intangible capital, estimates an intangibles share of only 11 percent.
returns in capital income is roughly 50 percent, approximating the 62 percent share estimated by the US Department of the Treasury as described in Cronin et al. (2013).

**B. Modeling US and RW Multinational Corporations**

We first discuss the details of our modeling of the multinational sector in the model, including the allocation of firm-specific capital and income shifting. We then describe the parameterization of this component of the model.

1. **Structure of the Model**

All of the multinational corporations – the US-MNC parent firm and its foreign subsidiary, and the foreign-based RW-MNC’s parent firm and its US subsidiary – are assumed to have Cobb-Douglas production functions. The appropriate way to model FSK is open to debate. We wish to capture several aspects of FSK stressed in the literature. The first is that FSK permanently earns above-normal returns. The second is that such FSK is relatively highly mobile (in comparison to ordinary capital $K$), that is, firms have considerable flexibility regarding where to locate production involving FSK. And the third is that because FSK earns above-normal returns which are typically taxed at the statutory tax rate – independent of tax features like accelerated depreciation or investment tax credits that determine the level of taxation of normal returns – it is primarily responsive to statutory (or average effective tax rates that approximate statutory tax rates when above-normal returns are relatively large) rather than the marginal effective tax rates that are the key factor in determining the level of investment once the location decision is made as well as the level of investment in capital that earns normal returns (Devereux and Griffith, 1998).

Our approach to modeling MNC decisions regarding where to locate the production that uses FSK generally follows the innovative approach developed by Bettendorf, Devereux, van der Horst, Loretz, and de Mooij (2010) and utilized to analyze the effects of corporate tax reform in
the EU by de Mooij and Devereux (2009). Under this approach, the MNC is assumed to own a unique firm-specific production input (FSK), such as patents or other proprietary technology, brand names, good will and reputation, coupled with unique managerial skills or knowledge of production processes, etc., which allows it to permanently earn above-normal returns or economic rents. We follow Bettendorf et al. in assuming that this firm-specific factor is “quasi-fixed,” that is, it is fixed in total supply in any given period, and that this fixed amount is allocated across the US and RW in response to the tax differential between the two countries, with the fixed share of factor returns going to FSK determined by its share parameter in the Cobb-Douglas production function. This formulation is admittedly somewhat ad hoc. In particular, to the extent that FSK reflects intangibles in the form of intellectual property, using FSK in the US does not reduce the extent to which the intellectual property can be used in RW, as implied by the assumption of a fixed total stock of FSK in any given period. However, with the constant share of returns to FSK implied by the Cobb-Douglas production functions, any reallocation of FSK across the US and RW is primarily associated with a similar reallocation of production of the multinational sector good across the two countries – rather than greater use of FSK at existing production levels. Indeed, in the simulations, the ratio of multinational production in the US to production in RW closely tracks the ratio of FSK in the US to FSK in RW. Thus, as described by Bettendorf et al., this formulation is a reasonable way to model MNC location decisions regarding where to produce the output that uses FSK, with the relative size of the above-normal returns earned by FSK determined by its share parameter in the Cobb-Douglas production function.5

5 In a recent exploration of issues related to the taxation of foreign profits, Devereux, Fuest, and Lockwood (2014) describe this as the case of “fixed management capacity,” as there is a fixed amount of firm-specific capital that must be allocated among different locations around the world. A similar approach is used by Becker and Fuest (2010), who consider “ownership skill” that creates above-normal returns, assuming first that the amount of this skill
Specifically, the allocation of the firm-specific factor across the US and RW in the model is assumed to be determined by the relative after-tax profits per unit earned by FSK in the two countries, assuming the constant portfolio elasticity relationship between the change in FSK and the change in the after-tax profits per unit described below; as noted above, statutory tax rates are used because they are the primary determinant of the level of taxation of the above-normal returns earned by FSK.\textsuperscript{6} The degree of mobility of FSK is determined by the magnitude of the portfolio elasticity. The allocation of FSK is also affected by the potential for profit shifting since, if profit shifting from high tax to low tax jurisdictions is relatively easy, then the allocation of FSK will not be as sensitive to tax differentials as some of the cost of a higher tax rate can be offset with increased profit shifting. In practice, profit shifting can occur in many ways, including the relocation of the ownership of intangibles, the use of transfer pricing, and the use of loan reallocations that facilitate interest stripping. However, to simplify the analysis, we model only total profit shifting rather than modeling each element separately, and restrict profit shifting to the earnings of FSK rather than extending profit shifting to all capital earnings. This profit shifting is modeled as follows. We first describe our treatment of income shifting, and then turn to the allocation of FSK, including how it is affected by income shifting.

Suppose that, before any profit shifting, the total before-tax profits accruing to the firm-specific factor invested domestically by the US-MNC parent are $\Pi^{USP} = \pi^{USP} FSK^{USP}$, and the analogous before-tax profits earned by the FSK invested in the firm’s subsidiary are $\Pi^{USS} = \pi^{USS} (FSK^{USS})$, where $\pi^{USP}$ ($\pi^{USS}$) are profits per unit of FSK for the US parent (US subsidiary). We assume that the US-MNC parent engages in profit shifting (and, analogously, the

\textsuperscript{6} This income is assumed to reflect earnings that are reported abroad, that is, earnings that are net of earnings reported in the US due to the application of the transfer pricing rules for intangibles.
RW-MNC subsidiary in the US), and that the total amount of income shifted is determined by the differential between the US statutory corporate tax rate and the tax haven tax rate.

Following Grubert and Altshuler (2013), de Mooij and Devereux (2009), and others, we assume that the costs of income shifting are a quadratic function of the fraction of before-tax profits shifted. For example, for the US parent the total costs of profit shifting are assumed to be

$$\phi^{PS} = \left[ (\beta^{PS} / 2)(m^{USP})^2 \right] \pi^{USP} FSK^{USP},$$

where $\beta^{PS}$ is the marginal cost of shifting profits, and $m^{USP}$ is the fraction of total before-tax profits shifted out of the US by the US-MNC parent.

The optimal amount of profit shifting is calculated by weighing the gains from shifting – the reduction in the statutory tax rate applied to shifted profits, or $(\tau_{FSK} - \tau_{TH})m^{USP} \pi^{USP} FSK^{USP}$, against the costs of shifting $\phi^{PS} = (\beta^{PS} / 2)(m^{USP})^2 \pi^{USP} FSK^{USP}$, where $\tau_{FSK}$ is the tax rate applied to the FSK owned by the US-MNC in the US and $\tau_{TH}$ is the effective tax rate, including the costs of deferring income discussed below, in a typical tax haven. The optimal amount of shifting is determined from the following expression (the first-order condition for choosing $m^{USP}$ to maximize the difference between these two terms)

$$(\tau_{FSK} - \tau_{TH})\pi^{USP} FSK^{USP} = (\beta^{PS})(m^{USP})\pi^{USP} FSK^{USP},$$

which implies

$$m^{USP} = \frac{\Pi^{USP/S}}{\Pi^{USP}} = \frac{1}{\beta^{PS}}(\tau_{FSK} - \tau_{TH}).$$

where $\Pi^{USP/S}$ is the amount of income shifted by the US parent. The fraction of income shifted is thus inversely related to the marginal costs of income shifting and directly related to the size of the tax differential between the statutory corporate income tax rate applied to $FSK$ and the tax haven tax rate. To obtain estimates of the constant marginal cost of profit shifting $\beta^{PS}$, we use
empirical estimates (discussed below) of the fraction of corporate profits that have been shifted out of the US at the existing tax rate differential.

Note that the estimate of $\beta_{PS}$ can be used to calculate the implicit tax semi-elasticity of profit shifting ($\eta_{PS}$) in the model, another parameter that, as discussed below, has been the focus of much attention in the literature. The tax semi-elasticity of profit shifting is defined as the percentage change in total profits reported by a US subsidiary in a country with respect to a change in the differential between the US statutory corporate tax rate and the corporate tax rate in that country. In our two-country model, the change in total profits reported abroad equals the amount of profit shifted from the US by the US parent. Differentiating the expression for the fraction of income shifted holding the tax haven tax rate constant yields

$$dm_{USP} = \frac{d\Pi_{USP}}{\Pi_{USP}} - \frac{1}{\beta_{PS}} d(\tau_{FSK} - \tau_{TH}) = \frac{1}{\beta_{PS}} d\tau_{FSK}.$$ 

This in turn implies

$$\left(\frac{\Pi_{USS}}{\Pi_{USP}}\right) \frac{d\Pi_{USP}}{\Pi_{USS}} = \frac{1}{\beta_{PS}} d(\tau_{FSK} - \tau_{TH}) = \frac{1}{\beta_{PS}} d\tau_{FSK},$$

so that the profit shifting tax semi-elasticity is the term in brackets, or

$$\eta_{PS} = \frac{1}{\beta_{PS}} \left(\frac{1}{\Pi_{USS}/\Pi_{USP}}\right).$$

Note that since $\Pi_{USS}/\Pi_{USP}$ will increase as the tax differential narrows, the profit shifting tax semi-elasticity is not constant in our formulation but instead declines as the tax differential is
reduced – an implication of the expression for the optimal fraction of shifting $m^{USP}$ defined above.

We turn next to the allocation of $FSK$ by the US multinational (the treatment of the RW multinational is analogous). We adopt a constant elasticity portfolio approach that is generally similar to that used by Bettendorf, Devereux, van der Horst, Loretz, and de Mooij (2010) and by Gravelle and Smetters (2006), modified to take into account the shifting of $FSK$ profits. To begin, consider the allocation of the total supply of $FSK$ owned by the US-MNC, $FSK^{UST}$, neglecting considerations of income shifting for the time being and denoting foreign variables with an asterisk to clarify the exposition. We assume the ratio of $FSK$ abroad, $*FSK^{US} = FSK^{USS}$, to $FSK$ in the United States, $FSK^{US} = FSK^{USP}$, is a constant elasticity ($\varepsilon_{FSK}$) function of the relative after-tax rates of return to $FSK$ in the two locations, or,

$$\frac{*FSK^{US}}{FSK^{UST} - *FSK^{US}} = \frac{FSK^{US}}{FSK^{US}} = A^{FSK} \left[ \frac{\pi_{FSK} (1 - *\tau_{FSK})}{\pi_{FSK} (1 - \tau_{FSK})} \right]^{\varepsilon_{FSK}},$$

where $A^{FSK}$ is a constant that is determined in the initial allocation of $FSK$, and $*\tau_{FSK}$, the effective tax rate on $FSK$ invested abroad, includes the actual foreign taxes paid, any current and deferred future residual US tax paid on repatriated income, and the additional costs of deferring repatriation (discussed below). This formulation implies

$$*FSK^{US} = \frac{A^{FSK} \left[ \frac{\pi_{FSK} (1 - *\tau_{FSK})}{\pi_{FSK} (1 - \tau_{FSK})} \right]^{\varepsilon_{FSK}}}{1 + A^{FSK} \left[ \frac{\pi_{FSK} (1 - *\tau_{FSK})}{\pi_{FSK} (1 - \tau_{FSK})} \right]^{\varepsilon_{FSK}}} FSK^{UST}.$$

We then modify this expression to take into account the effects of income shifting which, as discussed previously, reduce the extent to which a relatively high tax rate in the US
discourages investment in FSK by a multinational since it knows that a fraction \( m^{USP} \) of the before-tax income earned by FSK can be shifted abroad; we assume that this income is taxed at an average rate of \( \tau_{FSK} \). Incorporating income shifting, the expressions for allocating FSK become

\[
FSK^{US} = \frac{A^{FSK} \left[ \frac{\pi^{FSK} (1 - \frac{\tau_{FSK}}{FSK})}{\pi^{FSK} (1 - m^{USP}) (1 - \tau_{FSK}) + m^{USP} (1 - \frac{\tau_{FSK}}{FSK})} \right] \tau_{FSK}}{1 + A^{FSK} \left[ \frac{\pi^{FSK} (1 - \frac{\tau_{FSK}}{FSK})}{\pi^{FSK} (1 - m^{USP}) (1 - \tau_{FSK}) + m^{USP} (1 - \frac{\tau_{FSK}}{FSK})} \right] \tau_{FSK}},
\]

where, given the period structure of our model, the tax and income shifting terms in these FSK allocation equations are lagged one period. The allocation of FSK owned by the RW-MNC is determined analogously. Finally, because existing allocations of FSK are also not likely to be reversed immediately after the enactment of a rate reduction in the United States, we phase in this reallocation response over \( d_{s}^{FSK} \) years.

Given this allocation across the US and RW of the quasi-fixed factor FSK, each MNC then purchases ordinary capital and labor to produce output; that is, the allocation of FSK determines the location of production, and local inputs are purchased to produce output according to a Cobb-Douglas production function. Specifically, the fixed allocation of FSK is combined with (1) a domestic composite variable factor \( (KEL^{M}) \), which is also a Cobb-Douglas function of the ordinary capital \( (K^{M}) \) and effective labor \( (EL^{M}) \) employed in the multinational (M) corporate sector, and (2) an intermediate good \( (IG^{M}) \) purchased from the firm’s foreign affiliate. This production function provides considerable flexibility in characterizing the production of parent firms and subsidiaries of US and foreign MNCs, and the interactions between the various entities. For example, for the US parent firm, production of the intermediate good can reflect the
additional use of domestic US labor and capital required to support additional investment in RW by US-MNCs, a benefit of foreign direct investment by US firms stressed by Desai, Foley, and Hines (2009). At the same time, for the US-MNC parent firm, the intermediate good allows outsourcing to the foreign subsidiary of some of the production process. The same relationships hold for the RW-MNC. The derivation of the profit-maximizing input demands of the MNCs is provided in Appendix section A.2.

The next critical issue is the effect on income shifting of reductions in the US CIT rate. In the initial equilibrium, the total amount of income shifting from the US is determined by the difference between the US rate and the average effective tax rate in a typical tax haven, that is,

$$m^{USP} = \frac{\Pi^{USP/S}}{\Pi^{USP}} = \frac{1}{\beta^P} \left( \tau_{FSK} - \tau_{TH} \right).$$

A reduction in the US CIT rate would be expected to reverse such income shifting, but the magnitude of the response is unclear. We assume that income shifting and its reversal are symmetric, that is, we assume that the reversal of income shifting in response to a reduction in the US CIT rate is determined by this same expression, which is assumed to hold for all values of $$\tau_{FSK}^0 < \tau_{FSK} < \tau_{TH}$$; recall that we assume that the tax haven rate is fixed and includes actual foreign taxes paid (if any) plus the present value of the costs of deferral and the administrative costs of operating the tax shelter. This implies that income shifting declines proportionately with the size of the tax differential and that income shifting would be fully reversed if the US rate and the average effective tax haven rate were equal (we assume that the US CIT rate never falls below the average effective tax haven rate). Finally, existing income shifting arrangements are not likely to be reversed immediately after enactment of a rate reduction in the U.S. Accordingly,
we assume this reversal (including less new income shifting) will be phased in uniformly over a period of \( d_{RPS} \) years.

The income shifting parameter for the RW-MNC subsidiary located in the US is defined analogously. Thus reductions in the US CIT rate also result in a reversal of income shifting from the US to RW by the RW-MNC subsidiary.

2. Parameterization of the MNC Component of the Model

Because the operation of the MNC component of the model, especially its income shifting and FSK reallocation features, is a critical factor in the simulation results, we discuss the parameterization of the MNC sector at some length. In the initial equilibrium \((s=0)\), the tax rate applied to FSK earnings in the US, \( \tau_{0}^{FSK} \), is the combined federal and state statutory tax rate in the US, which in 2008 was \( \tau_{0}^{FSK} = 0.396 \). The average effective total tax rate applied to FSK earnings in RW, \( \tau_{0}^{FSK} \), is comprised of two components. The first is the actual average foreign tax rate paid abroad which, according to SOI data for 2008, was about 20 percent. The second is the total residual tax paid in the US when income is earned abroad, which includes the present value of any current and future taxes paid as well as the additional costs associated with tax-induced deferral. Grubert and Altshuler (GA) (2013) estimate this combined burden to be as high as 7 percent of before-tax profits for MNCs that have large stocks of unrepatriated profits; in their simulations, they use a 5 percent figure for investments in a low-tax tax haven and a 1 percent figure for investments in relatively high tax locations. In our simulations, we assume that the average residual US tax on actual repatriated dividends, taking into account both the costs of deferral and any future taxes, is 4 percent, roughly in the middle of the values noted above.

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7 See Desai, Foley and Hines (2004) for a discussion of the magnitude of the present value of these future payments, which were ignored in some earlier studies on the grounds that such repatriation is likely to be deferred for a long time (perhaps indefinitely, especially if additional foreign investment is attractive) and firms can find ways to finance their domestic investment needs without incurring any US tax liability due to the tax on repatriations.
Using 2008 SOI data on the residual taxes paid by US MNCs on all repatriated dividends (including those taxed under Subpart F), we estimate that the overall effective residual US tax rate on foreign earnings is 3.25 percent, which implies $*\tau_{0}^{FSK} = 0.2325$ in the initial equilibrium, so that the initial tax rate differential applicable to decisions regarding the allocation of $FSK$ is $\tau_{0}^{FSK} - *\tau_{0}^{FSK} = 0.396 - 0.2325 = 0.1635$.

With respect to $m_{0}^{USP}$, Clausing (2011) estimates that the fraction of US-MNC corporate profits that is shifted abroad, expressed as a percentage of the current level of corporate profits (after profit shifting), lies between 19–30 percent; the latter figure is her preferred estimate. More recently, Clausing (2015) estimates this fraction as between 32–46 percent in 2012. However, other studies suggest a lower range of 13–20 percent; these include Christian and Schultz (2005), Sullivan (2004), Avi-Yonah and Clausing (2008), Dyreng and Markle (2013), and Zucman (2014). It should be noted, however, that Dyreng and Markle note that because their sample size is considerably smaller than that analyzed by Clausing, “the estimates may not be as inconsistent as they originally appear” Dyreng and Markle (2013, p. 33).

Given this wide range of estimates, we consider two cases in our simulations. For our benchmark case, we assume that $\left[ m_{0}^{USP} / (1-m_{0}^{USP}) \right] = 0.20$ or $m_{0}^{USP} = 0.167$. However, in our sensitivity analysis, we also consider a “higher income shifting” case as suggested by the work of Clausing, in which case we assume that $\left[ m_{0}^{USP} / (1-m_{0}^{USP}) \right] = 0.30$ or $m_{0}^{USP} = 0.231$. As noted above, in the initial equilibrium, the combined state and local corporate tax rate in the US is 0.396. For the tax haven rate, we follow GA in assuming that the combined effective tax rate in

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8 Note that our income shifting ratio parameter, $m^{USP}$, is expressed as a fraction of total profits before shifting. Thus, Clausing’s 30 percent income shifting figure corresponds to $m^{USP} = 0.3 / (1.3) = 0.23$, and her 19 percent figure corresponds to $m^{USP} = 0.19 / (1.19) = 0.16$. In addition, 10 percent income shifting corresponds to $m^{USP} = 0.1 / (1.1) = 0.09$. 
the tax haven, in this case reflecting actual taxes paid plus administrative costs, is on the order of 7 percent; thus, $\tau^{TH} = 0.07$ and in the initial equilibrium $\tau^{FSK}_0 - \tau^{TH}_0 = 0.396 - 0.07 = 0.326$. Given this tax rate differential, the marginal cost of income shifting parameter is $\beta^{PS} = (\tau^{FSK} - \tau^{TH}) / m^{USP} = 0.326 / 0.167 = 1.96$ in the benchmark case and $\beta^{PS} = 0.326 / 0.231 = 1.41$ in the high-shifting case. These parameters imply profit shifting costs per unit of profit of $c^{PS} = (\beta^{PS} / 2)(m^{USP})^2 = (1.96 / 2)(0.167)^2 = 0.0273$ and $c^{PS} = (\beta^{PS} / 2)(m^{USP})^2 = (1.41 / 2)(0.231)^2 = 0.0376$, respectively. The profit shifting parameters and the profit shifting cost function for the RW subsidiary in the US are determined analogously. Note that each of these terms is subtracted from the appropriate MNC corporate tax base under the assumption that the costs of engaging in profit shifting are fully deductible. We assume that any reform-induced reversal of profit shifting is phased in over three years, or $d^{FSK}_t = 3$.

Finally, as described above, the estimates of the costs of adjustment parameter $\beta^{PS}$ can be related to empirical estimates of the tax semi-elasticity of profit shifting, $\eta^{PS}$. This literature provides a fairly wide range of estimates. For example, de Mooij (2005) surveys several studies of tax-motivated profit shifting, and concludes that a consensus estimate of the profit shifting tax semi-elasticity is $\eta^{PS} = 2.0$, although Bartlesman and Beetsma (2004) (and subsequently, Clausing (2011)) estimate semi-elasticities in excess of 3 and Clausing (2015) estimates semi-elasticities that range from 1.85 to 4.7, with an average semi-elasticity of 2.92. Dowd, Landefeld, and Moore (2014) use what Clausing (2015, p. 4) describes as “nearly ideal data” to examine income shifting by US multinationals. Specifically, Dowd, Landefeld, and Moore use SOI data for US firms only and estimate a tax semi-elasticity of profit shifting with respect to statutory tax rates of 1.6. They also estimate a tax semi-elasticity of 0.6 with respect to average effective tax
rates and note that the responsiveness of profit shifting is much greater for large tax differentials (e.g., between the US rate and the tax haven rate),\(^9\) concluding that “any US tax reform with a reduction in the corporate tax rate would result in profit shifting back to the US, but largely from very low tax jurisdictions (Dowd, Landefeld, and Moore, 2014), p. 22)).”\(^10\) On the other hand, in a recent survey, Heckemeyer and Overesch (2013) arrive at a significantly smaller consensus estimate of \(\eta_{PS} = 0.8\); they also note that the estimated tax responsiveness for US multinationals is smaller than for firms based in other countries. Additional evidence provided by Dharmapala and Reidel (2013) also suggests that the amount of profit shifting currently occurring is considerably smaller than that suggested by the larger estimates noted above. However, Clausing (2015) stresses that Dharmapala and Reidel and almost all of the studies surveyed by Heckemeyer and Overesch are based on financial statement data that includes few observations for tax haven countries, and the data that are available for tax havens are often incomplete and are thus not well-suited to analyzing income shifting, much of which occurs to tax havens; she concludes that these data neglect “the very observations that are driving the profit shifting phenomenon, affiliates operating in tax havens” (Clausing, 2015, p. 8). She also stresses that such low estimates of the profit shifting semi-elasticity are inconsistent with the large amounts of profits reported by US multinationals in tax haven countries; for example, she notes that seven tax havens with effective tax rates less than 5 percent account for 50 percent of all foreign income earned by the affiliates of US multinationals.

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\(^9\) They show that if the approximately 10% of countries that are tax havens are dropped from the sample, the estimated tax semi-elasticity drops significantly and is statistically indistinguishable from zero.

\(^10\) Clausing (2015) reports that she found similar non-linearities in her data, although she focuses on the linear case.
Our estimates for \( \beta^{PS} \) imply profit shifting semi-elasticities of

\[ \eta^{PS} = 1 / \left[ \beta^{PS} \left( \Pi^{US} / \Pi^{USP} \right) \right] = 1 / [(1.62)(0.25)] = 2.5 \]

in the benchmark case evaluated at the initial equilibrium, and

\[ \eta^{PS} = 1 / [(1.41)(0.25)] = 2.9 \]

in the high-shifting case, which is of course higher but still less than the values estimated by Bartlesman and Beetsma (2004) and Clausing (2011).

C. International Flows of “Ordinary” Capital Earning Normal Returns

As described above, the model assumes that firm-specific capital FSK is highly mobile. However, as stressed by Becker and Fuest (2011), different types of capital are likely to have different degrees of mobility. We model this by assuming that the capital that earns normal returns in the model \((K)\) is less mobile than FSK. Specifically, we also use a portfolio elasticity approach to modeling the mobility of ordinary capital. For example, consider the allocation of the fixed total stock of ordinary capital owned by foreigners, \(K^{RWT}\). We assume the ratio of the foreign stock of ordinary capital, \(K^F\), to exports of ordinary capital to the US, i.e., US capital imports, \(K^{IMP}\), is determined by a constant portfolio elasticity, \(\varepsilon^K\), response to relative returns to ordinary capital, after corporate taxes, in RW and the US, \(*r / r\), or

\[
\frac{K^{RWT} - K^{IMP}}{K^{IMP}} = \frac{K^F}{K^{IMP}} = A^K (*r / r)^{\varepsilon^K},
\]

where \(A^K\) is a constant determined in the calibration of the initial equilibrium. This yields an allocation of ordinary capital of

\[
\frac{K^{RWT} - K^{IMP}}{K^{IMP}} = \frac{K^F}{K^{IMP}} = A^K (*r / r)^{\varepsilon^K},
\]

\[
K^{IMP} = \left[ \frac{1}{1 + A^K (*r / r)^{\varepsilon^K}} \right] K^{RWT},
\]

\[
K^F = K^{RWT} - K^{IMP}.
\]
where, analogous to the case of $FSK$ above, the rates of return are lagged one period.

The fixed stock of foreign capital $K^{RWT}$ is thus used either by the RW-MNC parent, the US-MNC subsidiary, or for exports of capital to the US. In addition, the model assumes that the supply of labor to the MNC sector in RW is perfectly elastic at a fixed wage $w^{RW}$. The price and allocation of capital that earns ordinary returns and the supply and allocation of labor across the foreign multinational parent and the US subsidiary assume perfectly mobility within RW and are determined endogenously as described in Appendix section A.3.

Foreign residents thus earn income as returns to their ordinary capital invested in the MNC sectors in RW and in the US, from labor in the MNC sector in RW, and from the fixed total stock of RW-MNC $FSK$ that is allocated across the US and RW. This income is spent on non-exported domestic production or imports of the M-sector consumption good.

Gravelle and Smetters (2006) review the literature estimating the capital portfolio elasticity and argue that it suggests an aggregate value of around 3.0. Although $FSK$ is assumed to be highly mobile in the model, it is unclear how quickly $FSK$ that has moved abroad would return to the US in response to a reform that would result in a CIT rate in the neighborhood of 25 percent. Accordingly, we are fairly conservative in assuming a value of $\varepsilon^{FSK} = 3.0$ for firm-specific capital, and a value of $\varepsilon^K = 0.5$ for relatively immobile ordinary capital.

D. REPATRIATION OF FUNDS FROM THE US SUBSIDIARY TO THE US PARENT

A much debated issue is the extent to which CIT reform in the US, especially if it involves a move to a territorial system, might affect the repatriation of funds by US subsidiaries to their parent firms in the US. Two flows of repatriated funds must be determined—the fraction of current earnings that is repatriated in each period, and the fraction of the existing large stock of unrepatriated profits that would be repatriated in response to the enactment of a territorial
system. We describe our modeling of these two repatriation decisions in the following two sections.

1. The Flow of Repatriated Profits

Consider first the repatriation of current-year earnings by the US foreign subsidiary to its US parent. We assume that there are two sources of income subject to a repatriation decision by the US subsidiary: (1) the returns to firm-specific capital invested abroad, (2) the income that arises due to income shifting from the US parent to its foreign subsidiary of the returns to firm-specific capital invested in the US. Payments for intermediate goods, including royalties, are fully repatriated. In addition, in order to simplify the analysis, we assume that returns to US-owned ordinary capital that is invested abroad are always repatriated, as are all returns earned by the US subsidiaries of foreign multinationals, all returns earned by foreign-owned ordinary capital located in the US, all payments for the transfers of intermediate goods purchased by the US parent from its foreign subsidiary, and all payments for the transfers of intermediate goods between RW parents and their subsidiaries. We calibrate the model so that the total level of repatriations from the two sources identified abroad reflects the observed level; in a steady state equilibrium, the stock of unrepatriated profits must then be consistent with that flow.

Under these circumstances, total current income subject to a repatriation decision in period $s$ is

$$Y_{s}^{rep} = (1 - \tau_{s}^{FSK} FSK_{s}^{RW} FSK_{s}^{US} m_{s}^{USP} FSK_{s}^{US}),$$

where the terms on the right side of the equation correspond to the two items listed above. This income available for repatriation is divided into two flows, repatriations to the US parent, $Y_{s}^{rep}$, and unrepatriated profits, $Y_{s}^{unrep}$; the latter is added to $K_{s}^{unrep}$, which is the stock of unrepatriated
profits invested in ordinary capital abroad that earns the normal return \( r_s \). The fraction of the total income available for repatriation that is actually repatriated to the US parent in period \( s \) is denoted \( \zeta_s \); thus, \( Y_s^{\text{rep}} = \zeta_s Y_s^{\text{repavl}} \). and \( Y_s^{\text{unrep}} = (1 - \zeta_s)Y_s^{\text{repavl}} = \zeta_s^{\text{unrep}} Y_s^{\text{repavl}} \), with \( \zeta_s^{\text{unrep}} = 1 - \zeta_s \). and, since \( Y_s^{\text{unrep}} \) is added to the stock of unrepatriated profits in each period,

\[
K_{s+1}^{\text{unrep}} = K_s^{\text{unrep}} + Y_s^{\text{unrep}} = K_s^{\text{unrep}} + \zeta_s^{\text{unrep}} Y_s^{\text{repavl}}.
\]

Following GA, we assume that US MNCs incur costs when they do not repatriate funds to avoid paying US tax. These costs might arise, for example, if the US-MNC avoids the repatriation tax by financing desired domestic investment with additional domestic debt rather than repatriated profits (implicitly using the unrepatriated profits as collateral), but this increases the debt-asset ratio above the optimal level and thus increases borrowing costs (as described below). Alternatively, the unrepatriated funds may be invested in relatively low-yield assets.

Again following GA, we assume that these costs, per unit of \( Y_s^{\text{repavl}} \), are a quadratic function of the existing stock of unrepatriated profits, relative to current income, or

\[
\phi_s^{\text{unrep}} = \frac{\beta_s^{\text{unrep}}}{2} \left[ \frac{K_s^{\text{unrep}}}{Y_s^{\text{repavl}}} / \bar{n} \right]^2, \quad \bar{n} = n + g + ng,
\]

where \( \bar{n} \) is the sum of the population and productivity growth rates. The total excess costs of not repatriating are thus

\[
TC_s^{\text{unrep}} = \phi_s^{\text{unrep}} Y_s^{\text{repavl}}
\]

and the marginal cost with respect to an increase in \( Y_s^{\text{unrep}} \), which equals the change in the stock of unrepatriated profits, is

\[
MC_s^{\text{unrep}} = \beta^{\text{unrep}} (K_s^{\text{unrep}} / Y_s^{\text{repavl}})(\bar{n})^2.
\]

---

11 Thus, even if unrepatriated funds are in reality initially invested in cash assets, we assume those funds are in turn invested in ordinary capital abroad.
We assume that the level of current repatriations always corresponds to the steady state level associated with the current tax structure, and adjust the stock of repatriations as described below. In a steady state, $K_{s}^{unrep} = Y_{s}^{unrep} / \bar{n}$, in which case

$$\phi_{s}^{unrep} = \frac{\beta_{s}^{unrep}}{2} \left( \frac{Y_{s}^{unrep}}{Y_{s}^{repav}} \right)^{2} = (\beta_{s}^{unrep} / 2)(\bar{\zeta_{s}^{unrep}})^{2}.$$  

The US-MNC is assumed to choose an optimal $Y_{s}^{unrep}$ that balances the benefit of not repatriating profits (permanently in the steady state equilibrium) against its costs. The benefit of not repatriating $Y_{s}^{unrep}$ is the tax avoided, $\tau_{s}^{rep} Y_{s}^{unrep}$, where $\tau_{s}^{rep}$ is the residual US tax rate applied to repatriations, while the cost of not repatriating $Y_{s}^{unrep}$ is $(\beta_{s}^{unrep} / 2)\left[ (K_{s}^{unrep}) / (Y_{s}^{repav} / \bar{n}) \right]^{2} Y_{s}^{repav}$. Thus, the optimal $Y_{s}^{unrep}$ is determined from the following expression (the first-order condition for choosing $Y_{s}^{unrep}$ to maximize the difference between these two terms)

$$\tau_{s}^{rep} = \beta_{s}^{unrep} \left( K_{s}^{unrep} / Y_{s}^{repav} \right)(\bar{n})^{2}.$$  

Thus, at the optimum, the marginal cost of increasing repatriations by a dollar (the differential tax on repatriations) equals the marginal cost of increasing the stock of unrepatriated profits by a dollar; note that, as in GA, the marginal cost of not repatriating increases linearly with the stock of unrepatriated profits relative to current income. Assuming the level of repatriation reflects a steady state equilibrium, this expression can be rewritten as

$$\tau_{s}^{rep} = \beta_{s}^{unrep} \left[ (Y_{s}^{unrep} / \bar{n}) / Y_{s}^{repav} \right](\bar{n})^{2} = \beta_{s}^{unrep} (\bar{n}) \left( Y_{s}^{unrep} / Y_{s}^{repav} \right) = \beta_{s}^{unrep} (\bar{n}) \bar{\zeta_{s}^{unrep}}$$  

which implies that $\bar{\zeta_{s}^{unrep}}$, the optimal fraction of repatriated profits, is
\[ \zeta_{s}^{\text{unrep}} = \frac{Y_{s}^{\text{unrep}}}{Y_{s}^{\text{repav}}} = \left[ \frac{1}{\beta_{s}^{\text{unrep}}(\tilde{n})} \right] (\tau_{s}^{\text{rep}}) = \eta_{s}^{\text{unrep}} (\tau_{s}^{\text{rep}}), \]

where

\[ \eta_{s}^{\text{unrep}} = \left[ \frac{1}{\beta_{s}^{\text{unrep}}(\tilde{n})} \right] \]

is the tax semi-elasticity of the fraction of available funds that is not repatriated, and indicates that a higher repatriation tax rate in the US results in more funds not being repatriated and thus a larger stock of unrepatriated profits.

We use 2008 data, the latest available, to determine the flows of repatriated profits. However, there has been rapid recent growth in the stock of unrepatriated profits which, given our cost of deferral function described above, implies an increase in the excess costs of not repatriating. Accordingly, in order to better model the effects of implementing a territorial system in the current environment, we superimpose on this initial equilibrium an approximation to the current level of unrepatriated profits, \( K_{0}^{\text{unrep}} \), which has recently been estimated to equal $1.9 trillion. Given our steady state growth rate of \( \tilde{n} = 0.034 \), this necessarily implies annual unrepatriated profits \( Y_{0}^{\text{unrep}} \) of $66 billion\(^{12}\) and \( \zeta_{0}^{\text{unrep}} = 0.134 \) in the initial equilibrium. In addition, we need an estimate of the excess costs of deferring unrepatriated profits.

A large literature examines the cost of deferral. Early estimates suggested that this cost is fairly small, on the order of 1-2 percent of foreign income (Grubert and Mutti, 2001; Desai, Foley and Hines, 2001; Grubert and Altshuler, 2008). However, the significant increase in repatriations attributable to the 2005 repatriation holiday that allowed US MNCs to repatriate certain dividends subject to a 5.25 percent tax rate (before foreign tax credits) suggests that these

\(^{12}\) Although considerably smaller than actual unrepatriated profits, a larger flow would require a much larger stock in equilibrium, so we strike the compromise indicated in the text. Difficulty in matching actual stocks and flows is an issue that arises in many contexts in the calibration of a CGE model.
estimates may have understated the excess burdens associated with unrepatriated profits. Redmiles (2008) estimates that companies that repatriated under the tax holiday paid an average residual tax after foreign tax credits of 3.6 percent, suggesting that they were willing to pay at least that amount to avoid both actual and implicit future costs associated with deferring repatriation.

In their most recent work, GA stress that the marginal costs of accumulating deferrals is likely to increase as the size of unrepatriated profits increases, a proposition they confirm with an empirical analysis. Their estimates suggest that the combined marginal burden on deferrals (future taxes paid when the funds are eventually repatriated plus the present value of the cost of deferral until that time) may be as large as 7 percent of before-tax income for investments in low-tax countries by 2015. In their simulations, they assume combined (residual tax after foreign tax credits plus additional cost of deferral) burdens of 5 percent for low-tax countries and 1 percent for high-tax countries. Although all of these estimates are obviously very rough and it is difficult to determine an appropriate average value, we assume that the burden on unrepatriated profits is 4 percent, which is within the range of results described above and only slightly higher than the estimate of Redmiles. GA argue that the future taxes component of this figure is likely to be very small; accordingly, we assume that in the initial equilibrium \( \tau_{0}^{unrep} = 0.005 \) and that the remainder of the total burden on unrepatriated funds, the marginal cost of additional repatriations, is \( \beta^{unrep}(K_{0}^{unrep} / Y_{0}^{repavd})(\bar{\eta})^2 = \beta^{unrep}(\zeta_{0}^{unrep})(\bar{\eta}) = 0.035 \).

We model the tax rate on repatriations as a weighted average of the residual US tax rates after foreign tax credits applied to (1) actual repatriated dividends (which is 4 percent), (2) “deemed” repatriations or Subpart-F income, and (3) oil and gas and branch income that is always repatriated. With respect to deemed paid dividends, SOI data indicate that the ratio of the
gross-up to grossed-up dividends that were deemed paid under the Subpart-F rules was 23.4 percent in 2008, implying a residual US tax rate after foreign tax credits on deemed paid dividends of 11.6 percent. We estimate that the residual US tax rate applied to oil and gas and branch income in 2008 was 1.4 percent. The weighted average tax rate on all repatriated funds was 3.25 percent, that is $\tau^{\text{rep}}_0 = 0.0325$.\(^\text{13}\)

In the case of CIT reforms that maintain the existing worldwide system with respect to international tax provisions, we simply assume that the residual US tax rates on repatriations after foreign tax credits decline proportionately to the CIT rate reduction in the US.

In the case of reforms that involve a movement to a territorial tax system, the tax rate parameters would depend on the details of the proposed system. For example, the Camp proposal provides for a 95 percent dividends received deduction and a 25 percent US corporate income tax rate, which we model as a US residual tax rate on repatriated dividends of 1.25 percent; in addition, we assume that the present value of future residual US taxes on profits that are not repatriated drops to $\tau^{\text{unrep}} = 0.0025$. We assume that anti-tax-base erosion provisions are enacted that are sufficiently effective that changes in the allocation of FSK and changes in income shifting in response to changes in effective tax rates across the US and RW are consistent with those that would have occurred prior to the enactment of reform.

This implies that moving to a territorial tax system would increase the flow of total (actual and deemed) repatriated dividends by roughly 13.5 percent, which is almost identical to the most direct, although somewhat dated, evidence in the literature, which is provided by Desai,

\(^{13}\) SOI data for 2008 indicate that actual repatriated dividends (exclusive of the gross-up) were 22.0 percent of realized foreign-source taxable income. In addition deemed-paid dividends (subpart-F income), which we also treat as repatriated, were 16.2 percent of realized foreign-source taxable income.
Foley and Hines (2001) who estimate that a move to a territorial tax system would increase repatriations by 12.8 percent (although the Desai-Foley-Hines estimate assumes complete (rather than 95 percent) exemption). However, Gravelle (2012) notes that this figure is calculated on a relatively low base of repatriations, and argues that the increased amount of repatriations might be larger by roughly two-thirds with a more typical level of repatriations. More generally, Gravelle argues that on average about 60 percent of foreign source income is needed for replacement investment and to keep the capital stock growing at a steady state growth rate, so that one might expect about a long run repatriation rate of around 40 percent – which would imply an increase in repatriations of about 20 percent relative to current levels. She notes that average repatriation rate was 40 percent between 1968–2008, but was only about 20 percent for the last nine years of this period (2000–2008), and argues that some of the increase in retentions may be attributable to anticipation of another tax holiday or a move to a territorial system.

Gravelle also cites preliminary empirical evidence on the effects of the adoption of a territorial system in Japan, where repatriation rates increased significantly in the first two years after reform, presumably reflecting the return of some of the stock of unrepatriated profits, but then declined to an increase of about 21 percent in the third year after reform, and in the UK, where a preliminary estimate suggests that repatriations increased by roughly 6 percent of foreign income, both roughly two-thirds greater the increase in repatriations estimated by Desai-Foley-Hines and our 13.5 percent figure calculated above. This increase in the flow of repatriated dividends is equivalent to a 32.1 percent reduction in the flow of unrepatriated dividends $Y_{t}^{unrep}$.

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14 Note that a further complication is that under the so-called “new view” of dividend taxation as applied to international investment (Hartman, 1985), a permanent change in the repatriation tax rate should have no effect on repatriations for mature subsidiaries financing new investment from retained earnings.
and thus an equivalent reduction in the stock of unrepatriated profits $K_{unrep}$. We turn next to a discussion of the effects of this drop in $K_{unrep}$.

2. The Stock of Unrepatriated Profits

The second issue is the modeling of the fraction of the existing large stock of unrepatriated profits that is repatriated in response to the enactment of a territorial system. This stock has grown very rapidly in recent years — Tyson, Serwin, and Drabkin (2011) note that the stock of permanently reinvested earnings or PRE has increased by an average of 15.7 percent per year over the period 1999–2010, despite the effects of the temporary repatriation tax holiday enacted under the American Jobs Creation Act (AJCA) in 2004.

For the tax reform proposal that includes a move to a territorial system, we assume the proposals include the provision in the Camp discussion draft that imposes a one-time lump sum tax at a rate of 5.25 percent (15 percent of the initial tax rate of 35 percent) on the stock of unrepatriated profits that do not reflect previously taxed earnings, which can be paid in installments over an eight-year period, regardless of whether the funds are repatriated. In addition, all repatriations, even of previously taxed earnings, would be subject to the 1.25% residual US tax on repatriations. We also take into account the thin capitalization rules proposed in the Camp discussion draft, and the fact that royalties would no longer be shielded from tax with excess foreign tax credits; we do not, however, attempt to model the changes in available FTCs that might arise, depending on the details of the proposal — for example if expense allocation would no longer be allowed for purposes of calculating foreign tax credits for subpart-F income.15

15 In making these adjustments, however, we do not take into account any behavioral adjustments. Grubert (2001) finds that the revenue effects associated with the behavioral responses to the implementation of a territorial system are roughly offsetting; revenues decline as firms convert royalty payments that can no longer be shielded from tax
A move to a territorial system would encourage repatriation of this stock of unrepatriated funds. Blouin, Kroll and Robinson (2012) report that aggregate PRE was $882 billion in 2008, up from $206 billion in 1998, increasing dramatically after the temporary repatriation tax holiday enacted under the American Jobs Creation Act (AJCA) in 2004, perhaps in anticipation of another tax holiday or a move to a territorial tax system. Current estimates suggest that this stock is in the neighborhood of $1.9 trillion. In the model, the fraction of the stock of unrepatriated funds that is repatriated with a move to territorial is largely determined by the change in the level of repatriations, since the stock of unrepatriated profits must be consistent with the flow. Preliminary results suggest that the change in the flow is such that most of the existing stock is eventually repatriated.

However, the enactment of a territorial system might also result in a large one-time increase in repatriations, and we include a rough estimate of the effects of such a repatriation. The disposition and effects of this one-time repatriation must be specified. Most of the evidence on this issue comes from analyses of the effects of the temporary reduction in the tax rate applied to repatriations from 35% to 5.25% passed in the Homeland Investment Act, which was part of the American Jobs Creation Act (AJCA) of 2004. In the most often cited study of the effects of this tax holiday, Dharmapala, Foley, and Forbes (2011) conclude that their best estimate is that a $1 increase in repatriations due to the tax holiday was associated with an increase of almost $1 in payouts to shareholders (a total payout of $0.92, consisting of $0.79 of increased share repurchases — a convenient and low-tax means of distributing funds from a one-time tax holiday — and $0.13 in additional dividends), and had no measurable impact on domestic investment, employment, R&D expenditures, or debt levels, even for a subset of firms that appeared to be financially constrained (using six different measures for the existence of such constraints) or for by excess foreign tax credits to exempt dividends, but revenues increase as debt with interest that is no longer deductible in the US is shifted abroad.
a subset of firms that lobbied for the tax holiday.\textsuperscript{16} They argue this shows that (1) the domestic operations of US MNCs were not financially constrained by holding unrepatriated profits abroad (they note that, in general, large MNCs are among the least likely firms to be financially constrained, although using more debt at home instead of repatriated funds may be costly), and (2) US-MNCs are well governed, as they had already taken advantage of profitable investments, so they simply returned the excess funds to shareholders via higher share repurchases or dividends rather than expending the funds on unprofitable capital investments or employment.\textsuperscript{17,18} Their result on the fraction of repatriated funds that is distributed to shareholders is not estimated precisely, however, as the range of results they obtain indicates that roughly between 60-92 percent of funds were distributed to shareholders.

The strong results obtained by Dharmapala, Foley, and Forbes are controversial. For example, several other studies suggest that some of the repatriated funds may have been used to pay down debt. Blouin and Krull (2009) estimate that only 50 percent of repatriated funds went to shareholders and note that some of the remaining funds may have gone to debt reduction. Brennan (2013) estimates that at most 52 percent of repatriated funds were distributed in 2005 (he notes that additional distributions may have occurred in subsequent years) and argues that the actual amount was less than 30 percent; however, his results indicate that net debt levels (combined over parents and subsidiaries) increased, rather than decreased, with additional repatriations (he attributes this result to firms using debt to finance additional repatriations).

\textsuperscript{16} Indeed, Dharmapala, Foley and Forbes find a significant amount of “round tripping,” as a subsample of firms that repatriated $259 billion during the tax holiday in 2005 simultaneously injected $104 billion of new funds into their foreign affiliates over 2004-2005, suggesting that they should not be categorized as financially constrained.

\textsuperscript{17} They also note that legal restrictions in the AJCA that precluded using repatriated funds for increases in share repurchases and dividends were thus not effective, but that restrictions on repatriations are nevertheless costly as the firms that repatriated the most were those that devoted the most resources to strategies that reduce repatriation taxes.

\textsuperscript{18} These results are largely consistent with the survey data reported by Graham, Hanlon, and Shevlin (2010).
Some of the repatriated funds also might have gone to additional investment. Clausing (2006) argues that the tax holiday was not likely to increase domestic investment by most firms, consistent with the results of Dharmapala, Foley, and Forbes (2011) described above. One possible exception is firms that were capital constrained prior to the tax holiday, as increased repatriations may cause such firms to increase investment to the extent that some investment projects are profitable when using lower cost internal funds, but not when financed with external sources. Faulkender and Petersen (2009) estimate that their sample of financially constrained firms increased investment (with no employment effects) by 11% – a result that is of course inconsistent with the analysis of financially constrained firms by Dharmapala, Foley, and Forbes (2011) described above.

To strike a compromise between these various results, we assume that 80 percent of any one-time reform-induced increase in repatriated funds is distributed to shareholders, who reinvest the after-tax proceeds in the same pattern as existed before the reform, and that firms use the remaining 20 percent to reduce their debt-asset ratio. We also take into account the additional personal income taxes paid on these redistributions, assuming, as estimated by Dharmapala, Foley, and Forbes, that 85 percent of these distributions take the form of lightly taxed share repurchases; specifically, we assume that dividends are taxed at the average dividend rate, and share repurchases are taxed at one-quarter the average capital gains tax rate, since only the gains component of share repurchases would be subject to tax (Poterba and Weisbenner, 2000). In our benchmark simulation, we assume that increased repatriations do not lead to any increase in investment. This is of course consistent with the results of Dharmapala, Foley, and Forbes discussed above.

A separate issue is whether the increased flow of dividends might result in an increase in consumption as posited by Tyson, Serwin, and Drabkin (2011). They note that such a response is
contrary to standard theory, which predicts that a repatriation of dividends would not change the mix of consumption and saving. The structure of our model is consistent with this theory, as shareholders use the repatriated funds to maintain the same investment portfolio and the same balance between saving and consumption as before the enactment of reform; we thus do not assume that the increase in repatriation would increase consumption. However, as Tyson, Serwin, and Drabkin (2011) note, there is some evidence that some of an unexpected increase in dividends may lead to additional current consumption. They estimate this one time increase in consumption (and reduction in the capital stock) to be fairly modest – between $25-$38 billion; moreover, in a general equilibrium context, the negative effects of the associated reduction in saving and investment would have to be included in the analysis.

E. Trade and the Balance of Payments

International trade is modeled as follows. Trade occurs in two types of goods, both of which are produced exclusively in the multinational M sector: a consumption good and the intermediate good \((IG)\) that is produced by an MNC in one country for use in the production of the M-sector good by its affiliated company in the other country. For example, the US-MNC produces an intermediate good that is used in the production of the M-sector good by its foreign subsidiary in RW; as noted above, the importance of such complementarity in production is stressed by Desai, Foley, and Hines (2006). In addition, there are two types of international capital flows: the flow of firm-specific capital \((FSK)\) between the parents and subsidiaries of both the US-MNC and the RW-MNC, and the flow of capital that earns ordinary returns \((K)\) in response to differentials across countries in the relative after-tax returns to such capital. The determination of the equilibrium in the model with these trade and capital flows is described as follows.
The worldwide allocations of FSK and $K$, and the demands for the intermediate good by both multinationals and subsidiaries were described above. Given these variables, the levels of US imports of the consumption good (which equal RW exports) and US exports of the consumption good (which equal RW imports) are determined from the balance of payments equations for the two countries; that is exports and imports of consumption goods are determined as residuals that satisfy the balance of payments constraints in the US and RW, given the international flows of the two types of capital and intermediate goods.

Specifically, the US balance of payments equation requires that the sum of the current account (the first term in braces below) and the capital account (the second term in braces below) equal zero. The current account, which reflects net cash inflows into the US, is defined as the sum of (1) exports less imports of both the traded M-sector consumption good and the intermediate good $IG$, plus (2) net foreign capital income into the US, that is, income earned by US residents on their existing foreign capital holdings – of both firm-specific capital (FSK) and ordinary capital ($K$), taking income shifting into account – less income earned by foreigners on their existing capital holdings in the US. In the initial equilibrium, we assume that in both the US and RW ownership of foreign capital occurs primarily through ownership of own-country-based MNCs. However, to examine the effects of flows of (relatively immobile) ordinary capital $K$ in and out of the US in response to changes in domestic CIT rates, we assume that some of the US capital stock is owned by foreigners, denoted as $K^{RWF} = K^{IMP}$, so that the total US capital stock ($K^T$) is owned by either US residents ($K^{US}$) or foreigners. US residents also earn capital income on their holdings of the stock of unrepatriated profits held abroad, $K^{unrep}$ which earns the ordinary rate of return abroad. The capital account, which reflects net new investment in the US, is defined as the difference between the increases in the stocks of both types of capital in the US.
owned by foreigners and increases in the stocks of both types of capital in the RW owned by US residents.

Thus, the balance of payments equation requires that in each period $s$,

\begin{equation}
0 = \left[ p_s^M X_{s}^{MUSEXP} - (p_s^M) M_{s}^{IMP} \right] + \left[ p_s^M (I_{s}^{USEXP} + I_{s}^{RWEXP}) - (p_s^M) (I_{s}^{USIMP} + I_{s}^{RWIMP}) \right] + \xi_s^{rep} \left[ (1 - \tau_{FSK}) \pi_s (F_{s}^{US}) + (1 - \tau_{FSK}) (m_{s}^{US}) (\pi_s) (F_{s}^{US}) \right] - \left[ (1 - \tau_{FSK}) (1 - m_{s}^{RWS}) (\pi_s) (F_{s}^{RW}) \right] + \left[ r_{s} K_{s}^{USF} - r_{s} K_{s}^{RWF} \right] + \Delta K_{s+1}^{RWF} + \Delta K_{s+1}^{USF} - \Delta K_{s+1}^{unrep},
\end{equation}

where $I_{s}^{USEXP} = I_{s}^{USSIMP}$, $I_{s}^{RWEXP} = I_{s}^{RWSIMP}$, $I_{s}^{USIMP} = I_{s}^{USSIMP}$, $I_{s}^{RWIMP} = I_{s}^{RWSIMP}$, $I_{s}^{RWEXP} = I_{s}^{RWSIMP}$,

where $I_{s}^{USEXP}$ is exports of the intermediate good to its foreign subsidiary by the US-MNC parent, $I_{s}^{USIMP}$ is imports of the intermediate good from its foreign subsidiary by the US-MNC parent, and the other IG terms are defined analogously, $r$ is the normal return to capital in the US, $r^*$ is the normal return to capital in RW, $\pi$ is the (total) above-normal before-tax returns earned by FSK in the US, and $\pi^*$ is the (total) above-normal before-tax returns earned by FSK in RW, $\pi^{FSKUS}$ is FSK invested in RW by the US-MNC, $\pi^{FSKUS}$ is FSK invested in the US by the RW-MNC, $\xi_s^{rep}$ is the fraction of US subsidiary after-tax profits, including shifted profits, that is repatriated (with the rest of these profits $\xi_s^{unrep} \left[ (1 - \tau_{FSK}) \pi_s (F_{s}^{US}) + (1 - \tau_{FSK}) (m_{s}^{US}) (\pi_s) (F_{s}^{US}) \right]$ added to the stock of unrepatriated profits $\Delta K_{s+1}^{unrep}$), $K_{s}^{RWF}$ is the foreign-owned capital that earns ordinary returns and
is invested in the US, and $K^{USF}$ is US-owned capital in RW. Note that the prices and rates of return in the balance of payments equation reflect the effects of income shifting.\footnote{Note that we consider only changes in FDI in our analysis (the capital account terms reflect only changes in FDI); that is we neglect changes in portfolio investment, assuming that asset ownership remains unchanged or alternatively exhibits no net change.}

Note that the balance of payment equation implies that income shifting has an important effect on the macroeconomic effects of the reform, including the change in GDP. In particular, the impact effect of income shifting on net exports is captured by the two terms

$$-\left \{ \left [ (1 - \tau) (m^{USP} (FSK^{US} s)) \right ] + \left [ (1 - \tau) (m^{RWS} (FSK^{RW} s)) \right ] \right \} \pi_s,$$

where the first term captures the reduction in net exports due to US parent income shifted abroad which becomes foreign-source income for US residents used to purchase additional US imports, and the second term reflects the reduction in net exports due to RW subsidiary income shifted abroad which results in a reduction in foreign-source income for RW residents that had been used to purchase US exports. Both of these effects of income shifting act to reduce net exports, so that when this income shifting is reduced by a BBRR reform in the US, net exports and thus GDP tend to increase by roughly the full after-tax amount of the reduction in income shifting. In addition, the tax component of the reduction in income shifting increases CIT revenues in the US, allowing a “costless” rate reduction, that is, a rate reduction that – in contrast to the other elements of the BBRR reform – is not offset by base-broadening measures that increase the cost of capital and thus have a negative effect on investment. Finally, GDP is also increased by the reduction in the costs of income shifting, which are initially on the order of 2-4% of the amount of income shifted.
V. OTHER EXTENSIONS OF THE DIAMOND-ZODROW MODEL

The current version of the Diamond-Zodrow model includes several additional extensions of the model described in Zodrow and Diamond (2013).

A. Variable Debt-Asset Ratio

In the basic DZ Model, the debt-asset ratio \( b \) is fixed. In this analysis, we extend the basic model to include a variable debt-asset ratio in order to capture the effects of corporate tax reforms on the degree of leverage in the economy, including both (1) the extent to which the deductibility of interest expense encourages the use of excessive leverage, and (2) the extent to which the decision to not repatriate earnings from a subsidiary to its parent results in the increased use of leverage by the parent firm. We also consider explicitly the costs imposed on firms due to the use of suboptimal amounts of leverage.

We add a variable debt-equity ratio to the basic model in the following fairly simple and straightforward way. In the absence of taxes, economic theory suggests that the optimal debt-asset ratio reflects a tradeoff between the benefits and costs of greater leverage. The benefits of greater leverage reflect the increased ability of shareholders to effectively monitor the managers of a corporation by forcing them to finance risky new investment with debt that must be obtained on private capital markets subject to investor scrutiny rather than with more easily accessible and lower cost retained earnings. Assuming that firm managers who face increased scrutiny from financial markets are more likely to forego projects with relatively low returns rather than more profitable investments, the benefits of increased monitoring are likely to be high initially, as relatively low return marginal investments are foregone, but will decline as the marginal investment that may be foregone becomes increasingly more profitable. The costs of increased leverage reflect a higher probability of incurring a costly bankruptcy. These costs would initially
be small at low debt-asset ratios, but would increase with increasing leverage. This model thus implies a unique optimal debt-asset ratio in the absence of taxes.

In the presence of the corporate income tax, leverage has the additional benefit of generating deductions for interest expense (in contrast to equity finance, where dividends paid to equity holders are not deductible), resulting in an inefficiently high level of debt. In a recent meta-analysis of 46 different studies of the responsiveness of the degree of leverage to the corporate income tax rate, Feld, Heckemeyer and Overesch (2011) conclude that a 10 percentage point increase in the CIT rate increases the debt to asset ratio by 3.0 percentage points. This is quite similar to the results obtained in the often-cited study by Gordon and Lee (2001), who analyze a large sample of U.S. firms and estimate that the analogous increase in the debt-asset ratio in response to a 10 percentage point increase in the CIT rate would be 3.6 percentage points. By comparison, the consensus estimate in the meta analysis of de Mooij (2011) suggests a ten percentage point CIT rate reduction would reduce the debt-asset ratio by 1.7 percentage points, but de Mooij notes that the more recent studies have found responses that were larger by about 50 percent. Accordingly, we use a value of $\eta_{\text{CIT}} = 0.25$ in our simulations, where $\eta_{\text{CIT}}$ is the change in the debt-asset ratio (measured in percentage points) in response to a change in CIT statutory tax rate (also measured in percentage points). In addition, as described above, we assume that under a territorial tax system 20 percent of the repatriation of the existing stock of unrepatriated profits goes to a one-time reduction in the debt-asset ratio, $\Delta b^{\text{terr}} < 0$.

Combining these two effects yields a debt-asset ratio in period $s$ of

$$b_s = b_0 + \eta_{\text{CIT}} \left( \tau_b - \tau_{b0} \right) + \Delta b^{\text{terr}},$$

where $b_0$ is the initial debt-asset ratio, $\tau_b$ is the current corporate income tax rate, $\tau_{b0}$ is the initial corporate income tax rate, and $\Delta b^{\text{terr}}$ is the one-time reduction in the debt-asset ratio due to repatriation.
where $\Delta b^{err} = 0$ if the worldwide international tax system is maintained. Assuming that these constant semi-elasticity relationships hold over the entire range of corporate tax rates, the optimal debt-asset ratio in the absence of taxes ($b^*$) would be

$$b^* = b_0 - \eta_{b\tau} \tau_{b0} + \Delta b^{err}.$$ 

At the optimal debt-asset ratio, the benefits of limiting managerial discretion just offset the costs of a higher risk of a costly bankruptcy; we do not model these benefits and costs explicitly. Instead, following Keuschnigg (2012), we assume that the total efficiency costs per unit of capital of increasing the debt-asset ratio, relative to the optimum – due either to the tax advantages of debt or because existing funds abroad are not repatriated to the U.S. – are a quadratic function of the difference between the actual and optimal degrees of leverage, or

$$\Phi_b(b) = (\beta_b / 2)(b - b^*)^2,$$

where the debt cost parameter $\beta_b$ reflects the marginal increase in the excessive debt cost function due to an increase in the level of debt. Thus, the total efficiency costs of excessive debt are $\Phi_b(b)p^K$, where $p^K$ is the value of the firm’s capital stock. Note, however, that when calculating total firm profits, the portion of these costs due to excessive debt attributable to maintaining unrepatriated profits abroad, which are considered separately in the analysis of repatriation decisions presented above, are subtracted to avoid double counting.

These efficiency costs reflect the loss in output that occurs due to excessive debt, for example, as the managers of the firm devote more time to dealing with avoiding or preparing for the possibility of a costly bankruptcy rather than to more productive activities. Reductions in the CIT rate and in the effective tax rate on repatriations thus reduce the debt-asset ratio toward the optimal level, and reduce the distortionary costs of excessive leverage due to the tax system. We set $\beta_{b} = 0.40$ which yields an estimate of the costs of excessive debt equal to 4.5 percent of
corporate revenues, a result that is consistent with Gravelle and Hungerford’s (2008) estimate of efficiency costs of somewhat under 5 percent of revenues.

B. Multiple Capital Assets (Ordinary Capital)

In the basic DZ Model, there is a single type of capital good that is used in all of the production sectors. We extend the model to include multiple capital assets (in addition to the firm-specific capital \( FSK \) described above) in each of the three non-residential sectors. (Owner and rental housing are assumed to use only structures capital; we do not model land explicitly, which is assumed to be included in structures capital.) In each of the nonresidential sectors, we define a composite capital good, made up of three capital types, with an analogously defined investment good. The general approach is described as follows.

Consider, for example, the competitive corporate (C) sector. Define \( I^c_s \) the investment in period \( s \) in a composite capital good in the C sector, and \( K^c_s \) as the composite capital stock in that sector. The economic depreciation rate for the composite capital good, discussed further below, is denoted as \( \delta^c \), and its tax depreciation rate is \( \delta^{tc} \).

The three types of capital goods (in addition to firm-specific capital \( FSK \)) are equipment, structures, and inventories. Specifically, the composite capital good in the C sector \( K^c_s \) is assumed to be a CES function of three capital types, equipment \( k^{c-equ} \), structures \( k^{c-str} \), and inventories \( k^{c-inv} \). The composite capital goods in the multinational M sector and the noncorporate sector N are assumed to have the same CES structure with different parameters. The elasticities of substitution among the three capital assets (which by construction are assumed to be equal across each pair of assets) in the C, M, and N sectors are \( \sigma^{kc} \), \( \sigma^{km} \), and \( \sigma^{kn} \).

The cost of capital is calculated for each type of capital good in each industry following the procedure described in Appendix section A.4, which is based on the provisions of the tax
system in that period. For example, in the C-sector, these costs of capital are denoted
\[ \rho_s^{c\text{-eqt}}, \rho_s^{c\text{-str}}, \text{ and } \rho_s^{c\text{-inv}} \]. Producers choose their mix of capital assets, \( k_s^{c\text{-eqt}}, k_s^{c\text{-str}}, \) and \( k_s^{c\text{-inv}} \) to minimize the cost of creating the composite capital good \( K_s^c \), which yields the asset demand functions for each type of capital good. Details of the derivations of these demand functions are provided in Appendix section A.4.

C. Treatment of the Noncorporate Sector

The appropriate treatment of the noncorporate sector in a BBRR reform is not obvious, and we try two different approaches. In our benchmark case, we simply assume that the base broadening measures enacted in the corporate sector do not apply to the noncorporate sector – that is, we “freeze” the noncorporate sector. Under the second approach, the corporate base broadening measures are also applied to the noncorporate sector, with no offsetting rate reduction, on the grounds that such a rate reduction would be difficult to implement and an increase in the currently tax favored noncorporate sector would be desirable in that would improve the efficiency of resource allocation in the economy.
REFERENCES


APPENDIX

In this appendix, we provide additional details on the model and some other items discussed in the text. We begin by providing the main parameters used in the model in Table A1 below; for discussion of many of these choices, see Gunning, Diamond and Zodrow (2008).

Table A.1
Parameter Values

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho$</td>
<td>Rate of time preference</td>
<td>0.015</td>
</tr>
<tr>
<td>$\sigma_U$</td>
<td>Intertemporal elasticity of substitution (EOS)</td>
<td>0.4</td>
</tr>
<tr>
<td>$\sigma_C$</td>
<td>Intratemporal EOS</td>
<td>0.8</td>
</tr>
<tr>
<td>$\sigma_H$</td>
<td>EOS between composite good, housing</td>
<td>0.33</td>
</tr>
<tr>
<td>$\sigma_N$</td>
<td>EOS between corporate composite good and noncorporate good</td>
<td>2.0</td>
</tr>
<tr>
<td>$\sigma_M$</td>
<td>EOS between M-sector and C-sector corporate goods</td>
<td>2.0</td>
</tr>
<tr>
<td>$\sigma_I$</td>
<td>EOS between domestic and foreign produced goods</td>
<td>5.0</td>
</tr>
<tr>
<td>$\sigma_R$</td>
<td>EOS between rental and owner-occupied housing</td>
<td>1.5</td>
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<tr>
<td>$\alpha_C$</td>
<td>Utility weight on the composite consumption good</td>
<td>0.77</td>
</tr>
<tr>
<td>$\alpha_H$</td>
<td>Utility weight on non-housing consumption good</td>
<td>0.45</td>
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<tr>
<td>$\alpha_N$</td>
<td>Utility weight on composite corporate good</td>
<td>0.7</td>
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<tr>
<td>$\alpha_M$</td>
<td>Utility weight on M-sector corporate good</td>
<td>0.75</td>
</tr>
<tr>
<td>$\alpha_R$</td>
<td>Utility weight on owner-occupied housing</td>
<td>0.77</td>
</tr>
<tr>
<td>$\alpha_{LE}$</td>
<td>Leisure share of time endowment</td>
<td>0.35</td>
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</table>

Production Function Parameters

$\varepsilon_C, \varepsilon_M$ EOS for C-sector and M-sector corporate goods 1.0
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\varepsilon_N$</td>
<td>EOS for noncorporate good</td>
<td>1.0</td>
</tr>
<tr>
<td>$\varepsilon_H, \varepsilon_R$</td>
<td>EOS for owner and rental housing</td>
<td>1.0</td>
</tr>
<tr>
<td>$\gamma_C$</td>
<td>Capital shares for C-sector corporate goods</td>
<td>0.2</td>
</tr>
<tr>
<td>$\gamma_N$</td>
<td>Capital share for noncorporate good</td>
<td>0.3</td>
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<tr>
<td>$\gamma_H, \gamma_R$</td>
<td>Capital share for owner and rental housing</td>
<td>0.98</td>
</tr>
<tr>
<td>$\beta_X, \beta_N, \beta_H$</td>
<td>Adjustment cost parameters</td>
<td>0–10</td>
</tr>
<tr>
<td>$\zeta$</td>
<td>Dividend payout ratio in corporate sector</td>
<td>0.6</td>
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<tr>
<td>$b_C, b_N, b_H, b_R$</td>
<td>Debt-asset ratios</td>
<td>0.35</td>
</tr>
<tr>
<td>$\delta_C$</td>
<td>Depreciation rates in the corporate sector</td>
<td>0.046</td>
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<tr>
<td>$\delta_N$</td>
<td>Depreciation rates in the noncorporate sector</td>
<td>0.02</td>
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<tr>
<td>$\delta_H, \delta_R$</td>
<td>Depreciation rates in the owner and rental housing sectors</td>
<td>0.015</td>
</tr>
<tr>
<td>$\gamma_{KM}$</td>
<td>Capital share parameter in M-sector composite KEL factor</td>
<td>0.15</td>
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<tr>
<td>$\gamma_{MK}$</td>
<td>KEL share parameter in M-sector production function</td>
<td>0.7</td>
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<tr>
<td>$\gamma_{MI}$</td>
<td>Intermediate good share in M-sector production function</td>
<td>0.04</td>
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Other Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\varepsilon_K$</td>
<td>Elasticity of supply to US of ordinary capital $K$</td>
<td>0.5</td>
</tr>
<tr>
<td>$n$</td>
<td>Exogenous growth rate (population + productivity)</td>
<td>3.4</td>
</tr>
</tbody>
</table>
We then, in the following subsections of the appendix, (1) compare the treatments of differentially mobile capital in our model and them model constructed by Becker and Fuest (2011), (2) derive the factor demands for the US and RW multinationals, (3) show how factor prices are determined in RW, (4) derive the factor demands for the three types of capital assets (equipment, structures and inventories) that make up ordinary capital \((K)\) in the model, (5) derive the cost of capital for each of these three assets, and (6) discuss the elasticity of labor supply in the model.

A.1 Comparison with Becker and Fuest Model

Our model follows Becker and Fuest (2011) in assuming the existence of two types of internationally mobile capital with different levels of mobility. However, the two models differ in numerous ways. In particular, Becker and Fuest obtain strong results on the desirability of a base-broadening, rate-reducing reform when the highly mobile capital earns returns that are greater than those earned by less mobile capital; however, they get these results only under a strong set of assumptions that do not apply to our model.

In general, our modeling approach is similar to that of Becker and Fuest (BF), although it is cast in terms of the allocation by two aggregate multinational corporations of fixed amounts of firm-specific capital rather than in terms of the number of firms in each location. Specifically, in our model, firm-specific capital \((FSK)\) is highly mobile and earns above normal returns, while ordinary capital \((K)\) is much less mobile and earns normal returns. The decision regarding the location of \(FSK\) is the decision that determines where production takes place, such production uses local factors with productivities that are enhanced by the availability of the \(FSK\), and the location of \(FSK\) decision is largely determined by relative tax rates, all of which is consistent with BF. In addition, in our model, profit shifting opportunities are available for the above-
normal profits earned by FSK in the relatively high tax jurisdiction, a factor not considered in the BF model. (Note that the tax system affects only the allocation and not the level of FSK in our model, as the accumulation of FSK is assumed to be exogenous.)

However, our model also differs from the BF model in some important ways. The most important is that it has a dynamic structure, with both existing and new capital. By comparison, the BF model is a two-period model in which the location decision (of FSK in our context) is made in the first “decision” period and all production and all depreciation occur in the second “production” period. Thus the structure of the BF model effectively assumes away an important problem that arises in our analysis — a reduction in the corporate income tax rate in the US reduces the taxation of the income of existing capital, including FSK that is already in place and earning above-normal returns. The associated revenue loss limits the amount of rate reduction that can occur for any given amount of base broadening, which implies that the base-broadening, rate-reducing reform initially raises the cost of capital, reduces investment, and reduces the likelihood that the reform will generate positive macroeconomic results. This phenomenon can be illustrated with a simple “back of the envelope” static revenue calculation. Assuming constant profits $\pi$ per unit of FSK and initial stock of $FSK_0$, a reduction in the corporate tax rate of $\Delta T$ percentage points will reduce revenues by $\Delta T \pi FSK_0$. At the same time, the corporate rate reduction will attract additional FSK to the US, and all of the associated income will be taxed at the corporate rate $t$, giving rise to a revenue increase of $t(\eta \Delta T \pi FSK_0)$, where $\eta$ is the semi-elasticity of FSK to the tax rate differential between the US and the rest-of-the-world (RW). Thus, the net revenue effect of the rate reduction can be positive only if $\eta > 1/t$, which with a post-reform tax rate of $t=0.25$, would require $\eta > 4$. 
Finally, note that BF use expensing as their benchmark tax treatment of capital income. Their main result is that if the mobile firm is more profitable than the relatively immobile firm, then some amount of accelerated depreciation, relative to expensing, should be eliminated in order to reduce the corporate tax rate. However, if the existing tax system already provides for accelerated depreciation with a present value less than expensing, as is currently the case in the US, then it is not clear, even within the context of the BF model, whether a further reduction in the corporate tax rate “purchased” with less accelerated depreciation will be desirable.

**A.2 Factor Demands for the Multinational Companies**

In this section, we provide the derivation of the profit-maximizing input demands of the MNCs, given the allocation of FSK described in the text, which is treated as a fixed factor for purposes of this analysis. Since the RW sector is the primary extension of the model, the following discussion focuses on the RW-MNC parent firm and, to a lesser extent, on the US-MNC foreign subsidiary; to simplify the exposition, the asterisks denoting foreign variables will be suppressed. To simplify the analysis, the foreign firms are assumed to be myopic, maximizing profits under the assumption of a fixed price $p_X$ for output, fixed prices $r$ for ordinary capital and $w$ for labor, and a fixed price $p_{IG} = p_X$ for the intermediate good, which is modeled simply as purchases of the output of the M-sector in the other country. The foreign tax system is modeled as simply applying a tax-exclusive effective tax rate $\tau_{FSK}$ to the returns to the firm-specific factor and a tax-inclusive tax rate $T$ to the returns to ordinary capital. Specifically, the RW-MNC parent – for a given level of firm-specific capital $FSK$ – chooses $KEL$ (and thus $K$ and $EL$) and $IG$ to maximize before-tax profits $\Pi$ (and thus after-tax profits $(1 - \tau)\Pi$), which accrue to the firm-specific fixed factor

$$\Pi[p_X, p_{IG}, p_{KEL}, FSK] = p_X \left[ KEL \right]^{\alpha}(IG)^{\beta}FSK^{1-\alpha-\beta} - p_{KEL}KEL - p_{IG}IG,$$
where the composite capital-labor input is \( KEL = K^\gamma (EL)^{1-\gamma} \) and \( p_{KEL} \) is the implicit gross price (calculated below) of the composite factor \( KEL \), including taxes. In the first stage of the optimization process, the firm chooses \( KEL \) and \( IG \). The first order conditions (FOCs) are

\[
p_X \alpha [KEL]^{\alpha-1} (IG)^\beta FSK^{1-\alpha-\beta} = p_{KEL}
\]

\[
p_X \beta [KEL]^{\alpha} (IG)^{\beta-1} FSK^{1-\alpha-\beta} = p_{IG}.
\]

Taking the ratios of the first two expressions yields

\[
\frac{\alpha(IG)}{\beta(KEL)} = \frac{p_{KEL}}{p_{IG}}
\]

which implies

\[
IG = \frac{p_{KEL}}{p_{IG}} \frac{\beta}{\alpha} KEL.
\]

Substituting into the FOC for \( KEL \) yields

\[
p_X \alpha (KEL)^{\alpha-1} (IG)^\beta FSK^{1-\alpha-\beta} = p_{KEL}
\]

\[
KEL^{1-\alpha} = \frac{\alpha(IG)^\beta FSK^{1-\alpha-\beta}}{p_{KEL}/p_X}
\]

\[
KEL = \alpha^{1/(1-\alpha)} \left( \frac{p_{KEL}}{p_X} \right)^{-1/(1-\alpha)} FSK^{(1-\alpha-\beta)/(1-\alpha)} (IG)^{\beta/(1-\alpha)}
\]

\[
KEL = \left( KEL \right)^{(1-\alpha-\beta)/(1-\alpha)} = \left( p_X \right)^{1/(1-\alpha)} \left( p_{KEL} \right)^{-1/(1-\alpha)} \left( p_{IG} \right)^{-\beta/(1-\alpha)} \frac{p_{KEL}}{p_{IG}} \frac{\beta}{\alpha} KEL
\]

Substituting for \( IG \) yields
\[
IG = \frac{p_{KEL}}{p_{IG}} \beta \frac{KEL}{p_{KEL}} = \frac{p_{KEL}}{p_{IG}} \beta \left( p_X \right)^{1/(1-\alpha-\beta)} \left( p_{KEL} \right)^{-(1-\beta)/(1-\alpha-\beta)} \left( p_{IG} \right)^{-\beta/(1-\alpha-\beta)} \alpha^{(1-\beta)/(1-\alpha-\beta)} \beta^{\beta/(1-\alpha-\beta)} \text{FSK}
\]

\[
= \left( p_X \right)^{1/(1-\alpha-\beta)} \left( p_{KEL} \right)^{-\alpha/(1-\alpha-\beta)} \left( p_{IG} \right)^{-(1-\alpha)/(1-\alpha-\beta)} \alpha^{\alpha/(1-\alpha-\beta)} \beta^{\beta/(1-\alpha-\beta)} \text{FSK}
\]

Repeating, the optimal demands for \( KEL \) and \( IG \) expressed as a function of only parameters, fixed prices, and the fixed \( \text{FSK} \) are

\[
KEL = \left( p_X \right)^{1/(1-\alpha-\beta)} \left( p_{KEL} \right)^{-(1-\beta)/(1-\alpha-\beta)} \left( p_{IG} \right)^{-\beta/(1-\alpha-\beta)} \alpha^{(1-\beta)/(1-\alpha-\beta)} \beta^{\beta/(1-\alpha-\beta)} \text{FSK}
\]

\[
IG = \left( p_X \right)^{1/(1-\alpha-\beta)} \left( p_{KEL} \right)^{-\alpha/(1-\alpha-\beta)} \left( p_{IG} \right)^{-(1-\alpha)/(1-\alpha-\beta)} \alpha^{\alpha/(1-\alpha-\beta)} \beta^{\beta/(1-\alpha-\beta)} \text{FSK}
\]

Given these \( IG \) and \( KEL \), the firm must also choose the optimal \( K \) and \( L \), which must be chosen to minimize the cost of producing any given level of \( KEL \). Since the Cobb-Douglas production function is constant returns to scale, this is equivalent to minimizing the unit costs of production of \( KEL \). The cost minimization problem for this second stage of the optimization process is thus to choose \( K \) and \( EL \) to minimize

\[
r(1+T)K - w(EL) + \lambda \left[ 1 - K^\gamma (EL)^{1-\gamma} \right].
\]

For the Cobb-Douglas production function, the cost minimizing per unit factor demands are

\[
\frac{K}{KEL} = \left[ \frac{\gamma w}{(1-\gamma)r(1+T)} \right]^{1-\gamma}, \quad \frac{EL}{KEL} = \left( \frac{\gamma w}{(1-\gamma)r(1+T)} \right)^{-\gamma}.
\]

Thus, total factor demands for producing any given level of \( KEL \) are
where the implicit price of the composite factor expressed as a function only of demands function only of parameters and fixed prices, and is all that is needed to determine the factor that is, by construction, the term in braces is the implicit price of $KEL$, denoted as $\text{TC}(KEL)$, is thus

$$
\text{TC}(KEL) = \left\{ r(1+T) \left[ \frac{\gamma w}{(1-\gamma) r(1+T)} \right]^{1-\gamma} + w \left[ \frac{\gamma w}{(1-\gamma) r(1+T)} \right]^{-\gamma} \right\}(KEL)
$$

$$
= \left\{ r(1+T)^{\gamma} w^{1-\gamma} \left[ \frac{\gamma}{1-\gamma} \right]^{1-\gamma} + r(1+T)^{-\gamma} w^{-\gamma} \left[ \frac{\gamma}{1-\gamma} \right]^{-\gamma} \right\}(KEL)
$$

$$
= \left\{ r(1+T)^{\gamma} w^{1-\gamma} \left[ \frac{\gamma}{1-\gamma} \right]^{1-\gamma} + \left( \frac{\gamma}{1-\gamma} \right)^{\gamma} \right\}(KEL)
$$

$$
= p_{KEL}(KEL);
$$

that is, by construction, the term in braces is the implicit price of $KEL$ or $p_{KEL}$, which is a function only of parameters and fixed prices, and is all that is needed to determine the factor demands $KEL$ and $IG$, as determined above.

Thus, all of the factor demands for the multinational firm’s optimization problem, expressed as a function only of parameters, fixed prices and taxes, and fixed $FSK$, are

$$
KEL = \left( p_{KEL} \right)^{-\beta/(1-\alpha-\beta)} \left( p_x \right)^{(1-\alpha-\beta)} \left( p_{IG} \right)^{-\beta/(1-\alpha-\beta)} \alpha^{\beta/(1-\alpha-\beta)} \beta^{\beta/(1-\alpha-\beta)} FSK
$$

$$
IG = \left( p_{KEL} \right)^{-\beta/(1-\alpha-\beta)} \left( p_x \right)^{(1-\alpha-\beta)} \left( p_{IG} \right)^{-\beta/(1-\alpha-\beta)} \alpha^{\beta/(1-\alpha-\beta)} \beta^{\beta/(1-\alpha-\beta)} FSK
$$

where the implicit price of the composite factor $KEL$ is defined as

$$
p_{KEL} = \left[ r(1+T) \right]^{\gamma} w^{1-\gamma} \left[ \frac{\gamma}{1-\gamma} \right]^{1-\gamma} + \left( \frac{\gamma}{1-\gamma} \right)^{\gamma} ,
$$
and, given this level of \( KEL \), the factor demands for ordinary capital and labor (repeating from above) are

\[
K = \left[ \frac{\gamma \omega}{(1 - \gamma) r (1 + T)} \right]^{\gamma} (KEL)
\]

\[
EL = \left[ \frac{\gamma \omega}{(1 - \gamma) r (1 + T)} \right]^{-\gamma} (KEL).
\]

Note that this implies that the before-tax \( FSK \) profit function for the foreign multinational RW-MNC parent from its production in RW is

\[
\Pi[p_X, p_{IG}, p_{KEL}; FSK] = p_X \left[ KEL \right]^\alpha (IG)^\beta FSK^{1 - \alpha - \beta} - p_{KEL} KEL - p_{IG} IG
\]

\[
= p_X \left[ (p_X)^{1 - (1 - \alpha - \beta)} (p_{KEL})^{-(1 - \beta)/(1 - \alpha - \beta)} (p_{IG})^{-\beta(1 - 1 - \alpha - \beta)} \alpha^{(1 - \beta)/(1 - \alpha - \beta)} \beta^{(1 - \alpha - \beta)} FSK \right]^\alpha
\]

\[
\cdot \left[ (p_X)^{1/(1 - \alpha - \beta)} (p_{KEL})^{-\alpha/(1 - \alpha - \beta)} (p_{IG})^{-\beta(1 - 1 - \alpha - \beta)} \alpha^{\alpha/(1 - \alpha - \beta)} \beta^{(1 - \alpha - \beta)} FSK \right]^\beta
\]

\[
- p_{KEL} \left[ (p_X)^{1/(1 - \alpha - \beta)} (p_{KEL})^{-\alpha/(1 - \alpha - \beta)} (p_{IG})^{-\beta(1 - 1 - \alpha - \beta)} \alpha^{\alpha/(1 - \alpha - \beta)} \beta^{(1 - \alpha - \beta)} FSK \right]
\]

\[
- p_{IG} \left[ (p_X)^{1/(1 - \alpha - \beta)} (p_{KEL})^{-\alpha/(1 - \alpha - \beta)} (p_{IG})^{-\beta(1 - 1 - \alpha - \beta)} \alpha^{\alpha/(1 - \alpha - \beta)} \beta^{(1 - \alpha - \beta)} FSK \right].
\]

The profit function for this output is thus linear in firm-specific capital, or

\[
\Pi[p_X, p_{IG}, p_{KEL}; FSK] = (\pi^{FSK}) FSK
\]

where before-tax foreign profits per unit of \( FSK \) are

\[
\pi^{FSK} = p_X \left[ (p_X)^{1/(1 - \alpha - \beta)} (p_{KEL})^{-\alpha(1 - \alpha - \beta)/(1 - \alpha - \beta)} (p_{IG})^{-\beta(1 - 1 - \alpha - \beta)} \alpha^{\alpha/(1 - \alpha - \beta)} \beta^{(1 - \alpha - \beta)} FSK \right]^\alpha
\]

\[
\cdot \left[ (p_X)^{1/(1 - \alpha - \beta)} (p_{KEL})^{-\alpha(1 - \alpha - \beta)/(1 - \alpha - \beta)} (p_{IG})^{-\beta(1 - 1 - \alpha - \beta)} \alpha^{\alpha/(1 - \alpha - \beta)} \beta^{(1 - \alpha - \beta)} FSK \right]^\beta
\]

\[
- p_{KEL} \left[ (p_X)^{1/(1 - \alpha - \beta)} (p_{KEL})^{-\alpha(1 - \alpha - \beta)/(1 - \alpha - \beta)} (p_{IG})^{-\beta(1 - 1 - \alpha - \beta)} \alpha^{\alpha/(1 - \alpha - \beta)} \beta^{(1 - \alpha - \beta)} FSK \right]
\]

\[
- p_{IG} \left[ (p_X)^{1/(1 - \alpha - \beta)} (p_{KEL})^{-\alpha(1 - \alpha - \beta)/(1 - \alpha - \beta)} (p_{IG})^{-\beta(1 - 1 - \alpha - \beta)} \alpha^{\alpha/(1 - \alpha - \beta)} \beta^{(1 - \alpha - \beta)} FSK \right],
\]

\[
p_X = p_c (1 + m).
\]
Thus $\pi_{FSK}^F$ is also a function only of prices, parameters and the tax rate on ordinary capital, which is assumed to be the average effective rate applied to such capital.

### A.3 Determination of Factor Prices in RW

The derivation in the previous section provides enough information to determine the price of capital $*r^T$ and the supply of labor $*E^T_L$ in RW, given the fixed price of labor $*w$, using the equilibrium equations for the labor and capital markets in RW. (The asterisks are suppressed in the rest of this section to simplify notation.) The supply of effective labor to the MNC sector, $*E^T_L$, must equal the labor demands of the US-MNC subsidiary and RW-MNC parent, or

$$*E^T_L = *E^T_L^{US} + *E^T_L^{RW}$$

Similarly, the “ordinary” capital market equilibrium equation for RW specifies that the supply of capital, which equals the capital stock at the beginning of the period less any exports of capital to the US during that period, equals the sum of the demands of the US-MNC subsidiary and the RW-MNC parent firm, or

$$*K^T - \Delta K^F = \left[\frac{\gamma w}{(1-\gamma)r(1+T)}\right]^{1-\gamma} \left(p_{KEL}\right)^{-(1-\beta)/(1-\alpha-\beta)} \left(p_X\right)^{1/(1-\alpha-\beta)} \times \left(p_{IG}\right)^{-\beta/(1-\alpha-\beta)} \alpha^{(1-\beta)/(1-\alpha-\beta)} \beta^{\beta/(1-\alpha-\beta)} \left(*FSK^{US} + *FSK^{RW}\right)$$

Taking the ratio of these two factor market equilibrium conditions yields

$$\frac{*K^T - \Delta K^F}{*E^T_L} = \frac{\gamma w}{(1-\gamma)r(1+T)} \cdot$$
which, for later substitution into the expression for $p_{KEL}$, can be rewritten as

\[
[r(1+T)]^\gamma = \left[ \frac{K^T - \Delta K^F}{*EL^T} \right]^\gamma \left[ \frac{\gamma w}{(1-\gamma)} \right]^\gamma \quad \text{and} \quad w^{1-\gamma} = \left[ \frac{K^T - \Delta K^F}{*EL^T} \right]^{1-\gamma} \left[ \frac{(1-\gamma)r(1+T)}{\gamma} \right]^{1-\gamma}.
\]

Substituting into the expression for the price of $KEL$ yields

\[
p_{KEL} = \left[ \frac{K^T - \Delta K^F}{*EL^T} \right]^\gamma \left[ \frac{\gamma w}{(1-\gamma)} \right]^\gamma \left[ \left( \frac{\gamma}{1-\gamma} \right)^{1-\gamma} + \left( \frac{\gamma}{1-\gamma} \right)^{-\gamma} \right]
\]

\[
= \left[ \frac{K^T - \Delta K^F}{*EL^T} \right]^\gamma \left[ \frac{\gamma}{(1-\gamma)} \right]^\gamma \left[ \left( \frac{\gamma}{1-\gamma} \right)^{1-\gamma} + \left( \frac{\gamma}{1-\gamma} \right)^{-\gamma} \right] w
\]

\[
= \left[ \frac{K^T - \Delta K^F}{*EL^T} \right]^\gamma \left( \frac{1}{1-\gamma} \right) w.
\]

Substituting into the labor market equilibrium equation yields

\[
*EL^T = *EL^{US} + *EL^{RW}
\]

\[
= \left[ \frac{K^T - \Delta K^F}{*EL^T} \right]^\gamma \left[ \left( \frac{K^T - \Delta K^F}{*EL^T} \right)^{1-\gamma} \left( \frac{1}{1-\gamma} \right) w \right]^{-(1-\beta)/(1-\alpha-\beta)} \left(P_X\right)^{1/(1-\alpha-\beta)}
\]

\[
\times \left(p_{IG}\right)^{\beta/(1-\alpha-\beta)} \left(1-\beta/(1-\alpha-\beta)\right)^{(1-\beta)/(1-\alpha-\beta)}\left(\beta/(1-\alpha-\beta)\right)^{\beta/(1-\alpha-\beta)} \left(*FSK^{US} + *FSK^{RW}\right)
\]
\[ *EL^T = *EL^{US} + *EL^{RW} \]

\[
= \left[ \frac{*K^T - \Delta K_F}{*EL^T} \right]^{-\gamma} \left[ \frac{*K^T - \Delta K_F}{*EL^T} \right]^{-\gamma} \left[ \frac{1}{(1-\gamma)} \right]^W \]

\[
\cdot \left( P_X \right)^{(1-\alpha-\beta)} \left( P_{IG} \right)^{-\beta/(1-\alpha-\beta)} \alpha^{(1-\beta)/(1-\alpha-\beta)} \beta^{(1-\beta)/(1-\alpha-\beta)} \left( *FSK^{US} + *FSK^{RW} \right) \]

\[
\left( *EL^T \right)^{-\gamma} \left( *K^T - \Delta K_F \right)^{\gamma} = \left[ \frac{*K^T - \Delta K_F}{*EL^T} \right]^{\gamma/(1-\beta)} \left( 1-\gamma \right)^{(1-\beta)/(1-\alpha-\beta)} \left( P_{IG} \right)^{-\beta/(1-\alpha-\beta)} \alpha^{(1-\beta)/(1-\alpha-\beta)} \beta^{(1-\beta)/(1-\alpha-\beta)} \left( *FSK^{US} + *FSK^{RW} \right) \]

\[
\mu^{(1-\beta)/(1-\alpha-\beta)} = \left( *EL^T \right)^{-1} \left[ \frac{*K^T - \Delta K_F}{*EL^T} \right]^{-\alpha/(1-\alpha)} \left( 1-\gamma \right)^{(1-\beta)/(1-\alpha-\beta)} \left( P_{IG} \right)^{-\beta/(1-\alpha-\beta)} \alpha^{(1-\beta)/(1-\alpha-\beta)} \beta^{(1-\beta)/(1-\alpha-\beta)} \left( *FSK^{US} + *FSK^{RW} \right) \]

\[
w = \left( *EL^T \right)^{-(1-\alpha-\beta)/(1-\beta)} \left( 1-\gamma \right) \left[ \frac{*K^T - \Delta K_F}{*EL^T} \right]^{-\alpha/(1-\beta)} \alpha \beta^{(1-\beta)} \left( P_{IG} \right)^{-\beta/(1-\beta)} \left( *FSK^{US} + *FSK^{RW} \right)^{(1-\beta)/(1-\beta)} \left( P_X \right)^{(1-\beta)} \left( P_{IG} \right)^{-\beta/(1-\beta)} \left( *FSK^{US} + *FSK^{RW} \right)^{(1-\beta)/(1-\beta)} \left( 1-\gamma \right)^{(1-\beta)/(1-\alpha-\beta)} \left( *FSK^{US} + *FSK^{RW} \right) \]

The price of the composite factor KEL can also be written
Substituting into the capital market equilibrium equation yields

\[ P_{KEL} = [r(1+T)]^\gamma w^{1-\gamma} \left[ \left( \frac{\gamma}{1-\gamma} \right)^{\gamma} + \left( \frac{\gamma}{1-\gamma} \right)^{-\gamma} \right] \]

\[ = [r(1+T)]^\gamma \left[ \frac{*K^T - \Delta K^T}{*EL^T} \right]^{\gamma} \left[ r(1+T) \right]^{1-\gamma} \left[ \left( \frac{\gamma}{1-\gamma} \right)^{(1-\gamma)} \left( \frac{\gamma}{1-\gamma} \right)^{1-\gamma} + \left( \frac{\gamma}{1-\gamma} \right)^{-\gamma} \right] \]

\[ = \left[ \frac{*K^T - \Delta K^T}{*EL^T} \right]^{\gamma} \left( \frac{1}{\gamma} \right) r(1+T) \]
\[ r(1 + T) = (\star K^T - \Delta K^F)^{-(1-\alpha-\beta)/(1-\beta)} \gamma \left[ \frac{\star K^T - \Delta K^F}{\star EL^T} \right]^{\alpha \gamma/(1-\beta)} \]

\[ \times \alpha \beta^{\beta/(1-\beta)} \left( p_X \right)^{(1-\beta)/(1-\beta)} \left( p_{IG} \right)^{-\beta/(1-\beta)} \left( *F_{SK}^{US} + *F_{SK}^{RW} \right)^{(1-\alpha-\beta)/(1-\beta)}. \]

Thus, the factor prices in RW as a function of parameters, prices, FSKs, and the factor endowments of ordinary capital (less exports to the US) are

\[ w = \left( 1 - \gamma \right)^{-(1-\alpha-\beta)/(1-\beta)} \Omega_{KEL} \]

\[ r(1 + T) = \left( \gamma \right) (\star K^T - \Delta K^F)^{-(1-\alpha-\beta)/(1-\beta)} \Omega_{KEL}, \]

where

\[ \Omega_{KEL} = \left[ \frac{\star K^T - \Delta K^F}{\star EL^T} \right]^{\alpha \gamma/(1-\beta)} \alpha \beta^{\beta/(1-\beta)} \left( p_X \right)^{(1-\beta)/(1-\beta)} \left( p_{IG} \right)^{-\beta/(1-\beta)} \left( *F_{SK}^{US} + *F_{SK}^{RW} \right)^{(1-\alpha-\beta)/(1-\beta)}. \]
A.4 Multiple Capital Assets (Ordinary Capital)

The demand functions for the three capital assets (equipment, structures, and inventories) that make up ordinary capital \( (K) \) are derived as follows.

Consider, for example, the C-sector. The firm is assumed to choose the mix of capital assets to minimize the cost of producing \( K^c \). This optimization problem yields the Lagrangian

\[
L = \rho_s^{c-eqt} k_s^{c-eqt} + \rho_s^{c-str} k_s^{c-str} + \rho_s^{c-inv} k_s^{c-inv}
+ \lambda_k^{kc} \left[ K_s^{c-eqt} - A^{kc} \left[ \left( k_s^{c-eqt} \right)^{(c-\sigma_{kc})/\sigma_{kc}} \left( k_s^{c-str} \right)^{(c-\sigma_{kc})/\sigma_{kc}} \left( k_s^{c-inv} \right)^{(c-\sigma_{kc})/\sigma_{kc}} \right]^{c_{\sigma_{kc}}} \right].
\]

The solution to this cost minimization problem (see derivation below) is

\[
k_s^{c-eqt} = \frac{\kappa^{c-eqt} (\rho_s^{c-eqt})^{-\sigma_{kc}}}{\left( A^{kc} / K_s^{c} \right)^{\left( \kappa^{c-eqt} (\rho_s^{c-eqt})^{(c-\sigma_{kc})/\sigma_{kc}} + \kappa^{c-str} (\rho_s^{c-str})^{(c-\sigma_{kc})/\sigma_{kc}} + \kappa^{c-inv} (\rho_s^{c-inv})^{(c-\sigma_{kc})/\sigma_{kc}} \right)^{\sigma_{kc} / (\sigma_{kc} - 1)}}}
\]

\[
k_s^{c-str} = \frac{\kappa^{c-str} (\rho_s^{c-str})^{-\sigma_{kc}}}{\left( A^{kc} / K_s^{c} \right)^{\left( \kappa^{c-eqt} (\rho_s^{c-eqt})^{(c-\sigma_{kc})/\sigma_{kc}} + \kappa^{c-str} (\rho_s^{c-str})^{(c-\sigma_{kc})/\sigma_{kc}} + \kappa^{c-inv} (\rho_s^{c-inv})^{(c-\sigma_{kc})/\sigma_{kc}} \right)^{\sigma_{kc} / (\sigma_{kc} - 1)}}}
\]

\[
k_s^{c-inv} = \frac{\kappa^{c-inv} (\rho_s^{c-inv})^{-\sigma_{kc}}}{\left( A^{kc} / K_s^{c} \right)^{\left( \kappa^{c-eqt} (\rho_s^{c-eqt})^{(c-\sigma_{kc})/\sigma_{kc}} + \kappa^{c-str} (\rho_s^{c-str})^{(c-\sigma_{kc})/\sigma_{kc}} + \kappa^{c-inv} (\rho_s^{c-inv})^{(c-\sigma_{kc})/\sigma_{kc}} \right)^{\sigma_{kc} / (\sigma_{kc} - 1)}}}
\]

which yields the total demands for each type of capital in the C-sector. Given empirical data on the amounts of the three types of capital in the C-sector \( k_s^{c-eqt}, k_s^{c-str}, \) and \( k_s^{c-inv} \), the capital-type constant elasticity of substitution \( \sigma_{kc} \), and the cost of capital for each type of capital (\( \rho_s^{c-eqt}, \rho_s^{c-str}, \) and \( \rho_s^{c-inv} \) derived below), the weighting parameters (\( \kappa^{c-eqt}, \kappa^{c-str}, \) and \( \kappa^{c-inv} \)) of the CES composite capital good production function can be determined. For example, in the C-
sector

\[ \kappa^{c-equiv} = k_s^{c-equiv}(\rho_s^{c-equiv})^{\sigma_{iv}} \left( A^{kc} / K_s^c \right) \left[ \kappa^{c-equiv}(\rho_s^{c-equiv})^{1-\sigma_{iv}} + \kappa^{c-str}(\rho_s^{c-str})^{1-\sigma_{iv}} + \kappa^{c-inv}(\rho_s^{c-inv})^{1-\sigma_{iv}} \right]^{\sigma_{iv}/(1-\sigma_{iv})} \]

\[ \kappa^{c-str} = k_s^{c-str}(\rho_s^{c-str})^{\sigma_{iv}} \left( A^{kc} / K_s^c \right) \left[ \kappa^{c-equiv}(\rho_s^{c-equiv})^{1-\sigma_{iv}} + \kappa^{c-str}(\rho_s^{c-str})^{1-\sigma_{iv}} + \kappa^{c-inv}(\rho_s^{c-inv})^{1-\sigma_{iv}} \right]^{\sigma_{iv}/(1-\sigma_{iv})} \]

\[ \kappa^{c-inv} = k_s^{c-inv}(\rho_s^{c-inv})^{\sigma_{iv}} \left( A^{kc} / K_s^c \right) \left[ \kappa^{c-equiv}(\rho_s^{c-equiv})^{1-\sigma_{iv}} + \kappa^{c-str}(\rho_s^{c-str})^{1-\sigma_{iv}} + \kappa^{c-inv}(\rho_s^{c-inv})^{1-\sigma_{iv}} \right]^{\sigma_{iv}/(1-\sigma_{iv})}. \]

To simplify these expressions, note that since the composite capital good function is CES,

\[ \kappa^{c-equiv} + \kappa^{c-str} + \kappa^{c-inv} = 1, \]

or

\[ \left[ k_s^{c-equiv}(\rho_s^{c-equiv})^{\sigma_{iv}} + k_s^{c-str}(\rho_s^{c-str})^{\sigma_{iv}} + k_s^{c-inv}(\rho_s^{c-inv})^{\sigma_{iv}} \right] \left( A^{kc} / K_s^c \right) \]

\[ \times \left[ \kappa^{c-equiv}(\rho_s^{c-equiv})^{1-\sigma_{iv}} + \kappa^{c-str}(\rho_s^{c-str})^{1-\sigma_{iv}} + \kappa^{c-inv}(\rho_s^{c-inv})^{1-\sigma_{iv}} \right]^{\sigma_{iv}/(1-\sigma_{iv})} = 1 \]

which implies

\[ \left( A^{kc} / K_s^c \right) \left[ \kappa^{c-equiv}(\rho_s^{c-equiv})^{1-\sigma_{iv}} + \kappa^{c-str}(\rho_s^{c-str})^{1-\sigma_{iv}} + \kappa^{c-inv}(\rho_s^{c-inv})^{1-\sigma_{iv}} \right]^{\sigma_{iv}/(1-\sigma_{iv})} = \left[ k_s^{c-equiv}(\rho_s^{c-equiv})^{\sigma_{iv}} + k_s^{c-str}(\rho_s^{c-str})^{\sigma_{iv}} + k_s^{c-inv}(\rho_s^{c-inv})^{\sigma_{iv}} \right]. \]

Thus, the weighting parameters simplify to

\[ \kappa^{c-equiv} = \frac{k_s^{c-equiv}(\rho_s^{c-equiv})^{\sigma_{iv}}}{\left[ k_s^{c-equiv}(\rho_s^{c-equiv})^{\sigma_{iv}} + k_s^{c-str}(\rho_s^{c-str})^{\sigma_{iv}} + k_s^{c-inv}(\rho_s^{c-inv})^{\sigma_{iv}} \right]} \]

\[ \kappa^{c-str} = \frac{k_s^{c-str}(\rho_s^{c-str})^{\sigma_{iv}}}{\left[ k_s^{c-equiv}(\rho_s^{c-equiv})^{\sigma_{iv}} + k_s^{c-str}(\rho_s^{c-str})^{\sigma_{iv}} + k_s^{c-inv}(\rho_s^{c-inv})^{\sigma_{iv}} \right]} \]

\[ \kappa^{c-inv} = \frac{k_s^{c-inv}(\rho_s^{c-inv})^{\sigma_{iv}}}{\left[ k_s^{c-equiv}(\rho_s^{c-equiv})^{\sigma_{iv}} + k_s^{c-str}(\rho_s^{c-str})^{\sigma_{iv}} + k_s^{c-inv}(\rho_s^{c-inv})^{\sigma_{iv}} \right]} \]

Thus, in the firm investment optimization equation, the composite capital stock is given by the CES function of the different capital types shown above. Noting that inventories do not depreciate, the economic depreciation rate for the composite capital good is the weighted average of the depreciation rates of the various capital types \( \delta^c_s = k_s^{c-equiv}\delta_s^{c-equiv} + k_s^{c-str}\delta_s^{c-str} \), and the tax
The cost of capital expressions for the various capital types are obtained using the standard Hall-Jorgenson formulation. All equipment and structures are assumed to be produced in the competitive C sector at a price per unit of $p^c$, and inventories are simply the output of the relevant production sector and are priced accordingly. For example, for the purchase of equipment in the C-sector, the marginal investment in a unit of equipment is characterized by equality between the marginal cost per unit of $p^c$ and the marginal after-tax revenue flows generated by the asset, or

$$p^c = (1 - \tau_p) \int_0^\infty MRPC^{\text{eq}} e^{-\delta^{\text{eq}}s} e^{-d^s_s} ds$$

$$+ \tau_b \int_0^\infty \delta^{\text{eq}}(p^c[1 - \phi_{IA}^c(L^c)] e^{-\delta^{\text{eq}}s}) e^{-d_s s} ds + \tau_b IA^c p^c + ITC^c p^c,$$

where $MRPC^{\text{eq}}$ is the marginal revenue product of the asset, $d^c$ is the firm’s discount rate in the C sector, $IA^c$ is any (expressed as a fraction of the purchase price) given at the time of purchase such as bonus depreciation or partial expensing, $\phi_{IA}^c$ is the fraction of the investment allowance that is deducted from the amount of the purchase to be depreciated (e.g., $\phi_{IA}^c = 1$ for bonus depreciation), $ITC^c$ is any investment tax credit available for purchase of the asset expressed as a fraction of the cost of the asset, $p^c[1 - \phi_{IA}^c(L^c)] e^{-\delta^{\text{eq}}s}$ is the tax basis of the asset at time $s$, $\tau_p^c$ is the property tax rate applied to the asset assuming that property taxes are deductible against the corporate income tax, and the present value of the depreciation deductions allowed per dollar of purchases of equipment is denoted as

$$z^{\text{eq}} = \int_0^\infty \delta^{\text{eq}}(e^{-d^s_s + \delta^{\text{eq}}s}) [1 - \phi_{IA}^c(L^c)] ds = \frac{\delta^{\text{eq}}[1 - \phi_{IA}^c(L^c)]}{d^c + \delta^{\text{eq}}}.$$
Solving for the cost of capital (see appendix A.6 for the derivation) yields

\[ \rho^{\text{e-qt}} = \frac{MRP^{\text{e-qt}}}{p} - \delta^{\text{e-qt}} = \frac{\delta^{\text{e-qt}} + d^c}{1 - \tau_b} \left[ 1 - \left( \tau_s z^{\text{e-qt}} - \tau_b \right)^c - ITC^c \right] + \tau_p - \delta^{\text{e-qt}}. \]

The costs of capital for all types of capital assets in the C, M and N sectors are calculated analogously.

Consider next the solution to the capital mix problem. Note that for any amount of the composite capital good \( K^c_s = \bar{K} \), the first order conditions are

\[
0 = \frac{\partial L}{\partial k^{ce}_s} = \rho_s^{ce} -
\]

\[
\lambda_s^c A^c \kappa^{1/\sigma_{kc}} k_s^{1 - 1/\sigma_{kc}} \left[ \kappa^{1/\sigma_{kc}} \left( k_s^{\text{ce}} \right)^{(1/\sigma_{kc})/\sigma_{kc}} + \kappa^{1/\sigma_{kc}} \left( k_s^{\text{ci}} \right)^{(1/\sigma_{kc})/\sigma_{kc}} \right]^{\sigma_{kc}/(\sigma_{kc} - 1)}
\]

\[
0 = \frac{\partial L}{\partial k^{ci}_s} = \rho_s^{ci} -
\]

\[
\lambda_s^c A^c \kappa^{1/\sigma_{kc}} k_s^{1 - 1/\sigma_{kc}} \left[ \kappa^{1/\sigma_{kc}} \left( k_s^{\text{ce}} \right)^{(1/\sigma_{kc})/\sigma_{kc}} + \kappa^{1/\sigma_{kc}} \left( k_s^{\text{ci}} \right)^{(1/\sigma_{kc})/\sigma_{kc}} \right]^{\sigma_{kc}/(\sigma_{kc} - 1)}
\]

\[
0 = \frac{\partial L}{\partial \lambda_s^c} = -\bar{K} -
\]

\[
A^c \left[ \kappa^{1/\sigma_{kc}} \left( k_s^{\text{ce}} \right)^{(1/\sigma_{kc})/\sigma_{kc}} + \kappa^{1/\sigma_{kc}} \left( k_s^{\text{ci}} \right)^{(1/\sigma_{kc})/\sigma_{kc}} \right]^{\sigma_{kc}/(\sigma_{kc} - 1)}
\]

\[
\frac{\partial L}{\partial k^{ce}_s} / \frac{\partial L}{\partial k^{cs}_s} : \frac{\rho_s^{ce}}{\rho_s^{cs}} = \frac{\kappa^{1/\sigma_{kc}} k_s^{1 - 1/\sigma_{kc}}}{k_s^{1/\sigma_{kc}} k_s^{1 - 1/\sigma_{kc}}} \Rightarrow k_s^{ce} = \left( \frac{\rho_s^{ce}}{\rho_s^{cs}} \right)^{\sigma_{kc}} \frac{\kappa}{k_s} \frac{k_s^{ce}}{k_s^{ce}}
\]

\[
\frac{\partial L}{\partial k^{ce}_s} / \frac{\partial L}{\partial k^{ci}_s} : \frac{\rho_s^{ce}}{\rho_s^{ci}} = \frac{\kappa^{1/\sigma_{kc}} k_s^{1 - 1/\sigma_{kc}}}{k_s^{1/\sigma_{kc}} k_s^{1 - 1/\sigma_{kc}}} \Rightarrow k_s^{ci} = \left( \frac{\rho_s^{ce}}{\rho_s^{ci}} \right)^{\sigma_{kc}} \frac{\kappa}{k_s} \frac{k_s^{ci}}{k_s^{ci}}
\]

Solving for the capital demands, e.g., for equipment, yields...
\[
\begin{align*}
\left[ \kappa_{ce}^{\sigma_{\mu}} \left( k_s^{ce} \right)^{(\sigma_{\mu-1})/\sigma_{\mu}} + \kappa_{cs}^{\sigma_{\mu}} \left( k_s^{cs} \right)^{(\sigma_{\mu-1})/\sigma_{\mu}} + \kappa_{ci}^{\sigma_{\mu}} \left( k_s^{ci} \right)^{(\sigma_{\mu-1})/\sigma_{\mu}} \right] \gamma_{\mu/\left(\sigma_{\mu-1}\right)} &= \overline{K}/A^{ce} \\
\left[ \kappa_{ce}^{\sigma_{\mu}} \left( k_s^{ce} \right)^{(\sigma_{\mu-1})/\sigma_{\mu}} + \kappa_{cs}^{\sigma_{\mu}} \left( \frac{\rho_x^{ce}}{\rho_x^{cs}} \right) \left( k_s^{ce} \right)^{(\sigma_{\mu-1})/\sigma_{\mu}} \right] \gamma_{\mu/\left(\sigma_{\mu-1}\right)} &= \overline{K}/A^{ce} \\
\left[ \kappa_{ce} \left( \rho_x^{ce} \right)^{1/\sigma_{\mu}} \left( k_s^{ce} \right)^{(\sigma_{\mu-1})/\sigma_{\mu}} + \kappa_{cs} \left( \rho_x^{ce} \right)^{1/\sigma_{\mu}} \left( k_s^{ce} \right)^{(\sigma_{\mu-1})/\sigma_{\mu}} + \kappa_{ci} \left( \rho_x^{ce} \right)^{1/\sigma_{\mu}} \left( k_s^{ce} \right)^{(\sigma_{\mu-1})/\sigma_{\mu}} \right] \frac{\gamma_{\mu/\left(\sigma_{\mu-1}\right)}}{\kappa_{ce}} \left( k_s^{ce} \right)^{(\sigma_{\mu-1})/\sigma_{\mu}} &= \overline{K}/A^{ce} \\
\left[ \kappa_{ce} \left( \rho_x^{ce} \right)^{1/\sigma_{\mu}} \left( k_s^{ce} \right)^{(\sigma_{\mu-1})/\sigma_{\mu}} + \kappa_{cs} \left( \rho_x^{ce} \right)^{1/\sigma_{\mu}} \left( k_s^{ce} \right)^{(\sigma_{\mu-1})/\sigma_{\mu}} + \kappa_{ci} \left( \rho_x^{ce} \right)^{1/\sigma_{\mu}} \left( k_s^{ce} \right)^{(\sigma_{\mu-1})/\sigma_{\mu}} \right] \frac{\gamma_{\mu/\left(\sigma_{\mu-1}\right)}}{\kappa_{ce}} \left( k_s^{ce} \right)^{(\sigma_{\mu-1})/\sigma_{\mu}} &= \overline{K}/A^{ce} \\
k_s^{ce} &= \frac{\kappa_{ce}}{\left( \rho_x^{ce} \right)^{\sigma_{\mu}} \left( A^{ce} / \overline{K} \right)} \left[ \kappa_{ce} \left( \rho_x^{ce} \right)^{1/\sigma_{\mu}} + \kappa_{cs} \left( \rho_x^{ce} \right)^{1/\sigma_{\mu}} + \kappa_{ci} \left( \rho_x^{ce} \right)^{1/\sigma_{\mu}} \right] \gamma_{\mu/\left(\sigma_{\mu-1}\right)}
\end{align*}
\]
A.5 Cost of Capital Calculation

To calculate the cost of capital in the corporate sector, take the equilibrium condition for equipment purchases in the corporate sector, and solve for \( \frac{MRP^{c-eqt}}{p^c - \delta^{c-eqt}} \) to yield

\[
p^c = (1 - \tau_b) \int_0^\infty MRP^{c-eqt} e^{-\delta^{c-eqt} s} e^{-d^c s} ds + \tau_b \int_0^\infty \delta^{c-eqt} \left( p^c \left[ 1 - \varphi_{IA}^e (IA^c) \right] e^{-\delta^{c-eqt} s} \right) e^{-d^c s} ds
\]

\[
+ \tau_b IA^c p^c + ITC^c p^c - \int_0^\infty (1 - \tau_b) \varphi_{p}^e \left( p^c e^{-\delta^{c-eqt} s} \right) e^{-d^c s} ds
\]

\[
1 = (1 - \tau_b) \frac{MRP^{c-eqt}}{\delta^{c-eqt} + d^c} + z^{c-eqt} \tau_b IA^c + ITC^c - \frac{(1 - \tau_b) \tau_p^c}{\delta^{c-eqt} + d^c}
\]

\[
\delta^{c-eqt} + d^c = (1 - \tau_b) \frac{MRP^{c-eqt}}{p^c} + \tau_b \left[ z^{c-eqt} + \tau_b IA^c + ITC^c \right] (\delta^{c-eqt} + d^c) - (1 - \tau_b) \tau_p^c
\]

\[
\frac{\delta^{c-eqt} + d^c}{(1 - \tau_b)} = \frac{MRP^{c-eqt}}{p^c} + \frac{\tau_b z^{c-eqt} + \tau_b IA^c + ITC^c}{(1 - \tau_b)} (\delta^{c-eqt} + d^c) - \tau_p^c
\]

\[
\frac{MRP^{c-eqt}}{p^c} - \delta^{c-eqt} = \frac{(\delta^{c-eqt} + d^c) \left[ 1 - \tau_b z^{c-eqt} - \tau_b IA^c - ITC^c \right]}{(1 - \tau_b)} + \tau_p^c - \delta^{c-eqt}
\]

A.6 The Elasticity of Labor Supply in the Model

AAKSW (2001) argue that the best measure of the responsiveness of labor supply in their intertemporal model is the Frisch elasticity of labor supply, which measures the variation in labor supply in response to a change in the after-tax wage along an optimal path with the marginal utility of lifetime income or wealth (the multiplier on the lifetime income budget constraint) held constant; it thus captures a pure substitution effect in an intertemporal model that includes the substitution of leisure for consumption over time, analogous to the Marshallian constant income substitution effect in the standard single period model. CBO (2012) notes that estimates of Frisch elasticities are typically about 50% larger than estimates of the Marshallian substitution
elasticity. Because the intertemporal utility function in the AAKSW model is time separable, the Frisch elasticity isolates the effects of changes in the after-tax wage on current period consumption and leisure/labor supply. Their expression for the Frisch elasticity, $\eta^{FLS}$, is

$$\eta^{FLS} = \left( \frac{Le}{L} \right) \left[ \sigma^U \zeta^{LE} + \sigma^C (1 - \zeta^{LE}) \right] = \left( \frac{\zeta^{LE}}{1 - \zeta^{LE}} \right) \left[ \sigma^U \zeta^{LE} + \sigma^C (1 - \zeta^{LE}) \right],$$

where $\zeta^{LE}$ is the leisure share of the endowment.

The parameters AAKSW use are $\zeta^{LE} = 0.6$, $\sigma^U = 0.25$, and $\sigma^C = 0.8$. These choices imply a Frisch elasticity of $\eta^{FLS} = 0.705$, which they argue is consistent with the literature.

By comparison, our values for these parameters are $\zeta^{LE} = 0.35$, $\sigma^U = 0.35$, and $\sigma^C = 0.8$. These choices imply a Frisch elasticity of $\eta^{FLS} = \left( \frac{0.35}{0.65} \right) \left[ (0.35)(0.35) + (0.8)(0.65) \right] = 0.346$, very slightly under half of the labor supply responsiveness assumed by AAKSW.

On the other hand, in a very recent survey of Frisch elasticities based on micro data, CBO (2012) concludes that a reasonable range of estimates is between 0.27 and 0.53, with a central estimate of 0.40. We are only somewhat below that. CBO notes that several studies have estimates somewhat greater than one, and that the empirical macro literature estimates far larger Frisch elasticities, on the order of 2–4, which they argue are so large because they reflect cyclical factors (wages are relatively sticky while employment levels change significantly over the business cycle, resulting in large macro-based estimates of the Frisch elasticity). CBO also notes that their central estimate of 0.40 for the Frisch elasticity is about 50% greater than their central estimate of the substitution elasticity of 0.24. The review by Kniesner and Ziliak (2008) suggests
somewhat larger elasticities, as they estimate a (compensated) substitution elasticity of 0.328 and a Frisch elasticity that is 63% larger at 0.535.

Kniesner and Ziliak (2008) also estimate an income elasticity of labor supply of −0.517, which is relatively high; by comparison, the CBO (2012b) review suggests a range of 0 to −0.1. In contrast, because we assume a CES annual utility function, we assume an income elasticity of 1.0. This would seem to argue for using Frisch elasticities at the top of the range—e.g., something along the lines of the 0.7 used by AAKSW.

Given the CES utility function used in the model, the income elasticity of demand for leisure is one. Since labor supply is \( L = HT - Le \), the elasticity of a change in exogenous income on labor supply is calculated from

\[
\begin{align*}
    dL &= -dLe \\
    \frac{dL}{HT - L} &= -\frac{dLe}{Le} \\
    \frac{dL}{L} &= -\frac{HT - L}{L} \frac{dLe}{Le} = -\zeta L \frac{dLe}{Le} \\
    \eta^L &= -\frac{\zeta L}{\zeta} \eta^L = -\frac{\zeta L}{\zeta} \\
\end{align*}
\]
A.6 Cost of Capital Calculation

To calculate the cost of capital in the corporate sector, take the equilibrium condition for equipment purchases in the corporate sector, and solve for \( \frac{MRP_{c-eq}}{p^c} - \delta^{c-eq} \) to yield

\[
p^c = (1 - \tau_b) \int_0^\infty MR^c e^{-\delta^{c-eq}} e^{-d's} ds + \tau_b \int_0^\infty \delta^{c-eq} \left( p^c \left[ 1 - \phi_{IA}^c (IA^c) \right] e^{-\delta^{c-eq}} \right) e^{-d's} ds
\]

\[
+ \tau_b IA^c p^c + ITC^c p^c - \int_0^\infty (1 - \tau_b) \tau_p^c \left( p^c \right) e^{-\delta^{c-eq}} e^{-d's} ds
\]

\[
1 = (1 - \tau_b) \frac{MRP_{c-eq} / p^c}{\delta^{c-eq} + d^c} + \tau_b IA^c + ITC^c - \frac{(1 - \tau_b) \tau_p^c}{\delta^{c-eq} + d^c}
\]

\[
\delta^{c-eq} + d^c = (1 - \tau_b) MR^c / p^c + \tau_b \left[ z^{c-eq} + \tau_b IA^c + ITC^c \right] \left( \delta^{c-eq} + d^c \right) - (1 - \tau_b) \tau_p^c
\]

\[
\frac{\delta^{c-eq} + d^c}{(1 - \tau_b)} = \frac{MRP_{c-eq}}{p^c} + \frac{\tau_b z^{c-eq} + \tau_b IA^c + ITC^c}{(1 - \tau_b)} \left( \delta^{c-eq} + d^c \right) - \tau_p^c
\]

\[
\frac{MRP_{c-eq}}{p^c} - \delta^{c-eq} = \frac{\left( \delta^{c-eq} + d^c \right) \left[ 1 - \tau_p^c z^{c-eq} - \tau_b IA^c - ITC^c \right]}{(1 - \tau_b)} + \tau_p^c - \delta^{c-eq}.
\]