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The Redistributional Consequences of Tax Reform Under Financial Integration*

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Abstract

I quantify the welfare effects of replacing the US capital income tax with higher labor income taxes under international financial integration using a two-country, heterogeneous-agent incomplete markets model calibrated to represent the US and the rest of the world. Short-run and long-run factor price dynamics are key: after the tax reform, interest rates rise less under financial openness than in autarky. Therefore, wealthy households gain less. Post-tax wages also fall less as a result of the faster capital accumulation, so the poor are hurt less. Hence, the distributional impacts of the reform are significantly dampened relative to autarky although a majority of households prefer the *status quo*. Aggregate welfare effect to the US is a permanent 0.2% consumption equivalent loss under financial openness which is roughly 15% of the welfare loss under autarky.

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1 Introduction

Should the US capital income tax be eliminated? Capital tax cuts in general, such as the one introduced by the Bush administration in 2003 and extended through 2012, have been the subject of intense debate in both academic and policy circles.[1] Supporters of these tax reforms argue that they promote investment and output, and improve efficiency. Opponents, on the other hand, are concerned with the negative wealth distributional consequences of these reforms. They suggest that a capital tax cut primarily helps the rich.

Previous work studying the distributional effects of tax reforms has modelled the US as a closed economy, assuming that it has no access to international financial markets. However, the globalization process has evolved over the past 30 years, deepening financial imbalances and making the US the biggest debtor country in the world.[2] The redistributive consequences of tax reforms in such a setting have not yet been examined. This study is the first attempt in the literature to quantify the desirability of capital income tax reforms in which the US is modelled as part of a financially integrated global economy. In particular, taking as given a realistic wealth distribution for the US in a two-country, heterogeneous agent-incomplete markets framework, this paper explores how both macroeconomic aggregates and the distribution of wealth across households respond to replacing the capital income tax with higher labor income taxes.

The key argument of the current work is that in a large open economy like the US, a tax reform of this size can affect the dynamics of world factor prices and induce large international capital flows. These dynamics in turn alter the quantitative impact on the wealth redistribution and determine to what extent households may favor the tax reform.

Following Chamley (1986) and Judd (1985), a main finding in the Ramsey literature is that in the standard neoclassical growth model it is not optimal to tax capital in the long run. In a similar framework, a related policy prescription by Lucas (1990) was that if the highly distortionary capital income tax were to be replaced by a higher (and less distortionary) labor income tax in the US, households could enjoy significant welfare gains (a 1 percent increase in annual consumption) as the capital income tax cut stimulates

[1] The Bush tax reform, known as the Jobs and Growth Tax Relief Reconciliation Act (JGTRRA), encompasses a cut in both capital gains and dividend taxes. This paper however, focuses only on capital gains taxes and aims to address a central question in this literature regarding the elimination of capital income taxes.

[2] The US net foreign asset position reached -17% of its GDP in 2007, while the current account deficit reached 5.1%. Source: Lane and Milesi-Ferretti (2007) and World Development Indicators.

investment, output and consumption.[3] While the elimination of the capital income tax seems attractive in these closed economy models, it becomes even more attractive in a financially open economy since international borrowing amplifies the stimulus to investment and output and enable greater consumption smoothing during the transition period. Mendoza and Tesar (1998) pointed out the importance of this channel, in a two-country neoclassical growth model. In such a setting, the elimination of the capital income tax leads to welfare gains to the US up to 33% more than in a closed economy model.

My model economy preserves these economy-wide long run potential gains from eliminating the capital income tax. However, the government's need to increase other taxes, such as the labor income tax, in order to maintain fiscal solvency has adverse wealth distributional effects. In particular, the tax reform may be opposed by households who hold low levels of assets and rely predominantly on labor income; while supported by wealthy households who receive proportionally more capital income. Indeed, in a closely related work, Domeij and Heathcote (2004) quantitatively showed that in an autarkic economy, given the highly concentrated US wealth distribution, the elimination of the capital income tax would not be supported by the majority of the population. I argue that in order to make a more realistic statement on the desirability of a tax reform, openness should be an ingredient of the analysis.

The importance of looking at the problem under financial openness can be understood through the following mechanism. A capital income tax cut increases the demand for capital by the production sector, raising both the equilibrium capital stock and the after-tax interest rate in the economy. While this also implies a rise in wages, after-tax wages decline since the capital income tax cut is accompanied by a sufficiently higher labor income tax. The qualitative properties of this mechanism are common to both closed economy and large open economy models, but the quantitative effects differ. In a two-country setting, the policy-induced increase in the return to capital leads to an inflow of capital from the rest of the world. As a result, interest rates increase by less than under autarky. Hence, the gains to rich households are smaller.[4] In addition, the more rapid accumulation of capital raises the marginal product of labor relative to autarky, thereby mitigating the decline in after-tax wages. This implies that poor households are not hurt by the reform as much as a closed economy model would predict. This motivates the

[3] As Lucas put it, the welfare gain is twice that of eliminating 10% inflation, and about 20 times that of eliminating the business cycle.

[4] Throughout the text, 'rich' and 'poor' are used interchangeably for 'wealth-rich' and 'wealth-poor', respectively, unless stated otherwise.

question of the current paper: are these quantitative changes in wage and interest rate dynamics under financial openness sharp enough that a majority will support the tax reform?

To answer this question, I employ a two-country version of the Aiyagari (1994) model where the two countries are calibrated to represent the US and the rest of the world (ROW).[5] The framework is related to the heterogeneous-agent incomplete markets models first analyzed by Bewley (1986), İmrohoroğlu (1989), Huggett (1993), as well as Aiyagari (1994) which is a one-sector neoclassical growth model with uninsurable idiosyncratic labor income risk and borrowing constraints.[6] I further enhance the model by including government policy. In this setting, I conduct an experiment *à la* Lucas (1990) by introducing a unilateral, unanticipated and permanent capital income tax cut in the US.[7] To finance a fixed stream of government expenditures, both countries adjust their labor income taxes such that the present value of the government budget holds. The US economy is simulated both under financial autarky and financial integration, and the consequences of the reform are evaluated taking into account both steady state gains and the transitional dynamics. In particular, households with various initial wealth and labor productivity levels are tracked over time after the reform takes place, and their welfare is compared to the *status quo*. The calibration of the benchmark model of financial openness is realistic in the sense that at the initial steady state equilibrium both macroeconomic aggregates and asset holdings across different wealth groups in the US match the data closely.

I show that financial openness plays a key role in mitigating the adverse redistributional effects of the tax reform. For instance, households that are at the top 1% of the US wealth distribution prior to the reform enjoy around a permanent 12% consumption equivalent gain under financial autarky, while their gain is reduced to 6% under financial integration. On the other hand, households at the bottom 1% of the wealth distribution are estimated to suffer a permanent 5% consumption equivalent loss under financial autarky, while the loss shrinks to 1.8% under financial integration. Moreover, the fraction of the population with positive welfare gains is estimated as 3% larger under financial

[5]ROW represents Euro Area, Japan, oil exporters and emerging Asia. A list of the countries are given in the appendix.

[6]This class of models has become the standard workhorse approach in investigating the relationship between macroeconomic phenomena and their distributional consequences.

[7]See Aiyagari and McGrattan (1998), Flodén (2001), Domeij and Heathcote (1994), Röhrs and Winter (2011), and Azzimonti, de Fransisco and Quadrini (2012) with examples of government policy in a heterogeneous agent-incomplete markets framework.

openness than under financial autarky, with about 29% of the US households in favor of the reform.[8] Hence there is still not a majority to support a capital income tax cut when financial openness is taken into account.

A second result is that the aggregate welfare gain to the economy due to the elimination of capital tax is negative, although this welfare loss is negligibly small: a permanent 0.24% loss in consumption. The closed economy predicts a permanent 1.55% decline in consumption, implying a cost that is 6.5 times that of the open economy. In both model economies, a tax cut yields steady state gains but interestingly, the steady state gain under financial openness is lower. This is because in the long run, households service the foreign debt accumulated during the transition, thereby sacrificing some of their consumption in the new steady state. Nevertheless, the transition to the new steady state is much less costly for the open economy since international borrowing makes the transition path of aggregate consumption smoother.

The aggregate welfare result is in line with the literature studying capital taxation under incomplete asset markets characterized by uninsured idiosyncratic risk and borrowing constraints. Domeij and Heathcote (2004) find a negative result. Ábrahám and Cárceles-Poveda (2009) report negative aggregate welfare results studying tax reforms with endogenous borrowing constraints and flat rate taxes.

For a closed economy and in the presence of precautionary savings motive, Aiyagari (1995) suggests that households accumulate too much capital so that taxing capital helps bring the capital stock to the optimum level. Therefore, a positive capital income tax is optimal in the long run. İmrohoroğlu (1998) and Conesa, Kitao and Krueger (2009) study tax reforms in life cycle models when households are uninsured against idiosyncratic labor income risk and face borrowing constraints. In these environments, replacing the capital income tax by a higher labor income tax imposes greater burden on agents when they are younger and liquidity constrained, reducing their ability to smooth consumption. They also quantitatively characterize the optimal capital tax rate and find that a positive tax is optimal. It is still an open question what the optimal capital income tax should be when we move away from financial autarky. However, characterizing the optimal capital income tax is beyond the scope of this paper and left as future work.

In open economy models, domestic tax policy has been shown to have effects on other countries' tax policies. Klein, Quadrini and Ríos-Rull (2005) and Quadrini (2005) analyze

[8] According to US Census Bureau data (July 2012), this difference corresponds to roughly 9.9 million people on average.

tax policy when governments conduct optimal fiscal policy without commitment under international mobility of capital. Mendoza and Tesar (2004), Mendoza, Tesar and Zhang (2013) evaluate strategic tax reforms in Europe in a two-country neoclassical growth model. In the current paper, the ROW labor income tax needs to be altered in response to an elimination of the US capital income tax. Since the elimination of the US capital income tax does not create gains for the majority of the population, the reform is not desirable to implement. Hence, for this particular reform, we do not mention any need for the ROW government to give a strategic response by altering the ROW capital income tax. Still, it is important to note that the reforms under two-country representative agent models appear to yield markedly different aggregate welfare results compared to the current model. For the heterogeneous agent-incomplete markets models, therefore, the strategic implications of tax competition may also be different and should be left as a future research question.

This study is also related to two papers by Mendoza, Quadrini and Ríos-Rull (2009a; 2009b). In a two-country heterogeneous agents model, they depict how global financial imbalances have emerged as well as quantifying the welfare effects of financial integration (Mendoza, Quadrini and Ríos-Rull (2009a)). The current framework is complementary to this strand of the literature in two dimensions. First, it explains how a capital income tax cut may deteriorate the US net foreign asset and current account imbalances. In this case, increasing the capital taxes, rather than decreasing, may help reduce the global financial imbalances. Second, the current paper gives an understanding of how tax policy may mitigate or exacerbate the negative redistributional consequences of financial globalization through wage and interest rate dynamics. Financial liberalization, alone, is an important channel in altering these dynamics and creating adverse redistributional consequences especially in financially less developed countries and for poor households. The current work, therefore, suggests a mechanism for policy-makers in shaping their tax policies in these countries.

I proceed with the model in the next section. In section 3, I discuss the long run equilibrium effects of a capital income tax cut and explain the numerical solution as well as the calibration strategy. Section 4 provides the results and section 5 concludes.

2 The Model

I introduce a two-country heterogeneous-agent, incomplete markets model. There are two financially integrated countries in the world economy, *Home* and *Foreign*. Foreign variables are denoted by an *asterisk* (*). For convenience, the model is presented for *Home* only and *Foreign* variables are introduced when needed.

2.1 Production sector

Following the literature, all household-level variables are denoted by lowercase letters and aggregate variables are denoted by uppercase letters. In both countries, each household owns a firm producing output, y_t, using capital k_t, and labor n, according to a constant returns to scale production function

$$y_t = F(k_t, n) \tag{1}$$

Capital depreciates at the rate $\delta \in [0, 1]$. All parameters of production are the same across households and countries. In each country, households competitively supply physical capital to the firms at a real rental rate r_t^k and labor (inelastically) at a real wage rate w_t where both factors are assumed to be immobile internationally. Perfect competition in factor markets implies firms make zero profits in equilibrium.

2.2 Government

The government in each country collects tax revenues from labor and equity and issues debt D_{t+1} at each period t to finance an exogenous stream of real per capita government expenditures, G. The real one period return to government debt is risk-free and equal to r_t^d. In contrast to private debt, public debt is assumed not to be traded internationally as there would not be a well-defined portfolio choice between the two assets. The government does not make any transfers. At $t = 0$, the government introduces a tax reform so that a new pair of taxes τ^n and τ^k are imposed. The date$-t$ budget constraint for each government is as follows:

$$G + r_t^d D_t = D_{t+1} - D_t + N w_t \tau^n + K_t(r_t^k - \delta)\tau^k \tag{2}$$

$$G^* + r_t^{d*} D_t^* = D_{t+1}^* - D_t^* + N^* w_t^* \tau^{n*} + K_t^* (r_t^{k*} - \delta) \tau^{k*} \quad (3)$$

given D_0 and D_0^*.

2.3 Households

Each country is inhabited by a continuum of unit mass of households which receive shocks to labor efficiency, $\varepsilon_t \in E$ which are i.i.d. across households and persistent over time. This is the only uncertainty in the model. Household choices in period t are made after observing ε_t. A household receiving a shock ε_t earns a labor income $\varepsilon_t n w_t$. The efficiency shock ε_t evolves over time according to a m-state ($m < \infty$) first-order Markov process defined with an $m \times m$ transition probability matrix $\Pi = [\pi_{ij}]$, where $\pi_{ij} = \Pr(\varepsilon_{t+1} = \varepsilon_j | \varepsilon_t = \varepsilon_i)$. All elements of Π are non-negative and each row sums up to 1. I denote the finite history of these shocks from date 0 up to date t by $\varepsilon^t = \{\varepsilon_0, ..., \varepsilon_t\}$. To denote the probability distribution over E at any period t, I use the vector $p_t \in \mathbb{R}^m$. Initial distribution is denoted by p_0 and the date$-t$ distribution is then given by $p_t = p_0 \Pi^t$. E has a unique ergodic set, no cyclically moving subsets and for any given p_0, $\{p_t\}_{t=0}^{\infty}$ converges to the (unique) limit p^*. I start by assuming $p_0 = p^*$, therefore the aggregate effective labor supply N converges to a constant.[9]

Households maximize their expected life-time utility given by

$$E_0 \left[\sum_{t=0}^{\infty} \beta^t U(c_t) \right] \quad (4)$$

where $\beta \in (0, 1)$ is the discount rate. The period utility function $U(\cdot)$ is strictly increasing, strictly concave and continuously differentiable. In each period, a household's consumption is denoted by c_t and hours worked by n with $n \in [0, 1]$. I assume a single composite consumption good, traded across countries.

Households face the following budget constraint taking as given the relative prices and tax rates at each period

[9] Normalizing $\sum_j^m p_j^* \varepsilon_j = 1$, it follows that $n = N$.

$$c_t + \underbrace{b_{t+1} + d_{t+1} + k_{t+1}}_{\equiv a_{t+1}} \leq \varepsilon_t n w_t (1-\tau^n) + \underbrace{[(r_t^k - \delta)(1-\tau^k) + 1]k_t + (1+r_t^d)d_t + (1+r_t)b_t}_{\equiv (1+r_t)a_t}$$

Household expenditures are given on the left-hand side of the budget constraint. Accordingly, they may purchase consumption goods c_t and borrow or lend in the amount of their asset holdings, a_{t+1}. Specifically, households may invest in either 1-period, non-state-contingent private bonds, b_{t+1} which are internationally traded at an interest rate r_t, non-state-contingent public bonds d_{t+1}, which are traded only domestically at an interest rate r_t^d or capital goods, k_{t+1}. The right-hand side of the budget constraint includes factor and non-factor income of the household. Households' after-tax labor income is given by $\varepsilon_t n w_t (1-\tau^n)$ where $\tau^n \in [0,1]$ is a constant, flat-rate labor income tax. A flat-rate, constant tax rate $\tau^k \in [0,1]$ is also imposed on households' net return from physical capital and therefore physical capital has an after-tax return of $1 + (r_t^k - \delta)(1-\tau^k)$. Both tax rates may differ across countries. Finally, private bond holdings yield an income equal to $(1+r_t)b_t$ and public debt holdings yield $(1+r_t^d)d_t$. Notice that optimal portfolio allocation implies

$$r_t = r_t^d = (r_t^k - \delta)(1-\tau^k) \tag{5}$$

Hence, the international return on private bonds is equal to the net-of-tax return on physical capital at each period. Since the model assumes no aggregate TFP shocks and the real one-period return from private and public debt are guaranteed (assuming that there is no default on private or public debt in any countries) all three assets are considered perfect substitutes. Therefore, we are able to state the household's problem without considering the portfolio composition of assets. The budget constraint can now be rewritten as

$$c_t + a_{t+1} \leq \varepsilon_t n w_t (1-\tau^n) + (1+r_t)a_t \tag{6}$$

In each period, individuals are able to borrow up to an exogenous limit, denoted by $\underline{a}$. Therefore at any period t

$$a_t \geq \underline{a}. \tag{7}$$

The borrowing constraint is the same for all individuals in a country and the same across countries. When households face a borrowing constraint, this implies that a household can have a long position in one type of asset while having a short position in another to the extent that the net asset position does not fall below the limit.

Define $s_t = (a_t, \varepsilon_t)$ as the state vector of the household at any t. Given the deterministic sequences of factor prices $\{w_t, r_t^k, r_t^d, r_t\}_{\tau=0}^{\infty}$, a constant level of taxes and government expenditures $\{\tau^n, \tau^k, G\}$ and initial conditions $s_0 = (a_0, \varepsilon_0)$ in any country, a household maximizes (4), subject to (6) and (7).

The resource constraint in $Home$ is given by (and similarly defined for $Foreign$)

$$C_t + I_t + G + B_{t+1} - B_t = Y_t + r_t B_t \tag{8}$$

where $I_t \equiv K_{t+1} - (1-\delta)K_t$ is net domestic, private investment and $B_t \equiv A_t - K_t - D_t$ is the date$-t$ net foreign asset position for $Home$, where B_0, K_0 and D_0 are given. We similarly define the net foreign asset position for $Foreign$, $B_t^* \equiv A_t^* - K_t^* - D_t^*$ and also take B_0^*, K_0^* and D_0^* as given. Having defined the net foreign asset position, we can also define the $Home$ current account, $CA_t \equiv B_{t+1} - B_t$, net exports, $NX_t \equiv B_{t+1} - B_t(1+r_t)$ and net factor payments, $NFP_t \equiv r_t B_t$ which can be similarly defined for $Foreign$.

2.4 Equilibrium

Let A be the set of the possible values of household wealth (set of endogenous states). Since households are allowed to borrow up to an exogenous (negative) limit, $\underline{a}$, $A = [\underline{a}, \infty]$. Let $(A, \mathcal{A})$ and $(E, \mathcal{E})$ be measurable spaces where $\mathcal{A}$ denotes the Borel set that are subsets of A and $\mathcal{E}$ is the set of all subsets of E. Let $(S, \mathcal{S}) = (A \times E, \mathcal{A} \times \mathcal{E})$ be the product space and S is the set of all possible household states. The solution to the household's problem provides the decision rules for consumption, $c_t = h_c(a_t, \varepsilon_t)$ and asset holdings, $a_{t+1} = h_a(a_t, \varepsilon_t)$ given the initial conditions (a_0, ε_0) and if the history of idiosyncratic shocks up to t is ε^t. These rules determine the evolution of the distribution of agents over s_t. I define the joint distribution of households across both household wealth and labor efficiency at date t by $\Gamma_t(a_t, \varepsilon_t)$. A household with the state s_t will have a state vector lying in S_{t+1} next period, given this period's distribution $\Gamma_t(a_t, \varepsilon_t)$ and the decision rules $h_c(a_t, \varepsilon_t)$ and $h_a(a_t, \varepsilon_t)$. Given $\Gamma_0(a_0, \varepsilon_0)$, the distribution evolves with the law of motion defined by

$$\Gamma_{t+1}(a_{t+1}, \varepsilon_{t+1}) = \sum_{\varepsilon} \Pi(\varepsilon_{t+1}|\varepsilon_t)\Gamma_t(h_a^{-1}(a_{t+1}, \varepsilon_t), \varepsilon_t) \tag{9}$$

The definition of competitive equilibrium under financial integration is given below.

Definition 1 ***(Financial integration)*** *Initial joint distributions of individuals across both individual wealth and labor efficiency shocks in the two economies are given by* $\Gamma_0(a_0, \varepsilon_0)$ *and* $\Gamma_0^*(a_0^*, \varepsilon_0^*)$. *Idiosyncratic risk washes out in aggregate. Given initial distributions, net foreign asset positions,* B_0, B_0^*, *public debt* D_0, D_0^*, *capital stock* K_0, K_0^*, *fiscal policy instruments* $\{G, G^*, \tau^n, \tau^{n*}, \tau^k, \tau^{k*}\}$, *a general equilibrium under financial integration is defined by*

1. Households' policy functions $\{h_c(s_t),\ h_c^*(s_t),\ h_a(s_t),\ h_a^*(s_t)\}_{t=0}^{\infty}$

2. A competitively determined, deterministic path of relative prices $\{w_t, w_t^*, r_t^d, r_t^{d*},$

   $r_t^k, r_t^{k*}, r_t\}_{t=0}^{\infty}$

3. A deterministic path of macroeconomic aggregates $\{C_t, C_t^*, A_{t+1}, A_{t+1}^* K_{t+1}, K_{t+1}^*,$

   $B_{t+1}, B_{t+1}^*, D_{t+1}, D_{t+1}^*\}_{t=0}^{\infty}$

4. Distributions $\{\Gamma_t(a_t, \varepsilon_t), \Gamma_t^*(a_t^*, \varepsilon_t)\}_{t=1}^{\infty}$

such that

- Given the sequences of plans and policies, the plans are optimal for individuals and firms (as described below).

- The aggregates are consistent with household behavior,

$$\int_s c_t(s_t)d\Gamma_t = C_t, \int_s a_t(s_{t-1})d\Gamma_t = A_t, \text{ for all } t. \tag{10}$$

$$\int_s c_t^*(s_t)d\Gamma_t^* = C_t^*, \int_s a_t^*(s_{t-1})d\Gamma_t^* = A_t^*, \text{ for all } t. \tag{11}$$

- Labor markets clear domestically,

$$\int_s \varepsilon_t n d\Gamma_t = N \text{ and} \int_s \varepsilon_t n^* d\Gamma_t^* = N^*, \tag{12}$$

- Goods market clears,

$$C_t + C_t^* + I_t + I_t^* + G + G^* = \int_s y_t(s_t)d\Gamma_t + \int_s y_t^*(s_t)d\Gamma_t^*, \text{ for all } t. \tag{13}$$

- Asset market clears,

$$B_t + B_t^* = 0, \text{ for all } t. \tag{14}$$

- The government budget holds in each country for all t.
- The sequence of distributions Γ_t, Γ_t^* is consistent with the initial distribution, individual policies and idiosyncratic shocks for $t \geq 1$.

2.5 Characterizing the equilibrium

The first order conditions from the optimization problems above are given below.

1. Firm's optimization:

$$r_t^k = F_k(k_t, n) \tag{15}$$

$$w_t = F_n(k_t, n) \tag{16}$$

The conditions for *Foreign* can be defined similarly. Given these two first order conditions and that labor supply is inelastic, all households hold the same level of capital stock. Hence, the assumption that production is operated by households helps identify the level of capital stock in the households' portfolio.[10]

2. Household's optimization:

$$U_c(s_t) = \beta E_{\varepsilon_{t+1}|\varepsilon_t}(1 + r_{t+1})[U_c(s_{t+1}) + \tilde{\lambda}(s_{t+1})] \tag{17}$$

where and $\tilde{\lambda}$ is the Lagrange multiplier associated with the borrowing constraint. Again, similar conditions are defined for *Foreign.*

[10] The assumption that production is operated at the household level is also used in Mendoza, Quadrini, and Rios-Rull (2009a).

3 The tax reform

The tax reform occurs at $t = 0$, when the world economy is in the steady state. The *Home* government introduces a permanent, unanticipated capital income tax cut, and increases the labor income tax to compensate the lost revenue. The reform is transmitted to *Foreign*, requiring a change in the labor tax to maintain fiscal solvency. Hence, Foreign introduces the tax reform at $t = 0$.

In this section, I provide some intuition for how tax reforms affect the steady-state allocations and how these results compare to those of a closed economy. I start with explaining how the international interest rate is determined in the steady state.[11] Consider that both countries are populated by a unit measure of households and labor is inelastically supplied. Assume that the production function is defined as Cobb-Douglas, $F(k, n) = k^{\alpha} n^{1-\alpha}$ where α is the share of capital in production.

Optimal portfolio choice in addition to firm's optimization implies that in the US after-tax net return to capital is equal to the interest rate

$$(r^k - \delta)(1 - \tau_k) = (\alpha k^{\alpha-1} n^{1-\alpha} - \delta)(1 - \tau_k) = r \tag{18}$$

and similarly in *Foreign*,

$$(r^{k*} - \delta)(1 - \tau_k^*) = (\alpha k^{*\alpha-1} n^{*1-\alpha} - \delta)(1 - \tau_k^*) = r \tag{19}$$

Note that the economy-wide and household-level capital stock and hours worked are equal, i.e. $k = K$, $n = N = 1$. If there exists an equilibrium with financial integration, these two conditions must yield

$$r = (\alpha K^{\alpha-1} - \delta)(1 - \tau_k) = (\alpha K^{*\alpha-1} - \delta)(1 - \tau_k^*) \tag{20}$$

Therefore, after-tax net returns to physical capital are equalized across countries under financial integration. If an equilibrium with $\tau_k \neq \tau_k^*$ exists, this implies cross-country differences in capital stock and employment. In particular, if $\tau_k < \tau_k^*$, aggregate capital in Home is greater than Foreign, i.e. $K > K^*$. Notice that if physical capital were traded internationally and households paid taxes according to the resident principle then optimality would require that cross-country capital income tax rates be equalized, $\tau_k =$

[11] A closed economy version of a similar analysis can be found in Aiyagari (1995).

τ_k^*.[12]

Moreover, government's steady-state budget constraint can be expressed as follows:

$$K + D = \frac{K}{1-\tau_k} + \frac{\tau_n w - G}{r} \tag{21}$$

and

$$K^* + D^* = \frac{K^*}{1-\tau_k^*} + \frac{\tau_n^* w^* - G^*}{r} \tag{22}$$

For a given set of tax rates and government expenditures, the $K+D$ curve is decreasing in r for both countries. This is because as r rises, r^k rises and w falls. This implies lower K. This is similar for $Foreign$. As $r \to \infty$, K and $w \to 0$. On the other hand, if $r \to 0$, then K and $w \to \infty$. Supply of assets are determined by the household's problem and as defined above, aggregate household savings in each country are given by $\int_s a d\Gamma = A$ and $\int_s a^* d\Gamma^* = A^*$. As shown by Aiyagari (1994; 1995), A is an increasing function of r (which follows from the fact that household policy functions are increasing in r for each country. The equations (20)-(22) along with households' aggregate savings determine the equilibrium in the world asset market. Furthermore, under market incompleteness, aggregate asset holdings tend to infinity as r approaches the rate of time preference, $1/\beta - 1$ from below. As discussed by Aiyagari (1994;1995), a household wants to maintain a smooth marginal utility of consumption when $r = 1/\beta - 1$. When households face uninsurable labor income risk, however, the possibility of having bad income shocks in the future requires households to accumulate infinite amount of assets in order to maintain a smooth marginal utility of consumption profile.

An equilibrium with financial integration exists if there exists a steady state interest rate r such that

$$A(r) - K - D + A^*(r) - K^* - D^* = 0 \tag{23}$$

[12] The resident principle requires that Home's households are imposed with the same tax rate for their domestic and foreign capital holdings. If equity were traded internationally and under the assumption of resident principle, the optimal portfolio allocation for Home residents would imply $r = (\alpha K^{\alpha-1} - \delta)(1 - \tau_k) = (\alpha K^{*\alpha-1} - \delta)(1-\tau_k)$ where $K = K_1 + K_2$ is the total domestic equity, K_1 is the (aggregate) domestic equity holding of Home residents and K_2 is the (aggregate) domestic equity holding of Foreign residents. A similar condition for Foreign residents can be stated as $r = (\alpha K^{\alpha-1} - \delta)(1-\tau_k^*) = (\alpha K^{*\alpha-1} - \delta)(1-\tau_k^*)$ where total foreign equity can be defined similarly, $K^* = K_1^* + K_2^*$. In this case, cross-country capital tax rates would be equalized, which would be unrealistic given the cross-country differences in tax rates in the data.

i.e. if the global asset market clears.

When countries are symmetric, i.e. if they have identical sets of tax rates and government spending, there exists an equilibrium with balanced trade (or zero net foreign asset position), i.e.

$$B(r) = A(r) - K - D = 0 \tag{24}$$

and

$$B^{*}(r) = A^{*}(r) - K^{*} - D^{*} = 0 \tag{25}$$

which yields asset market clearing at the global level

$$B(r) + B^{*}(r) = 0. \tag{26}$$

This is the case where asset demand and supply curves of the two countries are on top of each other, similar to the autarky case. See Figure 1 for a possible graph.

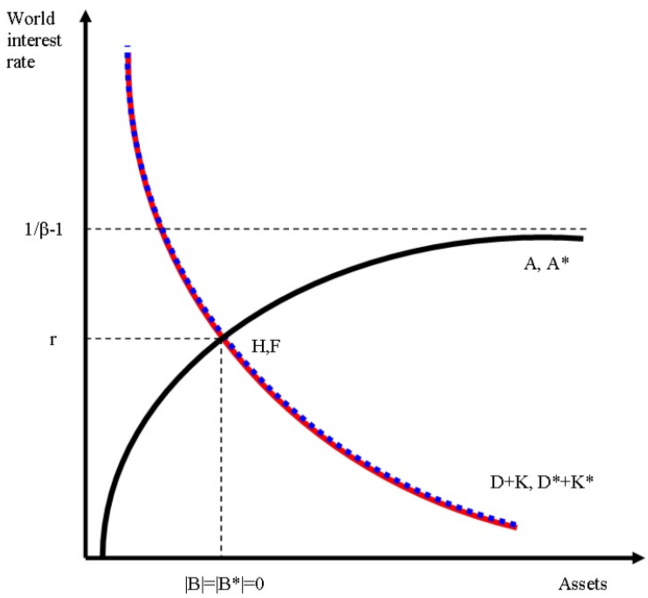

Figure 1: Steady-state equilibrium under financial integration where countries have identical fiscal policy parameters and balanced trade

In a more realistic case, assume that the two countries apply different capital income taxes and say capital income tax in Home, τ_k is lower. This implies the asset demand curve for Home, $K + D$ lies to the right of the asset demand curve for Foreign (See Figure 2). The logic is as follows. For a given world interest rate r, if τ_k is lower r_k is lower and K/N ratio and K is higher (See equation (21); similar logic applies to Foreign by equation (22); which implies w is higher and K is higher. For the sake of simplicity and to highlight the effects of fiscal policy, I assume that the initial conditions of the two countries are different only due to the differences in fiscal policy parameters. Hence I assume that Home has a lower capital income tax in the pre-reform steady state. This implies that from the comparative static analysis above, the $K + D$ curve for Home lies to the right of the $K^* + D^*$ curve of Foreign, i.e. the steady-state capital stock in Home is higher due to the lower capital income tax rate.

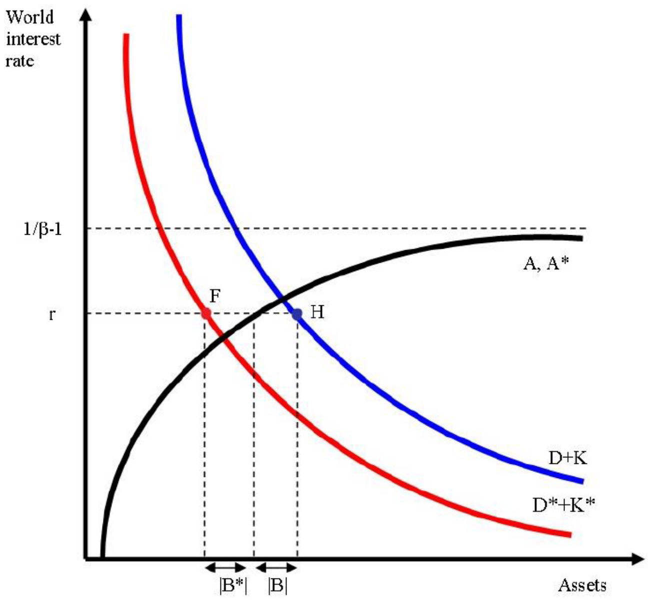

Figure 2: Pre-reform steady-state equilibrium where Home imposes a lower capital income tax than Foreign

As a result, there is excess supply of capital in Home and excess demand for capital in Foreign yielding a negative foreign asset position for Home and a positive foreign asset position for Foreign at the equilibrium interest rate, i.e. for a given world interest rate r,

$$B(r) = A(r) - K - D < 0 \tag{27}$$

and

$$B^*(r) = A^*(r) - K^* - D^* > 0. \tag{28}$$

Therefore, in my model, the global net foreign asset imbalances is mainly a consequence of the cross-country capital tax differences.[13] Cross-country differences in labor income taxes, government expenditures, or public debt stock also cause shifts in these curves and most importantly, the asset supply curves do not necessarily overlap. But as shown in the next section, the properties of the initial steady state equilibrium are qualitatively similar to those depicted in Figure 2.

Removing the capital income tax in Home implies that *Home (Foreign)* increases (decreases) its capital stock, *Home*'s (*Foreign*'s) net foreign asset position deteriorates (improves) and the world interest rate rises due to *Home* tax reform. This also implies higher output for *Home*. *Foreign*, on the other hand, suffers a loss of capital stock and lower output. However, a quantitative experiment is required to see how the government debt stock evolves and the new labor income tax is determined in response to a capital tax cut. In this framework, the post-reform steady state equilibrium allocations are solved simultaneously with the transition path. The next section explains these dynamics in detail.

3.1 Numerical solution and calibration

Since the model involves inequality constraints, local approximation techniques are not appropriate to approach the problem at hand. I use a technique called the endogenous grid point method by Carroll (2006), blending the time-iteration method by Coleman (1990) and policy function iteration.[14] I solve the pre and post-tax reform steady states

[13] In Mendoza et al. (2008a) for example, global imbalances are modeled as a result of heterogeneity of countries in the degree of their market incompleteness, which is reflected in the cross-country differences between household borrowing constraints.

[14] Time iteration is a convenient method that can deal with inequality constraints easily. It also relies on interpolation techniques and therefore preserves the continuity of the state space. Coleman (1990) suggests using a root-finding algorithm (a variant of Newton's method) to solve for the decision rules which requires a lot of computing time. Carroll (2006) however, provides a faster method that avoids a nonlinear equation solver. In particular, we only compute the expected marginal utility in the Euler equation and then solve for the current period's consumption algebraically.

as well as the transitional path based on the endogenous grid point method.

Assuming the post-tax steady state is converged at time T, the post-reform steady state can be computed once the levels of public debt, D_T and D_T^* are known. These however, depend on their values in the transition, therefore the final steady state and the transition need to be computed simultaneously. First, the pre-reform steady state is computed. Then the post-reform steady state and the transition are computed based on a variant of shooting algorithm. Once the paths of government debt are known for each country, the post-reform labor income tax rates are determined endogenously. In addition, the parameters of government expenditures are determined endogenously. The details of the solution technique are provided in the appendix.

I calibrate the model to match the US and ROW macroeconomic aggregates and wealth distribution (only for the US). ROW consists of Japan, Euro Area, Emerging Asia and Oil Exporting Countries (A complete list of the countries can be found in the appendix). The number of targets to be matched is high compared to the existing literature, and there is little room in the model to match both the aggregates and the distributions. Despite these challenges, the current parameterization is able to match the targets to a great extent.

Preferences and Technology: Benchmark model parameterization is summarized in table 1 below. Accordingly, capital's share in output is 0.36, and the depreciation rate is 0.06. I assume a CRRA utility function with the coefficient of risk aversion is 1, implying log utility. The discount rate is set at 0.965 and the resulting steady state capital-output ratio is 3.40 for the US and 3.27 for the ROW.

Borrowing limits: I set them in each country at $\underline{a} = 0$, hence households are not allowed to borrow.

Labor productivity process: These are taken from Domeij and Heathcote (2004) where it is assumed that there are three productivity shock levels, $E = \{\varepsilon^h, \varepsilon^m, \varepsilon^l\}$ with $\varepsilon^h = 4.74$, $\varepsilon^m = 0.847$ and $\varepsilon^l = 0.170$, and identical in both countries. The transition probabilities are given by

$$\Pi = \begin{bmatrix} \Pi_{11} & 1-\Pi_{11} & 0 \\ \frac{1-\Pi_{22}}{2} & \Pi_{22} & \frac{1-\Pi_{22}}{2} \\ 0 & \Pi_{11} & 1-\Pi_{11} \end{bmatrix} = \begin{bmatrix} 0.90 & 0.10 & 0 \\ 0.005 & 0.99 & 0.005 \\ 0 & 0.10 & 0.90 \end{bmatrix}$$

This parameterization yields an endogenous wealth distribution that matches the overall wealth inequality, the Gini coefficient closely in the data (1992).

Table 1: Distributional properties of the pre-reform steady-state

	Model		Data
	US (FI)	ROW (FI)	US
Wealth Gini (Pre-reform)	0.76	0.76	0.78
Asset holding distribution			
Top 1%	11.30%	11.31%	29.6%
Top 10 %	59.48%	58.41%	66.1%
Top 20 %	82.52%	81.58%	79.5%
Bottom 40 %	1.43%	1.10%	1.33%

In the model, the poorest 40% of the US households (under financial integration) hold 1.43% of total wealth and the richest 10% hold 59.48%. As we move towards the right-end of the asset distribution however, the model is less able to match the data. However, since it is the wealth-poor households that are most likely to suffer from the reform, matching the left-tail of the asset distribution closely is sufficient to determine the fraction in favor of the reform. On the other hand, since the asset holdings of the rich are underestimated, the potential aggregate welfare gains of the tax reform are underestimated, as well. Since a household will support the reform as long as the household's gain is positive, the relatively weak estimation of the right-tail of the distribution does not affect the analysis on the desirability of the tax reform.

Government policy: I set the US capital and labor income tax at 39.7% and 26.9%, respectively, following Domeij and Heathcote (2004) where they report the average tax rates for the period 1990-1996, based on the methodology of Mendoza, Razin and Tesar (1998).[15] Since these estimates are based on OECD data, the tax estimates are unavailable for many countries in the ROW and calculated only for G7 countries. If I restrict the set of countries to G7, however, the resulting allocations are unable to capture macroeconomic aggregates in the data, especially the US external debt position.[16] Therefore, I set the capital tax rate for the ROW in order to match the global financial imbalances. The capital income tax rate for the ROW is 45%. Another way of interpreting these taxes is that the institutional imperfections in the ROW are reflected as a wedge on capital and

[15] Landry (2011) updated these estimates for 2009, and the capital and labor income tax for the US are 38% and 22.3%, respectively.

[16] The major foreign holders of U.S. treasury securities in 2012 include Japan, China, emerging Asian countries and oil exporters.

labor returns.[17] I set the labor income tax rate for the ROW at 22% to create a wealth distribution similar to that of the US I set D_0 and D_0^* to match the US and ROW public debt-to-GDP ratio (which also determines the government spending-to-GDP ratio, given the tax rates.) These values match the data closely.

Table 2: Parameterization in the pre-reform steady state

Technology, preferences	α	β	δ	σ	$\underline{a}$	
& borrowing limit	0.36	0.965	0.06	1	0	
Fiscal policy	D/Y	D^*/Y^*	τ^k	τ^{k*}	τ^n	τ^{n*}
	0.66	0.60	0.397	0.45	0.269	0.22

The model yields the net foreign asset-to-GDP ratio for the US as -19.5%, which is close to the data reported by Lane and Milesi-Ferretti (2007). These values range between -16% and -20% during 2004-2007. For ROW, the model yields the NFA-to-world GDP ratio of 9.87% which is close to 9.5% observed in 2006. Public debt-to-GDP ratio for the US is 66% while for the ROW is 60%. For the US in 2009, this value was 67% (Central Government Debt from *World Development Indicators*). For the ROW, the data are not reported for several countries and the average public debt-to-GDP ratio is 59% in 2009 for the remaining set of countries. The government spending-to-GDP ratio for the US and ROW is 21.6% and 19.3%, respectively. In 2009, these were 17.5% and 18.8% (average) respectively (Central Government Final Consumption Expenditure from *World Development Indicators).*

4 Results

4.1 Macroeconomic consequences of tax reform

I first present the impact of the tax reform on macroeconomic aggregates. When the world economy is in the steady-state, the US capital income tax is replaced by a higher labor income tax. The reform is permanent and unanticipated. The ROW labor income tax also increases in order to recover the loss in tax revenues. The resulting labor income tax rates in the model economies are given in Table 3 below.

[17] See Caselli and Feyrer (2009) and Chen, Imrohoroglu and Imrohoroglu (2009) for similar interpretations.

Table 3: Tax rates in the pre and post-reform steady-states

	Financial integration				Financial Autarky	
	US		ROW		US	
	Initial	Final	Initial	Final	Initial	Final
Capital income tax	0.397	0.00	0.45	0.45	0.397	0.00
Labor income tax	0.269	0.34	0.21	0.22	0.269	0.35

Figure 4 presents the dynamics of economy-wide variables. Consumption, capital and output are given in terms of percentage changes relative to the initial steady state, while all other variables are defined relative to output and therefore their percentage point deviations from the initial steady state are plotted.

The macroeconomic effects of the reform in an open economy differs from the closed economy in three main dimensions: *i) long run gains*, *ii) short run costs*, and *iii) adjustment in labor income taxes.*

i) Long run and ii) short run: The reform stimulates investment and output in the long run in the US, and international borrowing enables the rise in these two variables to be greater relative to autarky. The reform also requires US households to sacrifice some of their consumption in the short run: we observe a drastic fall in consumption on impact under both financial integration and autarky. When US households have access to international markets, rising investment can be financed via foreign funds and therefore the transition becomes less painful.

Towards the post-reform steady state, the consumption path recovers and in the post-reform steady state, it reaches to a higher level compared to the pre-reform steady state. The long run gains in the open economy are lower relative to the closed economy. This is because in the long run, the US households service their debt and therefore cut some of their consumption. The US tax reform has major international spillover effects. In particular, ROW suffers an aggregate consumption loss on impact. Their capital stock declines and output falls.

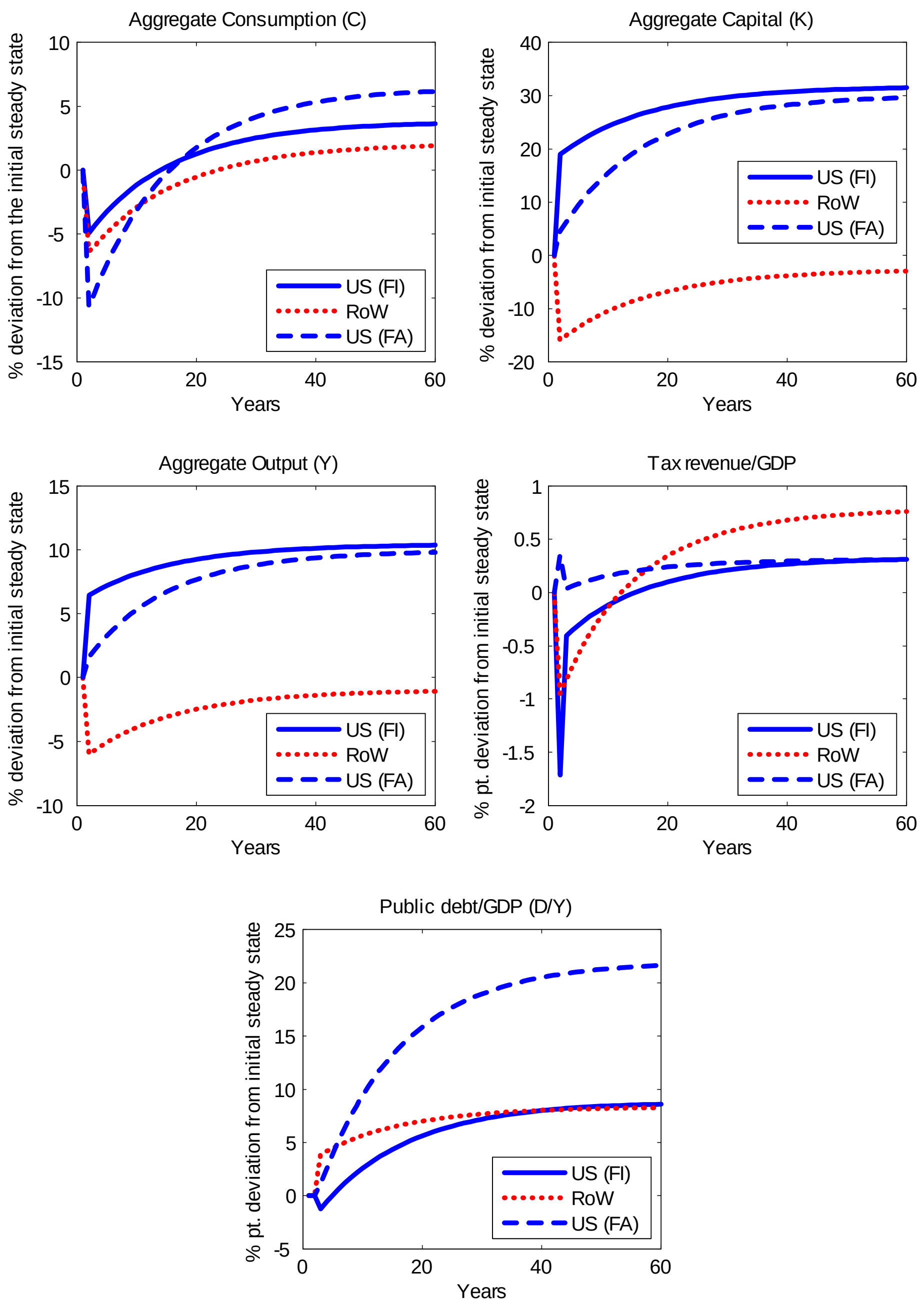

Figure 4. Transition dynamics of macroeconomic aggregates.

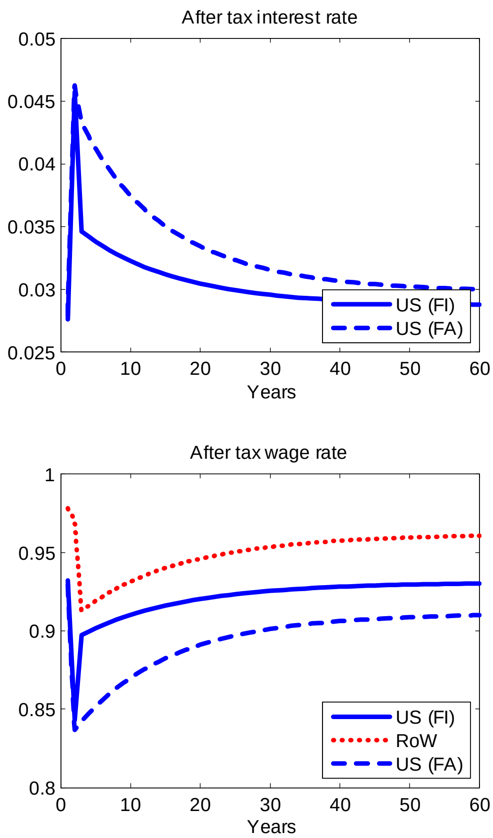

Figure 5. Transition dynamics of factor prices

Figure 6 plots the external account dynamics. A capital tax cut in the US causes a sudden deterioration of its net foreign asset position, and the liabilities relative to GDP rise by about 50 percentage points relative to the initial steady state. US net exports decline on impact, and reaches to a higher level in the short run exceeding its pre-reform level. US current account, which can be derived as the difference between aggregate saving and investment, depicts a similar pattern. This implies that global financial imbalances increase sharply, deteriorating further the external debt position of the US Figure 5 shows the factor price movements.

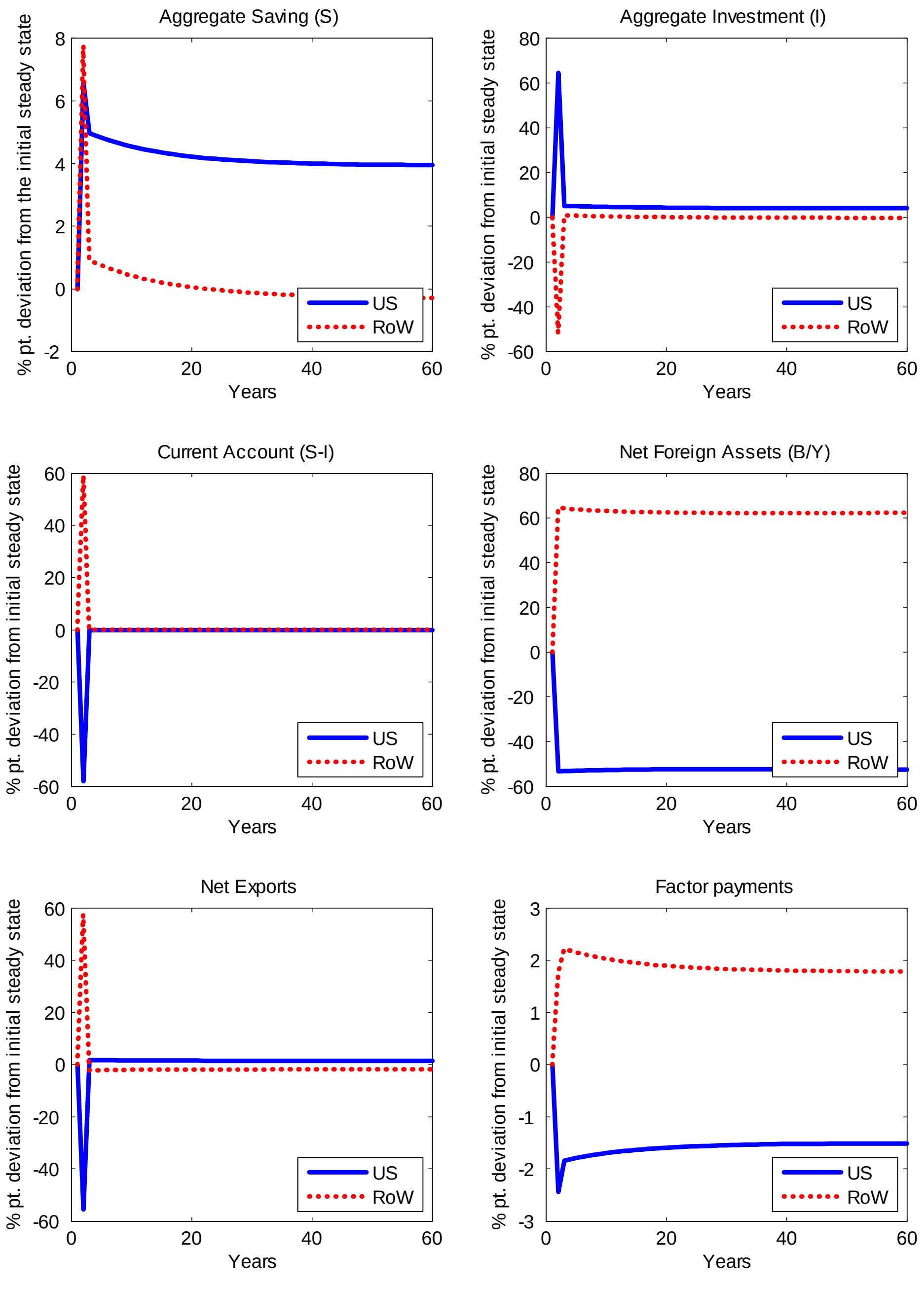

Figure 6. Transition dynamics of external accounts

With the elimination of capital income tax, the world interest rate rises. As capital stock adjusts, the interest rate starts to decline. However, the long run level of the interest rate is higher than the pre-reform level. The rise in the labor income tax creates an inital decline in the after-tax wage rate, and it starts rising as capital accumulation increases. The after-tax wages in the US cannot reach the level of the pre-reform equilibrium. As can be seen in Figure 5, the movements of factor prices are smaller in magnitude for the open economy when compared to the closed economy.

iii) Labor income tax adjustment: Since capital income tax is set at 0 under the tax reform, the only source of tax revenue to the government is the labor income. A rise in the capital stock implies that the pre-tax wage rate rises. Given the greater ability to accumulate capital in the open economy, wages rise more and therefore the government needs to raise labor income tax by less relative to the closed economy. Table 3 reports these numbers. The implications of the price changes are particularly important for the welfare analyses, and I will continue their discussion in the next session.

Mendoza and Tesar (1998) refer to similar channels in their analysis of tax reforms in the global economy[18] and the qualitative dynamics are similar to a great extent. One major difference between the current framework and the neoclassical growth model is, however, the long run movements of factor prices. Under the neoclassical paradigm, the steady state interest rate is exogenously determined by the model's parameters, and the reforming country causes changes in the price dynamics *only* during the transition, while in this model, as a consequence of market incompleteness, it is always endogenously determined.

Macroeconomic dynamics give us an idea about the consequences of the reform and the potential gains and costs. However, as shown in the next section, these gains and costs are not distributed equally for all households.

4.2 Welfare consequences of tax reform

Now I look more closely at households and show how their welfare is affected. I also calculate the fractions of population in favor of the tax reform under financial integration and autarky. For this purpose, I simulate a large artificial population of households that match the initial steady state distributions and the wealth distribution observed in the US data. Using the computed equilibrium sequence of interest rates in the transition under

[18] Instead of adjusting the labor tax, they increase the consumption tax.

the reform and the interest rate under the *status quo*, I track the two model economies for many years. I calculate expected welfare gains for households with various initial asset/productivity combinations. More precisely, I compute the consumption equivalent welfare gain for a household with a given state pair (a_0, ε_0) where the *welfare gain for a household* is defined as $g(a_0, \varepsilon_0)$ that solves

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_t^{NR}(1 + g(a_0, \varepsilon_0))) = E_0 \sum_{t=0}^{\infty} \beta^t U(c_t^R) \tag{29}$$

where c_t^{NR} is the consumption if no reform occurs, and c_t^R is the consumption under the tax reform. Therefore, $g(a_0, \varepsilon_0)$ is the proportional increase in the consumption of a household under *status quo* that would make that household indifferent between going through the reform and remaining in *status quo.* Figure 7 below shows the welfare consequences for the US households across different wealth levels under financial integration.

The left vertical axis and the solid line show the consumption equivalent welfare gain of a household with a given level of wealth; and the right vertical axis and the dashed line gives the cumulative distribution function of the households in the US under financial integration. As seen in the graph, households with low asset holdings (the wealth-poor) suffer a negative welfare gain, and as the wealth level increases, welfare gains become positive. The measure of households with negative welfare gains is large when we look at the distribution function on the right axis: 70.83% of the US population. Hence, we conclude that under financial integration, the fraction in favor of the reform is 29.17%.

As discussed earlier, factor price dynamics play an important role in determining who gains and who loses from a tax reform. An increase in the after-tax interest rate benefits the whole population, as the borrowing limit is set at 0, all households are net lenders. Higher interest rate increases the return to their savings and, therefore, increases their ability to do consumption smoothing. Along the transition path and in the long run, the after-tax (world) interest rate rises less under financial integration compared to autarky and the gains become smaller. On the other hand, after-tax wage rate declines after the tax reform and the change in the after-tax wage is also smaller under financial integration.

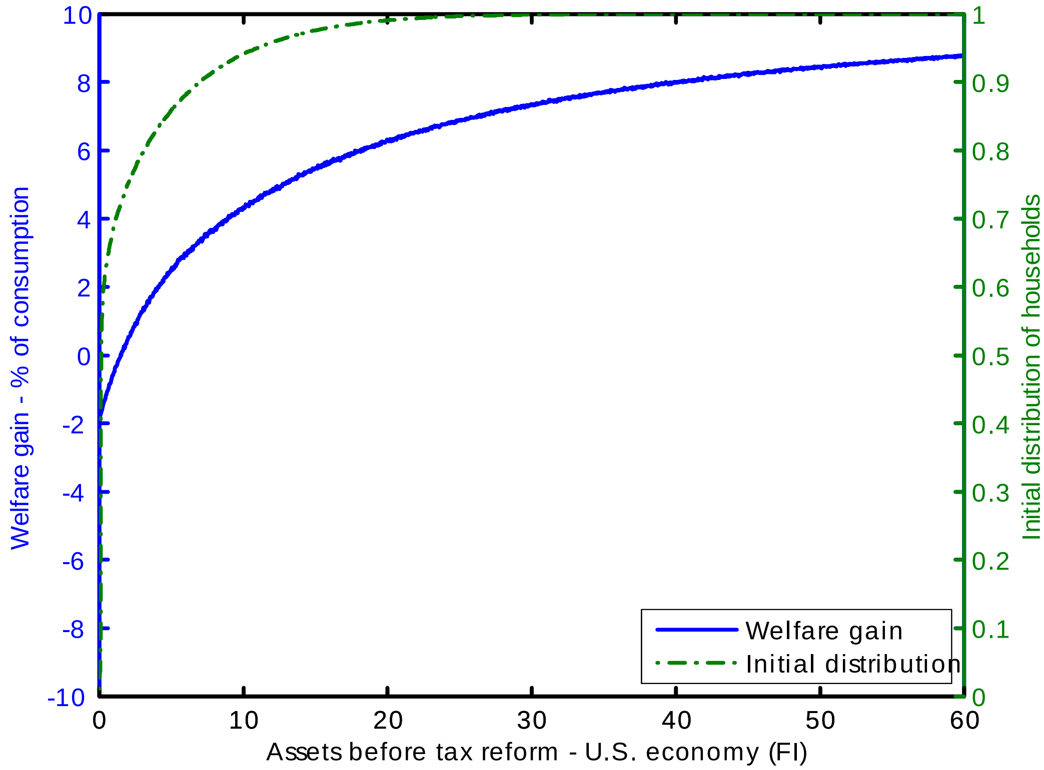

Figure 7. Welfare gains across wealth levels (Financial Integration)

Since the primary source of earnings is labor income for wealth-poor households, a decline in after-tax wage outweighs the gains from an increase in the interest rate, if there are any. Obviously for example, a household that is at the borrowing limit suffers the biggest loss. But the cost is mitigated under financial integration: the wealth-poor are affected less by the negative consequences of the reform under financial openness. Figure 8 shows the welfare gains of eliminating the capital income tax under financial autarky. The gains and losses are greatly overestimated under financial autarky.

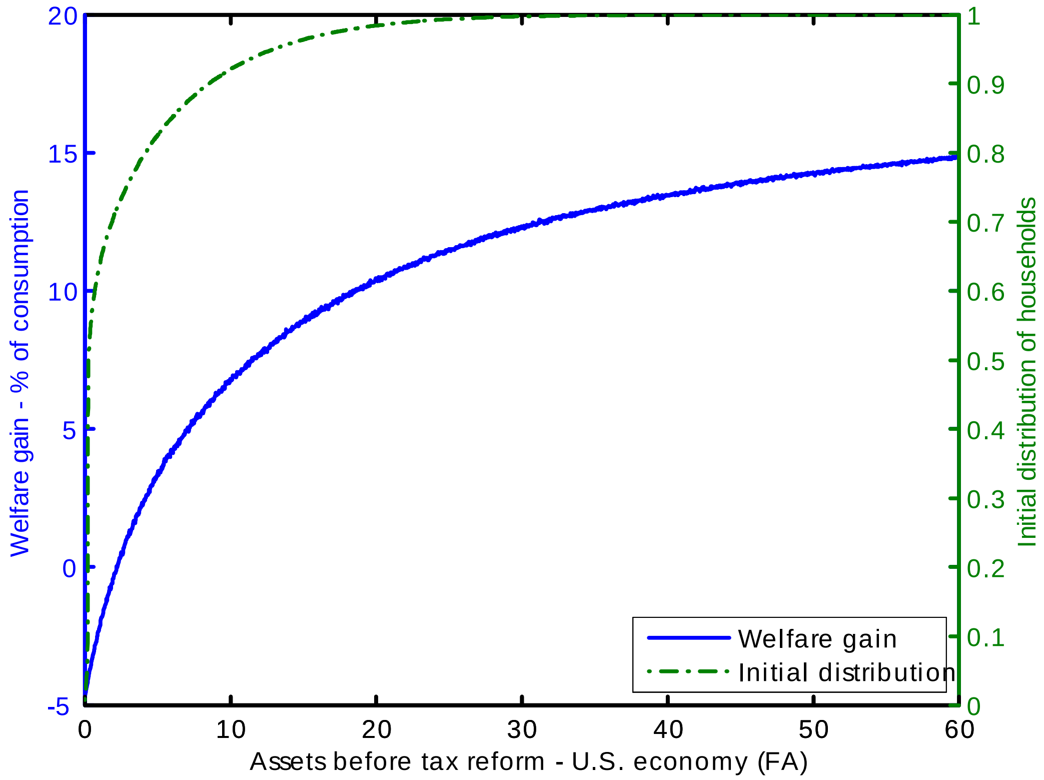

Figure 8. Welfare gains across wealth levels (Autarky)

Next, I decompose households according to their initial productivity levels (Figure 9). This is important because a household that starts with a high productivity is also more likely to accumulate a high level of assets than a household with low productivity (because productivity shocks are positively correlated with wealth) given that their initial asset levels are the same. Consequently, the household with a high productivity level is more likely to benefit from a capital income tax cut. However, productivity shocks constitute an important part of the labor income, and high productivity households are also taxed more for their labor income. As a result, there are two opposing forces in assessing the welfare gains for households according to their productivity. Figure 9 below shows the welfare gains for the US economy under financial integration.

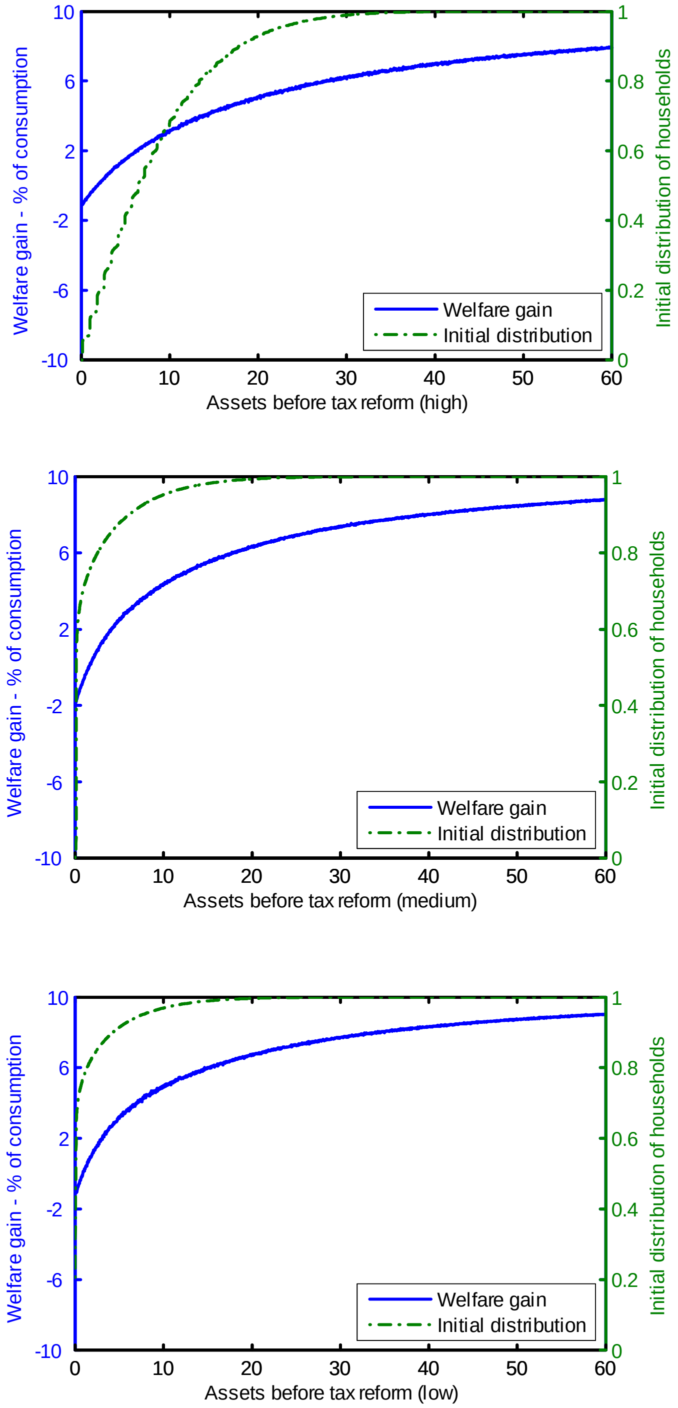

Figure 9. Welfare gains across productivity levels
(Financial integration)

The first panel shows the consumption equivalent welfare gain (%) for households with high productivity shocks prior to the reform. For this group of households, only a small fraction has a negative welfare gain which makes up 29.17% of the high-productivity group. The majority of the high productivity households support the reform. For medium and low productivity households, however, the fraction in favor is smaller: 26.55% and 24.54%, respectively. Given that the high productivity households have a small share in the US population (2.5%), the reform is not favored by a majority as shown in Figure 7 earlier.

When the US is modeled as a closed economy however, the fraction in favor of the reform is underestimated. Table 4 compares the results under two models below.

Table 4: Fraction in favor of tax reform

	Financial integration	Autarky
Fraction in favor	29.17%	26.08%
High productivity group	86.15%	80.26%
Medium productivity group	26.55%	23.62%
Low productivity group	24.54%	20.97%

Table 4 shows that a closed economy model underestimates the fraction in favor of the reform by 3.09% compared to the open economy. Similar differences can be observed when we look at the three different groups, the major difference being in the high productivity group, with 5.89%.

I also compute the aggregate welfare effect of the reform to the economy assuming an utilitarian social welfare function in which a benevolent social planner assigns equal weight to all households in the US The aggregate welfare gain is computed as the proportional increase in the consumption of all agents under *status quo* that makes the planner indifferent between remaining in the *status quo* (with the consumption increase) and implementing the tax reform. In this aggregate welfare measure, the percentage increase in consumption is the same for all agents within each country. Therefore, this is also the percentage increase in aggregate consumption. More precisely, the aggregate welfare gain for a country is defined as g^A that solves

$$\int_{(a_0,\varepsilon_0)} E_0 \sum_{t=0}^{\infty} \beta^t U(c_t^{NR}(1+g^A))d\Gamma_0 = \int_{(a_0,\varepsilon_0)} E_0 \sum_{t=0}^{\infty} \beta^t U(c_t^{R})d\Gamma_0 \tag{30}$$

Table 5 summarizes the results. The reform is costly and through financial openness, the aggregate welfare loss is 84.5% smaller relative to autarky. Steady state gains are smaller, as servicing debt requires consumption losses as discussed earlier. However, international borrowing reduces the transitional cost to a great extent. The net gain is -0.24% under financial openness.

Table 5: Aggregate welfare gain

	Financial integration	Autarky
Aggregate gain	-0.24%	-1.55%
SS gain	2.16%	3.69%
Transitional cost	-2.45%	-5.14%

5 Conclusion

I analyze the macroeconomic and welfare consequences of eliminating the US capital income tax unilaterally under financial integration with heterogeneous agents and incomplete markets. The labor income tax is raised to maintain fiscal solvency. The reform stimulates investment and output which are expanded further by capital inflows from abroad; it also provides welfare gains to the US in the long run. These positive consequences are accompanied with sizable fiscal and financial imbalances and transmitted to the rest of the world resulting in welfare losses abroad on impact.

The cost of transition to the reformed steady state is reduced to the extent that US households can borrow from abroad. However, under a realistic calibration of the model the short run costs exceed the gains. The net cost in the open economy is about 15% of the cost in a closed economy, heterogeneous agent-incomplete markets model.

The costs and gains of reform are not shared equally across households. Wealth-poor households that primarily rely on labor income lose due to a labor tax raise while not gaining much from a capital income tax cut. The wealth-rich, on the other hand, enjoy welfare gains. International capital flows help alleviate the costs of the reform to the poor; while reducing the gains to the rich through their impact on factor prices. Given the high wealth inequality in the US, the reform cannot be supported by the majority of population.

My final comments are on two important questions left as future work. The first one is on market incompleteness and efficiency. Providing households with insurance against idiosyncratic risk is an obvious yet difficult way to improve welfare. Therefore, government policy can be justified as one way of improving welfare. Dávila, Hong, Krusell and Ríos-

Rull (2012), for example, suggest that taking as given the environment with uninsured idiosyncratic labor income risk, it may be constrained optimal to *subsidize* capital. In this paper, I do not draw conclusions on what the optimal tax or subsidy on capital should be under market incompleteness and financial integration and leave this as an open question.

The second research avenue is related to questions which are mostly centered around European countries. The literature is still silent on the analyses of issues regarding tax competition, tax harmonization and fiscal consolidation using open economy models *and* taking into account realistic wealth or income distributions for these countries. The current study shows that aggregate welfare implications of tax reforms in an open economy, heterogeneous agent-incomplete markets model can be quite different compared to representative agent models, suggesting that the consequences of strategic tax policies under the current class of models may also be potentially different.

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A Appendix

A.1 List of countries

The following countries constitute the rest of the world:

1. Japan

2. Euro Area: Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia, and Spain.

3. Oil Exporters: Algeria, Angola, Azerbaijan, Bahrain, Republic of Congo, Ecuador, Equatorial Guinea, Gabon, I.R. of Iran, Kuwait, Libya, Nigeria, Norway, Oman, Qatar, Russia, Saudi Arabia, Syrian Arab Republic, Turkmenistan, United Arab Emirates, Venezuela, and the Republic of Yemen.

4. Emerging Asia: China, Hong Kong SAR, Indonesia, Korea, Malaysia, the Phillipines, Singapore, Taiwan Province of China, and Thailand.

A.2 Computational Algorithm

A.2.1 Pre-reform steady state:

I provide the algorithm for the case with inelastic labor supply.

1. Create grids on next period's assets and this period's shocks, (a', ε). Define $a' \epsilon A = \{a_1, a_2, ..., a_N\}$ where a_1 is the borrowing limit in each country; and define the productivity shocks so that. $\varepsilon \ \epsilon E = \{\varepsilon_{1,...}, \varepsilon_M\}$.

2. Make a guess on the world interest rate, r. Notice that $r \in (0, 1/\beta - 1)$. Set values for D_0 and D_0^*. Given the tax rates, it is straightforward to compute the implied K/N ratio and remaining factor prices for both countries: r^k, r^{k*} , w and w^*.

3. Make a guess for the initial cumulative distribution of households over assets and shocks, $\Gamma_0(a', \varepsilon)$. A uniform distribution function is a good guess.

4. Make an initial guess on tomorrow's consumption policy function, $c_0(a', \varepsilon)$. A good guess can be based on the budget constraint.

5. Construct the RHS of the Euler equation, for all pairs of $(a', \varepsilon) \in A \times E$

$$RHS = \beta(1+r) \sum_{\varepsilon' \in E} \Pi(\varepsilon'|\varepsilon) U_c(c_0(a', \varepsilon))$$

6. Using the Euler equation, solve for today's consumption function algebraically. I.e. find $\tilde{c}$ that solves

$$U_c(\tilde{c}) = RHS$$

Note that this step makes the computation very efficient and fast compared to methods that require a nonlinear equation solver.

7. Using the budget constraint, compute today's asset holdings $\bar{a}(a', \varepsilon)$ such that

$$\bar{a}(a', \varepsilon) = [\tilde{c} + a' - Nw(1-\tau^n)\varepsilon]/(1+r) \tag{31}$$

Hence, we find today's assets given tomorrow's asset holding is a' and today's productivity shock is ε. Notice that $\bar{a}(a', \varepsilon)$ is not necessarily on the grids defined in A, that is, the grids we find now are endogenous grid points. Update the initial guess for consumption as follows.

a. If $\bar{a}(a', \varepsilon)$ causes the borrowing constraint to bind next period, compute the new guess $\tilde{c}_0(a', \varepsilon)$ using piecewise linear interpolation on the closest grid points a_i and a_j such that, $a_i < \bar{a}(a', \varepsilon) < a_j$ and using consumption rules at $c_0(a_i, \varepsilon)$ and $c_0(a_j, \varepsilon)$.

b. If $\bar{a}(a', \varepsilon)$ causes the borrowing constraint not to bind next period, then set $\tilde{c}_0(a', \varepsilon)$ $= \tilde{c}$ from step 6.

8. Check convergence for any asset grid and productivity shock, based on the metric

$$\max\{|\tilde{c}_0(a', \varepsilon) - c_0(a', \varepsilon)|\} < \varepsilon$$

where ε is a small number. If convergence is not achieved, go to step 5.

9. Given the initial guess for distribution, $\Gamma_0(a', \varepsilon)$, interpolate on grid points a_i and a_j to find the distribution over the endogenous grid points, $\Gamma(h_a^{-1}(a', \varepsilon)), \varepsilon)$. The inverse of the policy functions is already calculated in an earlier step, which makes this step also very efficient. Hence $h_a^{-1}(a_{t+1}, \varepsilon_t) = \bar{a}(a', \varepsilon)$. Then using the Markov transition matrix, find tomorrow's distribution

$$\Gamma(a', \varepsilon') = \sum_{\varepsilon} \Pi(\varepsilon'|\varepsilon)\Gamma(\bar{a}(a', \varepsilon), \varepsilon)$$

Construct a metric as in step 8 to check convergence.

10. Repeat these steps for two countries, compute aggregate savings and check whether global asset market clears. Update the interest rate, r using bisection method.

11. Calculate the output level, and check if the public debt-to-GDP ratio is satisfied. Then calculate the implied government expenditure, G.

A.2.2 Transition and post-reform steady state:

1. Set T, the number of periods to converge to the new steady state.

2. Pick a new value for τ^k. The new tax is imposed before the decisions are made in period 1.

3. Make a guess for the path of Home capital stock, $\{K_t\}_{t=2}^{T-1}$. Given that the labor supply is inelastic, the implied series for factor prices and $\{K_t^*\}_{t=2}^{T-1}$ can be obtained.

4. Using the government budget constraint for all periods, and for given values of D_0 and G, find the new implied labor income tax, τ^n. It is convenient to assume that $D_T = D_{T-1}$ as in Domeij and Heathcote (2004).[19]

5. Having found τ^n, find the sequence of government debt, $\{D_t\}_{t=2}^{T}$. Repeat this for Foreign.

6. Calculate the post-reform steady state, following the instructions in the pre-reform steady state.

7. For both countries, solve for the household's optimization problem along the transition path, starting from the final steady state going backwards. Application of the endogenous grid point method is similar to the description in the pre-reform steady state above. Find the consumption rules back until period 1. Find the implied

[19] A full shooting algorithm is explained in Mendoza and Tesar (1998). Their methodology would require me to make a guess on the new τ^n, check whether the present value of the government budget is satisfied and update τ^n if necessary. Given the relative complexity of heterogeneous-agent incomplete markets models, the current technique is more conveniently applied.

asset holdings, and the post-tax household distribution over assets and productivity shocks at period 1.

8. Then update the distributions forward, using the Markov transition matrix and households' optimal saving decisions. Do the aggregations, compute the implied sequence of capital stock $\{\tilde{K}_t\}_{t=2}^{T-1}$ for Home using $\tilde{K}_t = A_t - D_t + A_t^* - K_t^* - D_t^*$.

9. Check whether the inital path of capital stock has converged to the implied series. If so, check whether T is sufficiently large or not.