Global Imbalances and Taxing Capital Flows*

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We study a monetary economy with two large open economies displaying net real and financial flows. If default on cross-border loans is possible, taxing financial flows can reduce its negative consequences. In doing so it can improve welfare unilaterally, in some cases in a Pareto sense, via altering the terms of trade and reducing the costs of such default.

JEL Codes: F34, G15, G18.

1. Introduction

In an accompanying, more policy-oriented, paper, "Global Macroeconomic and Financial Supervision: Where Next?,"[1] [one of us] argues that in a world in which power is concentrated at the national level (a Westphalian system), it is futile to expect to be able to put direct pressure on countries running (excessively) large current account surpluses. Instead, the (international) authorities should focus on the capital account. Where capital flows lead to an unsustainable accumulation of debt in the deficit country, so that a costly restructuring has to take place, it can be advantageous to both

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[1]Goodhart (2012).

the surplus and deficit countries to impose restrictions on the ex ante capital flows and hence on the extent of the current account surplus/deficits.

While the intuition for this general argument is reasonably straightforward, it is a technically more difficult task to demonstrate this in a formal model. This is the purpose of this paper. We take a two-country model with a surplus (China; Germany) and a deficit (United States; southern Europe) country, in which default on debt exists and involves costs, and show that some limitation of capital flows, via taxes on such flows, can result in a Pareto improvement over the unconstrained case. Global current account imbalances have been heavily concentrated among a small group of regions and countries, and until recently have displayed an unusually high degree of persistence. As the world economy recovers from the current economic turbulence, the global imbalances may be seen as an obstacle to the nascent global economic recovery.[2]

The literature has approached the issue of capital flows in several ways. Caballero, Farhi, and Gourinchas (2006) point out that a potential growth difference and heterogeneity in countries' capacity to generate financial assets should be deemed as two determinants of global imbalance. Demographics have an important impact on the pattern of trade balance due to standard life-cycle savings reasons (Henrikson 2002). Fogli and Perri (2006), mapping the connection between volatility of the shocks and the external balance, find that the "Great Moderation"[3] can explain as much as 20 percent of the observed imbalance. Some argue that U.S. deficit can be explained by optimistic forecasts of future GDP growth as a share of world net GDP. Engel and Rogers (2006) develop a long-run equilibrium model showing that current account is determined by the expected future share of world GDP relative to current share of world GDP.

[2]See, for example, Roubini and Setser (2004), Blanchard, Giavazzi, and Sa (2005), Obstfeld and Rogoff (2005), Krugman (2007), Carney (2011), Shirakawa (2011), and Stevents (2011).

[3]As the relative volatility of shocks drops, a country encounters less risk (i.e., the "Great Moderation"), which leads to less precautionary saving and results in a deterioration of its external balance. To get more capital from abroad, the interest rate has to be increased. This discourages the capital outflow from the country.

Our model is the first, as far as we know, to study the relationship between capital flows and the costs involved with default;[4,5] rather than focus on the causes of capital flows, we focus on the effects. Capital flows are needed to smooth intertemporal consumption when countries exhibit varying rates of productivity growth. However, if default is sometimes unavoidable, then the costs of default need to be considered alongside the benefits of consumption smoothing. In this setting, we introduce per-unit taxes on the flows into and out of countries, collected by the relevant national government and returned fully or in part back to the domestic residents. The taxes serve to reduce the volume of capital flows, and hence provide the ability to smooth consumption but also lower the eventual costs of default.

We study a monetary economy in order to separate the effects of (real) trade from financial (nominal) flows. Money enters the economy via a central bank in each country, which accommodates money demand, at a given interest rate, by printing national fiat money. The demand for money arises from the cash-in-advance constraint imposed on commodity purchases. As money balances are held at the cost of foregone interest, positive interest rates reduce the efficiency of trade, so monetary policy is non-neutral. The presence of initial nominal wealth (outside money) means that fiscal policy is non-Ricardian and guarantees the uniqueness of prices.[6] Trade, in both goods and bonds, within countries must occur in the fiat currency of that country. Foreign currency can be obtained via a foreign exchange market at market prices. Finally, representative households can lend/borrow to each other in an international bond market; for simplicity, trade in the bond will occur in one currency only. Agents are not forced to honor their obligations, but rather weigh the marginal cost of repaying against the non-pecuniary cost of defaulting. Our agents are assumed to be ex ante identical but ex post different

[4]The model is an example within the general framework presented in Peiris (2010) and Peiris and Tsomocos (2010), which is in turn based on Geanakoplos and Tsomocos (2002) and is in the spirit of Lucas (1982).

[5]See Korinek (2011) for an overview on the literature on macroprudential capital controls.

[6]See Woodford (1994) for the fiscal theory of price level. Bloise and Polemarchakis (2006) give an overview of the non-neutrality of money and price-level determinacy with non-Ricardian fiscal policy.

in their propensity to default, and so default in our model captures the overall probability of default of a given population. As such, our model involves two frictions: positive interest rates and the possibility of default.[7] It is the interaction of these two frictions which results in capital flows being sub-optimal in an unconstrained economy and therefore allows the unilateral introduction of capital flow taxes to improve welfare bilaterally.

The paper proceeds as follows. Section 2 describes the structure of the model, while section 3 studies the properties of the model. Section 4 then examines the effect of introducing taxes on capital flows, while section 5 considers the optimality of policy. Finally, section 6 concludes. A full list of variables and all proofs are in the appendices.

2. The Model

There are two periods: $t = \{1, 2\}$ and no uncertainty. Production and consumption occur in both periods. The international economy consists of two countries, denoted by $i, j \in I = \{1, 2\}$, each inhabited by a single continuum of identical households, distributed uniformly over $[0, 1]$. Each household produces a single homogeneous good. In total, there are two goods produced globally, one in each country, but they are perfect substitutes. For example, American corn is identical to Chinese corn. The means of payment of all transactions is in fiat money and is denominated in the currency of the country of origin (of goods and bonds). Goods transactions are subject to a cash-in-advance requirement resulting in a timing mismatch between expenditures and receipts, thereby creating a transactions demand for money. Prices are flexible and expectations are rational (perfect foresight). A full list of notations is presented in table 1 in appendix 1.

We study a particular equilibrium: one where differences in the circumstances of the economy drive international trade and capital flows. In the theoretical setup given below, we do not specify the conditions which provide for such an outcome, but rather analyze an equilibrium involving a current/capital account imbalance. We

[7] Section 2.5 describes the methodology used to model strategic default.

also assume a parameterization where the borrowing representative agent defaults *partially*. We can demonstrate, and did so in an earlier version of the paper, that these assumptions were valid within reasonable parameterizations of the model.

2.1 Households

We denote households by $h \in H = \{1, 2\}$. Household 1 belongs to country 1 and household 2 belongs to country 2. At each date-event, each household produces a single, homogeneous product, unique to each country. The output produced at time t by a representative household h of country i is $y_i^h(t)$. Output is produced by exerting effort, $l^h(t)$, and costing leisure of $1/2[l^h(t)]^2$. Production is a simple linear function of lost leisure:

$$y_i(t) = y_i^h(t) = A^h(t)l^h(t), \tag{1}$$

where $A^h(t)$ is a real productivity shock which affects the productivity of labor and the second equality comes about because all agents in each country are identical and of unit measure.[8]

The consumption of agent h at time t of a good of country i is $c_i^h(t)$. The nominal price of goods of country i at time t is $P_i(t)$. The goods produced in each country are perfect substitutes, and agents only care about their aggregate consumption $c^h(t) = c_1^h(t) + c_2^h(t)$. Households commence each period with a small amount of fiat money of their country of origin, considered to be monetary (seingorage) transfers from the monetary authority accrued from a previous period (for agent h at time t, this is $w_i^h(t)$) and any transfers from the fiscal authority of that country.

We assume that a household cannot consume what it produces; instead, it has to purchase consumption goods, with cash, from other households[9] and must use the currency of the country of origin for the goods they wish to purchase. For example, a Chinese resident must use dollars to purchase American goods. Specifically, we

[8]Capital flows come about for several reasons. Here we focus only on flows resulting from the desire to smooth intertemporal consumption. In future versions we shall also consider flows caused by differing international productive potential.

[9]In this, we follow Lucas and Stokey (1987).

assume that households sell their entire output at the beginning of each period and must purchase back what they require for consumption. This requirement results in a timing mismatch between monetary expenditures and income and generates a demand for additional cash balances.

Additional money balances are obtained from the national central bank of the country of their origin (denoted $b_i^h(t)$) at nominal interest rate $r_i(t)$, set exogenously by the monetary authority. Money borrowed here is due back immediately before the end of each period. Such money-market transactions are a direct means whereby the monetary authority of each country injects liquidity into the domestic economy. We assume that the monetary authority follows an interest rate policy: money supply adjusts to equal money demand at the given interest rate.

A household wishing to purchase foreign goods must do so by entering into the foreign exchange market and selling domestic currency in exchange for foreign currency. A householder of country i selling a unit of his currency will receive $e_{ij}(t)$ units of country j currency in period t. In general, $e_{ij}(t)$ represents the rate at which country i money will exchange for country j money at time t. As the goods produced in each country are perfect substitutes, and there are no impediments or frictions to trade, the law of one price holds, i.e., $e_{ij}(t) = \frac{P_j(t)}{P_i(t)}$.

Finally, there is an international intertemporal bond market. Households selling bonds receive $\frac{\bar{b}_1^h(2)}{1+\bar{r}_1(1)}$, incurring the nominal liability of $\bar{b}_1^h(2)$, at the nominal interest rate $\bar{r}_1(1)$. We use the convention of a bar for variables which are intertemporal. Households purchasing the bond spend $\frac{\bar{b}_1^h(2)}{1+\bar{r}_1(1)}$. We assume that there is a single bond available for trade in country 1. Sellers of this bond cannot be forced to honor their contractual obligation, and the amount which they honor is $D_1^h(2)$. If they choose not to meet their full obligations, they incur a non-pecuniary penalty (λ) proportional to the real value of default ($\frac{1}{z}\lambda\frac{(\bar{b}_1^h(2)-D_1^h(2))^z}{P_1(2)}$, where we assume z is 1). As a consequence, the purchaser of the bond will only receive a fraction $K_1(2)$ of what was promised $\bar{b}_1^h(2)$.

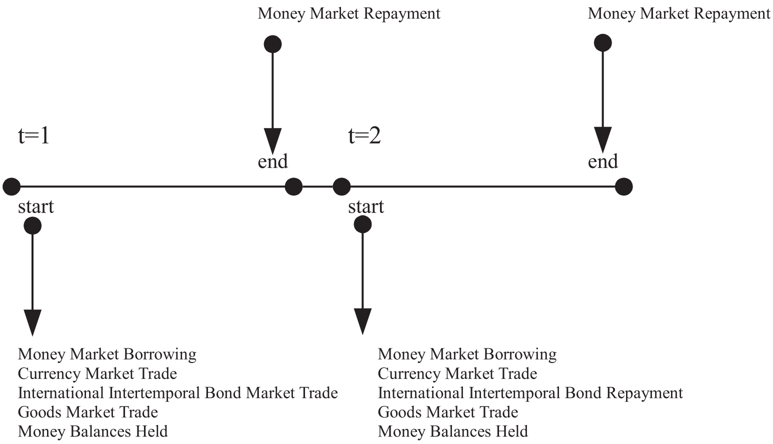
We will consider a fiscal regime where both capital exports and imports are taxed by the domestic fiscal authorities, and whose revenues are returned to domestic residents in the form of a lump-sum transfer at the beginning of the second period or to the domestic monetary authority at the end of the second period. In our example, country 1 is a capital importer and country 2 is a capital exporter. The resident of country 1 that wishes to borrow $\frac{\bar{b}_1^1(2)}{1+\bar{r}_1(1)}$ in the international bond market is taxed an amount τ_1, and so must pay a tax of $\tau_1 \frac{\bar{b}_1^1(2)}{1+\bar{r}_1(1)}$ to the country 1 fiscal authority. Similarly, the resident of country 2 that wishes to spend $\frac{\bar{b}_1^2(2)}{1+\bar{r}_1(1)}$ on country 1 bonds must pay $e_{12}(1)\tau_2 \frac{\bar{b}_1^2(2)}{1+\bar{r}_1(1)}$ in taxes to the country 2 fiscal authority. The fiscal revenue in each country is invested with the domestic monetary authority, after which household 1 receives a lump-sum transfer equal to $T_1^1(2) = \phi\tau_1 \frac{\bar{b}_1^1(2)}{1+\bar{r}_1(1)}(1 + r_1(1))$ and household 2 receives $T_2^2(2) = \phi e_{12}(1)\tau_2 \frac{\bar{b}_1^2(2)}{1+\bar{r}_1(1)}(1+r_2(1))$. Specifically, a proportion of the revenue $(1-\phi)$ will be returned to the monetary authority at the end of the second period and can be considered fiscal revenues "wasted" due to the inefficiency of the fiscal authority operations. We show later that the proportion of revenues returned to households is irrelevant to the main results (welfare effects) of introducing capital flow taxes. This also implies that, provided the value of the tax receipts is held constant, where the taxes are levied and by whom does not affect the result. For instance, one may consider it more appropriate that the country receiving the capital flow might tax both the lender and the borrower; our results are robust to such a (perhaps more realistic) specification.

In the first period, the money market opens simultaneously with the foreign exchange market, the goods market, and the international bond market. Money-market liabilities are due at the end of each period and are repaid with the money balances held due to the cash-in-advance constraint. The timeline is shown in figure 1.

The preferences of the representative household of country 1, the importer of capital, are described by the lifetime expected utility

$$\sum_t \left[\frac{c^1(t)^{1-\rho} - 1}{1-\rho} - \frac{1}{2}\kappa^1(t)[l^1(t)]^2 \right] - \lambda \frac{(\bar{b}_1^1(2) - D_1^1(2))^+}{P_1(1)}. \qquad (2)$$

Figure 1. Sequence of Events



The representative household of country 1 needs to take into account the punishment for defaulting on its intertemporal loan repayment. The preferences of the representative household of country 2 are similarly defined, but, as the householder is an exporter of capital, these exclude any penalty for default.

$$\sum_{t,i}\left[\frac{c_i^2(t)^{1-\rho}-1}{1-\rho}-\frac{1}{2}\kappa^2(t)[l^2(t)]^2\right]. \tag{3}$$

For simplicity, we assume a rate-of-time preference of 1. $0 < \rho < 1$ is the coefficient of relative risk aversion and κ^h is the preference for (lost) leisure.

Next we present the budget constraints of the capital inflow country, country 1, and the capital outflow country, country 2. To reduce notation, we collapse the cash-in-advance constraint to be one in which the money balances held by agents are at least the nominal income from sales.[10]

[10]See Nakajima and Polemarchakis (2005) for a full derivation of how the cash-in-advance constraint collapses to the constraints presented in the following budget constraints.

2.1.1 Capital Inflow Country

The budget constraint for the household of country $h = i = 1$ in the first transaction moment of period 1 is

$$P_1(1)c_1^1(1) + e_{12}(1)P_2(1)c_2^1(1) + \tau_1 \frac{\bar{b}_1^1(2)}{1+\bar{r}_1(1)} \leq w_1^1(1) + \frac{b_1^1(1)}{1+r_1(1)} + \frac{\bar{b}_1^1(2)}{1+\bar{r}_1(1)}, \tag{4}$$

expenditure on purchasing country 1 output + country 2 output + tax paid on debt incurred in the intertemporal international bond market ≤ the initial monetary balance + intratemporal borrowing from the central bank 1 + intertemporal borrowing in the international bond market due at the beginning of period 2.

At the end of period 1, when money-market liabilities are due, the budget constraint is

$$b_1^1(1) \leq P_1(1)y_1(1), \tag{5}$$

loans repaid to central bank ≤ income from sales.

In the second period, the budget constraint is similar,[11] except that the repayments from the international bond market come due:

$$D_1^1(2) + P_1(2)c_1^1(2) + e_{12}(2)P_2(2)c_2^1(2) \leq w_1^1(2) + \frac{b_1^1(2)}{1+r_1(2)} + T_1^1(2), \tag{6}$$

repayments in intertemporal international bond market + expenditure on purchasing country 1 output + country 2 output ≤ the initial monetary balance + intratemporal borrowing from the central bank 1 + fiscal transfers.

When money-market liabilities are due, the budget constraint is identical:

$$b_1^1(2) \leq P_1(2)y_1(2), \tag{7}$$

loans repaid to central bank ≤ income from sales.

[11] N.B. The penalty for defaulting is non-pecuniary.

We have substituted in the cash-in-advance constraint, which turns out to be $m_i^h(t) = P_i(t)y_i^h(t)$, to the above budget constraints,[12] where $m_i^h(t)$ is the money balances held by agents as a result of the cash-in-advance constraint.

2.1.2 Capital Outflow Country

The budget constraint for the household of country $h = i = 2$ in the first transaction moment of period 1 is

$$P_2(1)c_2^2(1) + e_{21}(1)\left[P_1(1)c_1^2(1) + \tau_2\frac{\bar{b}_1^2(2)}{1+\bar{r}_1(1)} + \frac{\bar{b}_1^2(2)}{1+\bar{r}_1(1)}\right] \leq w_2^2(1) + \frac{b_2^2(1)}{1+r_2(1)}, \tag{8}$$

expenditure on purchasing country 2 output + country 1 output + tax paid on intertemporal international bonds bought in country 1 + intertemporal international bonds bought in country 1 ≤ the initial monetary balance + intratemporal borrowing from the central bank 2.

At the end of period 1, when money-market liabilities are due, the budget constraint is

$$b_2^2(1) \leq P_2(1)y_2(1), \tag{9}$$

loans repaid to central bank ≤ income from sales.

In the second period, the budget constraint is similar, except that the repayments from the international bond market come due:

$$P_2(2)c_2^2(2) + e_{21}(2)P_1(2)c_1^2(2) \leq w_2^2(2) + \frac{b_2^2(2)}{1+r_2(2)} + e_{21}(2)K(2)\bar{b}_1^2(2) + T_2^2(2), \tag{10}$$

expenditure on purchasing country 2 output + country 1 output ≤ the initial monetary balance + intratemporal borrowing from the central

[12] See Nakajima and Polemarchakis (2005) for a detailed exposition of the cash-in-advance constraint used here.

bank 2 + income from intertemporal international bonds bought in country 1 + fiscal transfers.

When money-market liabilities are due, the budget constraint is identical to before:

$$b_2^2(2) \leq P_2(2)y_2(2), \tag{11}$$

loans repaid to central bank ≤ income from sales. We have substituted in the cash-in-advance constraint, which turns out to be $m_i^h(t) = P_i(t)y_i^h(t)$, to the above budget constraints,[13] where $m_i^h(t)$ is the money balances held by agents as a result of the cash-in-advance constraint.

2.2 The Fiscal Authorities

The fiscal authority in each country will levy a tax τ_i on capital inflows and outflows in the first period. The revenue will be distributed back to domestic residents in the form of a lump-sum transfer T_i, after being reinvested at the monetary authority in period 1.

For the capital importer, country 1, the tax revenue will be invested at its central bank:

$$\begin{aligned} \frac{b_1^{T1}(1)}{1+r_1(1)} &= \tau_1 \frac{\bar{b}_1^h}{1+\bar{r}_1(1)} \\ T_1^1(2) &= \phi b_1^{T1}(1) \\ T_1^{M1}(2) &= (1-\phi)b_1^{T1}(1). \end{aligned} \tag{12}$$

Similarly for the capital exporter, country 2, the tax revenue will be invested at its own central bank:

$$\begin{aligned} \frac{b_2^{T2}(1)}{1+r_2(1)} &= \tau_2 e_{12}(1) \frac{\bar{b}_1^2(2)}{1+\bar{r}_1(1)} \\ T_2^2(2) &= \phi b_2^{T2}(1) \\ T_2^{M2}(2) &= (1-\phi)b_2^{T2}(1). \end{aligned} \tag{13}$$

[13]See Nakajima and Polemarchakis (2005) for a detailed exposition of the cash-in-advance constraint used here.

2.3 The Monetary Authorities

The monetary endowments of agents at the beginning of period 1, $w_i^h(1)$, are liabilities of the monetary authority $(W_i(1))$. In addition, an amount of money is printed each period, $M_i(1)$ in period 1 and $\tilde{M}_i(2)$ in period 2, and lent to domestic residents at the pre-specified interest rate $r_i(t)$.

The budget constraint in period 1 that the monetary authority in each case faces is

$$M_i(1) = \frac{b_i^M(1)}{1 + r_i(1)} + W_i(1), \tag{14}$$

where $W_i(1)$ is given. At the end of period, the money market clears by

$$\begin{aligned} M_i(1) &= b_i^M(1) + b_i^T(1) \\ &= (M_i(1) - W_i(1))(1 + r_i(1)) + b_i^T(1) \\ b_i^T(1) &= W_i(1)(1 + r_i(1)) - M_i(1)r_i(1). \end{aligned} \tag{15}$$

As the total interest earned on the money market is $W_i(1)$, at the beginning of the second period, the monetary authority then makes a transfer to the domestic household of $W_i(2) = W_i(1) - b_i^{Ti}(1) = M_i(1)r_i(1) - W_i(1)r_i(1)$.

The budget constraint at the beginning of the second period that the monetary authority faces is

$$\tilde{M}_i(2) = \frac{b_i^M(2)}{1 + r_i(2)} + W_i(2). \tag{16}$$

At the end of the second period it is

$$\tilde{M}_i(2) + T_i^i(2) = b_i^M(2), \tag{17}$$

where the period 2 money supply is $M_i(2) = \tilde{M}_i(2) + T_i^i(2)$ and where $W_i(1)$ is given. The lifetime budget constraint of the monetary authority must satisfy

$$M_i(2)\frac{r_i(2)}{1 + r_i(2)} + T_i^{Mi}(2) = W_i(1),$$

that is, the seigniorage revenue for the monetary authority plus the transfer from the fiscal authority must equal its initial liability.

2.4 Equilibrium Conditions

Since households are identical, the market clearing conditions are as follows:

- Goods markets clear:

$$c_1^1(t) + c_1^2(t) = y_1(t), \quad c_2^1(t) + c_2^2(t) = y^2(t). \tag{18}$$

- Money markets clear:

$$b_1^1(1) = b_1^M(1) + b_1^{T1}(1), \quad b_1^1(2) = b_1^M(2), \tag{19}$$

$$b_2^2(1) = b_2^M(1) + b_2^{T2}(1), \quad b_2^2(2) = b_2^M(2). \tag{20}$$

- Money held by agents is the total money supply:

$$m_1^1(1) = M_1(1), \quad m_1^1(2) = M_1(2), \tag{21}$$

$$m_2^2(1) = M_2(1), \quad m_2^2(2) = M_2(2). \tag{22}$$

- International bond market clears:

$$\bar{b}_1^1(2) = \bar{b}_1^2(2), \quad D_1^1(2) = \bar{b}_1^2(2)K. \tag{23}$$

- International currency market clears:

$$e_{12}(1)P_2(1)c_2^1(1) = P_1(1)c_1^2(1) + \frac{\bar{b}_1^2(2)}{1 + \bar{r}_1(1)}, \tag{24}$$

$$e_{12}(2)P_2(2)c_2^1(2) = P_1(2)c_1^2(2) - K_1(2)\bar{b}_1^2(2). \tag{25}$$

- Initial cash balances are liabilities of the central bank:

$$w_1^1(t) = W_1(t), \quad w_2^2(t) = W_2(t). \tag{26}$$

Definition. *Given initial nominal wealth, $\{w_i^h(t), W_i(t)\}$, interest rate policy, $\{r_i(t)\}$, and fiscal policy, $\{\tau_i\}$, a competitive equilibrium consists of an allocation, $\{c_i^h(t), y_i(t), l(h,t)\}$, a portfolio of households, $\{\bar{b}_1^h\}$, a portfolio of the monetary-fiscal authority, $\{M_i(t)\}$, transfers, $\{T\}$, spot-market prices, $\{P_i(t)\}$, and international bond prices, $\frac{1}{1+\bar{r}_1(1)}$, such that*

- given W and $\{r_i(t), M_i(t)\}$, fiscal policy $\{\tau_i\}$ determines transfers T_i;
- the monetary authority accommodates the money demand, $M_i(t) = \frac{b_i^h(t)}{1+r_i(t)}$;
- given interest rates, $r_i(t)$, spot-market prices, $P_i(t)$, bond price $\frac{1}{\overline{r}_1(1)}$, and transfers, T_i, the household's problem is solved by $c_i^h(t)$, $l(h,t)$, $y_i(t)$, $\overline{b}_1^h$, D_1^h; and
- all markets clear.

Next we describe the methodology for modeling strategic default.

2.5 A Note on Endogenous Default

In our model, default is endogenous and thus a decision variable for agents. The first treatment of endogenous default in the presence of default penalties was by Shubik and Wilson (1977) and was analyzed in a general equilibrium framework by Dubey, Geanokoplos, and Shubik (2005). Each additional unit of income will have a marginal value for agents. However, not delivering an additional unit according to one's contractual obligation and choosing to default will incur a marginal penalty. When the marginal value (utility) is higher than the marginal penalty, then agents will default on that additional unit of income. In our model the representative households enter into risky contracts. When the time comes to honor their contractual obligation, they can either default completely on their promise in the long-term loan, default partially, or deliver fully. In the case that they default, they will sustain a disutility equal to the amount they default multiplied by the (marginal) default penalty. Default in this model can be either strategic or due to ill fortune. The following conditions characterize these three cases:

(i) Debtors default completely when the marginal gain for zero delivery of the asset they sell is higher than the marginal loss from defaulting.

(ii) If at zero delivery the marginal utility gain is less than the marginal disutility from defaulting, then they will default up to the level that the marginal gain is equal to the marginal loss.

(iii) Debtors will deliver fully when their marginal gain for full delivery is lower than the marginal loss.

In our model, the positive level of default in the absence of aggregate uncertainty can be thought of as being the outcome of a population which differs in their propensity to repay their debt and hence describes the probability of default. It can then be regarded as an appropriate microfoundation for the commonly used probabilities of default in applied analysis of credit risk, corporate default, etc. (see Merton 1974). The non-pecuniary costs incurred in the event of default can be thought of as the cost of being excluded from capital markets (see Eaton and Gersovitz 1981 or, more recently, Arellano 2008, Kletzer and Wright 2000, Kovrijnykh and Szentes 2007, and Yue 2010).

2.6 First-Order Conditions

The first-order condition for household 1 of country 1 is

$$A_1(t)\frac{c^1(t)^{-\rho}}{\kappa_1(t)l^1(t)} = 1 + r_1(t), \tag{27}$$

$$\frac{c^1(1)^{-\rho}}{P_1(1)}(1-\tau_1) = (1+\overline{r}_1(1))\frac{c^1(2)^{-\rho}}{P_1(2)}, \tag{28}$$

$$\lambda = c^1(2)^{-\rho}. \tag{29}$$

The first-order condition for household 2 of country 2 is

$$A^2(t)\frac{c^2(t)^{-\rho}}{\kappa^2(t)l^2(t)} = 1 + r_2(t), \tag{30}$$

$$\frac{c^2(1)^{-\rho}}{P_1(1)}(1+\tau_2) = (1+\overline{r}_1(1))K\frac{c^2(2)^{-\rho}}{P_1(2)}. \tag{31}$$

Finally, the law of one price holds for goods and determines the exchange rate:

$$\frac{P_1(t)}{e_{21}(t)P_2(t)} = 1.$$

Equations (27) and (30) give the marginal rate of substitution between consumption and leisure. Equations (28) and (31) are the standard Euler equation, except that the Euler equation for the household in country 2 also depends on the expected delivery rate. In equation (29), households weigh the marginal cost and benefit of defaulting; we consider an equilibrium where default occurs and hence this condition holds. This condition is referred to as an *on-the-verge* condition, following Dubey, Geanokoplos, and Shubik (2005).

3. Equilibrium Analysis

In this section we examine the properties of the equilibria. We first examine the importance of capital flow taxes in determining the equilibrium allocation, as set out in the proposition below. The next two propositions separate the welfare effects of introducing capital flow taxes on the allocation (proposition 2) and the deadweight loss of default (proposition 3). We analyze the properties of equilibrium with a linear default penalty here.

Proofs for propositions 1–3 can be found in the appendix.

PROPOSITION 1. *Given nominal wealth, $w_i^h(t) = W_i(t)$, interest rate policy, $r_i(t)$, and fiscal policy, τ_i, the allocation depends on the tax rate on capital exports, τ_2, and not the tax rate on capital imports, τ_1.*

The irrelevance of the inflow tax, τ_1, in determining the equilibrium allocation is a consequence of the linear punishment for default imposed on household 1. The inflow tax reduces household 1's (the borrower/seller of the bond) demand for transferring wealth from period 2 to period 1. The resulting higher real wealth in period 2, however, is used to repay a greater proportion of his liability in the international bond market (increasing the delivery rate on his bond liability) and leaves his demand for goods (and lost leisure) unaffected. As period 2 demands do not change, neither does his demand in period 1: the higher inflow tax is offset by a lower (inflation-adjusted) intertemporal interest rate. When capital outflows are taxed, household 2's (the lender/buyer of the bond) demand increases in period 1 and falls in period 2, and, as he does not need to transfer wealth between goods and there is a deadweight cost of default, outflow taxes have real effects. Note that the lump-sum transfer also has no effect as a consequence of the linear default punishment.

PROPOSITION 2. *Given nominal wealth, $w_i^h(t) = W_i(t)$, interest rate policy, $r_i(t)$, and fiscal policy, τ_i, the tax rate on capital exports, τ_2, worsens the allocation for capital importers, household 1, and improves the allocation for capital exporters, household 2.*

This result follows from proposition 1. A higher capital export tax, reducing the real value of debt which household 1 issues, means that he must produce more in period 1 to finance his consumption. On the other hand, household 2 now needs to produce less, as he can consume more of country 1's output. As household 1 produces more, he suffers a greater cost in lost leisure and compensates by consuming less, and vice versa for household 2: The reduction in bond trade reduces the consumption of household 1 both home and abroad and stimulates country 1 GDP, while the opposite occurs for household 2 and country 2.

PROPOSITION 3. *Given nominal wealth, $w_i^h(t) = W_i(t)$, interest rate policy, $r_i(t)$, and fiscal policy, τ_i, the tax rate on capital imports, τ_1, reduces the deadweight loss of default for capital importers, household 1, and similarly for the tax rate on capital exports, τ_2, whenever $\frac{1}{\rho(1+\tau_2)} > \epsilon_1^2(1) - \epsilon_1^1(1)$, where $\epsilon_i^h(t)$ is the elasticity of consumption with respect to τ_2 and ρ is the coefficient of relative risk aversion.*

A higher borrowing tax reduces the amount household 1 borrows and thus increases the amount he can repay in period 2, increasing the delivery rate. As the allocation has not changed, the effect of this is a Pareto improvement.

Increasing the rate of capital export tax, τ_2, reduces the amount of loans which household 2 purchases, thus reducing the volume of debt issued by household 1. This reduction in debt allows him to repay a greater proportion of his debt, and the delivery rate improves. The elasticity condition for reducing the deadweight cost of default is a consequence of the price effects which need to occur for the capital importer to be sufficiently affected by a tax on the foreign agent (the capital exporter). That is, the terms of trade cannot move so much in the direction of the capital exporter to make it worthwhile to increase the rate of default rather than suffer additional, more severe, terms-of-trade effects.

We can now summarize the welfare effects of introducing a tax on capital imports by combining the results of propositions 1 and 3.

PROPOSITION 4. *Given nominal wealth, $w_i^h(t) = W_i(t)$, interest rate policy, $r_i(t)$, and fiscal policy, τ_i, an increase in the tax rate on capital imports, τ_1, leads to a weak Pareto improvement.*

As the allocation is unchanged by an introduction of the capital inflow tax, but the deadweight cost of default falls, welfare improves for the debtor and remains unchanged for the creditor.

4. Irrelevance of Fiscal Transfers

We have hitherto assumed that fiscal revenues are completely returned to domestic residents with interest. It may seem that when household 1 is taxed, the higher nominal income in the second period is causing the reduction in the deadweight cost of default. In fact, the fiscal revenues have no effect on the components of the deadweight cost of default: the real value of debt repayments and the delivery rate are unaffected by the lump-sum transfers. Using $\bar{b}_1^1(2)K(2) = D_1^1(2)$, for a linear default penalty ($z = 1$), we find the deadweight cost of default is

$$\lambda \frac{(\bar{b}_1^1(2) - D_1^1(2))}{P_1(1)} = \lambda \frac{D}{P_1(1)} \left(\frac{1}{K(2)} - 1 \right). \tag{32}$$

PROPOSITION 5. *Given nominal wealth, $w_i^h(t) = W_i(t)$, interest rate policy, $r_i(t)$, and fiscal policy, τ_i, lump-sum transfers have no real effects (on allocation or on the deadweight cost of default).*

Though somewhat surprising, proposition 5 is a consequence of the representative agent assumption in each country. Clearly, if there are multiple agents, how the fiscal revenue is spent will have wealth effects on agents and alter the ability of agents to produce, consume, and deliver on promises. With a representative agent in each country, all nominal wealth/price effects are exactly offset by exchange rate adjustments. Lump-sum transfers increase the price level in the second period, and agents finance higher nominal expenditures with greater borrowing from the monetary authority. In real terms, there is no effect: inflation increases the nominal liabilities in the international bond market but does not affect it in real terms.

The above proposition assumes that some, or all, of the fiscal revenue collected in the first period disappears from the economy: there is some unmodeled cost involved in collecting or spending the revenue. In order to satisfy the overall fiscal-monetary authority budget constraint, this can be thought of as collected revenue being returned to the monetary authority.

5. On Optimal Policy

So far we have abstracted from the optimality of policy. This is a difficult problem in the system we are studying, as there are two inefficiencies. Positive interest rates result in the supply of labor being sub-optimally low, and default may be unavoidable given its associated non-pecuniary costs. We assume here that policy has no control over the non-pecuniary punishment for default. Interest rate policy is, however, more innocuous. Our results hold for *any* positive (even arbitrarily low) interest rates and thus, as an approximation, can be considered valid under the Friedman rule. So the policy variable of interest, then, is the tax rate on capital flow. We have proved in proposition 4 that increasing taxes on capital inflows leads to a weak Pareto improvement. This Pareto improvement will continue to occur provided that the delivery rate is less than one (i.e., default is anticipated). This is because increasing the tax rate increases the delivery rate monotonically[14]: given an exogenous interest rate policy, the optimal tax rate on capital inflows will preclude default. Of course, the allocation will be inefficient because the level of borrowing is inefficient, but fiscal policy is able to reduce the deadweight cost of default and hence improve welfare for the borrower. A similar argument applies to the optimal tax on capital outflows, though the benefit of taxing capital outflows will accrue to the lending country and its domestic residents. The reason here is that, from proposition 2, increasing the rate of taxes on loans alters the allocation in

[14] This can be seen in the proof to proposition 3.

favor of the lender. This will continue so long as the rate of repayment on the international bond is less than one. The optimal tax on capital outflows will then preclude default, but welfare will increasingly favor the lending country/agent. Why is it that we do not consider further taxation of capital flows in the absence of default? The reason is twofold. Firstly, the terms-of-trade effects when taxation on capital flows is introduced, in the absence of default, make the results highly sensitive to the interest rate structure present. Secondly, such a policy, if beneficial, would most likely lead to a beggar-thy-neighbor effect on the terms of trade, with no benefit to its trading partner (recall that even taxing capital outflows in the presence of default may reduce the deadweight cost of default), and thus is more suited to be studied in a framework which explicitly considers the strategic interaction between governments or a "trade war" rather than the framework here, which is designed to study the trade-off between the non-pecuniary costs of default and the terms of trade.

6. Conclusion

"Global imbalances," or large current account positions (equivalently large cross-border flows of capital), have not been unusual phenomena in recent economic history. Economies growing strongly, from a relatively small base, have often had large current account surpluses. What has generated concern has been the size and persistence of these current account positions over the past decade or so and the fact that they involve some of the world's largest economies. Large financial flows clearly reflect large real trade surpluses, but the consequences of the financial flows are not innocuous. Financial flows engender leverage, credit, and ultimately often default. Here we study the use of taxing capital flows as a mechanism to limit the consequences of default caused by large current/capital account surpluses/deficits.

In aggregate, default, or the expectation of default, reduces the desire of creditors to lend, because they fear they will not recover their money. And debtors fear the pecuniary and non-pecuniary costs they would face in the event of default. Pecuniary costs include bankruptcy proceedings, legal fees, and restructuring costs, while non-pecuniary costs include the loss of reputation and inability to access credit markets immediately. For debtors, we focus on the consequences of the latter in this paper: however, the macroeconomic consequences of default include lower intertemporal bond trade and inefficient consumption and production (GDP).

The simple example presented in this paper separates the effect of introducing capital flow taxes on GDP, trade, and default. We show that it is the trade-off between the deadweight cost of default and the allocation (production/consumption) which allows taxation to have potentially beneficial effects. Our results have a number of limitations. Our production technology depends only on labor supplied and, as a consequence, capital flows do not directly affect the productive capacity of the economy. We consider the effects of a linear punishment for default, removing many of the interactions between nominal flows and the real economy. We do not consider heterogeneity—particularly the interaction between traded and nontraded goods—and, finally, we do not allow a formal role for a government to spend its revenues on public goods. However, in spite of these limitations, we feel our paper shows, in a concise manner, that the scope for taxing nominal capital flows may be a useful macroprudential policy tool.

Appendix 1. List of Variables

Table 1. List of Variables of Economy

Variable	Details
i, j	Index of Countries
h	Index of Households
$\overline{r}$	Interest Rate on International Bond
r	Short-Term Interest Rate
P	Prices of Goods
e	Exchange Rate
c	Consumption
y	Gross Domestic Product
l	Labor Supplied
b	Liability in Money Market
$\overline{b}$	Trade in International Bond Market

(continued)

Table 1. (Continued)

Variable	Details
D	Amount of International Bond Promises Honored
K	Delivery Rate on International Bond Market Liabilities
w	Initial Wealth in Each Period Transferred by the Monetary Authority
M	Money Supply
m	Money Balances Held by Agents
λ	Default Punishment per Unit of Real Default
ρ	Coefficient of Relative Risk Aversion
A	Coefficient of Productivity
κ	Preference for Leisure
τ	Tax Rate Levied on International Bond Market Activity
T	Lump-Sum Transfer
ϕ	Proportion of Fiscal Revenues Returned to Domestic Household

Appendix 2. Proofs

Proof of Proposition 1

Using the period 1 budget constraint of the country 1 householder (8) and (9) and the law of one price, we get

$$P_1(1)c_1^1(1) + e_{21}(1)P_2(1)c_2^1(1) = (1-\tau_1)\frac{\bar{b}_1^1(2)}{1+\bar{r}_1(1)} + \frac{P_1(1)y_1^1(1)}{1+r_1(1)} + w_1^1(1) \quad (33)$$

$$P_1(1)c^1(1) =$$

$$P_1(1)[c^1(1) - \frac{y_1^1(1)}{1+r_1(1)}] =$$

$$P_1(1) = \frac{(1-\tau_1)\frac{\bar{b}_1^1(2)}{1+\bar{r}_1(1)} + w_1^1(1)}{c^1(1) - \frac{y_1^1(1)}{1+r_1(1)}}. \quad (34)$$

From market clearing in the currency market, we know that $e_{21}(1)P_2(1)c_2^1(1) = P_1(1)c_1^2(1) + \frac{\bar{b}_1^2(2)}{1+\bar{r}_1(1)}$. From market clearing in the intertemporal bond market, $b_1^1 = b_1^2$, so (33) becomes

$$P_1(1)c_1^1(1) + P_1(1)c_1^2(1) + \frac{\bar{b}_1^1(2)}{1+\bar{r}_1(1)} = (1-\tau_1)\frac{\bar{b}_1^1(2)}{1+\bar{r}_1(1)} + \frac{P_1(1)y_1^1(1)}{1+r_1(1)} + w_1^1(1)$$

$$P_1(1)\left[c_1^1(1) + c_1^2(1) - \frac{y_1^1(1)}{1+r_1(1)}\right] = w_1^1(1) - \tau_1\frac{\bar{b}_1^1(2)}{1+\bar{r}_1(1)}$$

$$P_1(1) = \frac{w_1^1(1) - \tau_1\frac{\bar{b}_1^1(2)}{1+\bar{r}_1(1)}}{c_1^1(1) + c_1^2(1) - \frac{y_1^1(1)}{1+r_1(1)}} = \frac{w_1^1(1) - \tau_1\frac{\bar{b}_1^1(2)}{1+\bar{r}_1(1)}}{y_1^1(1)}\frac{1+r_1(1)}{r_1(1)}, \tag{35}$$

where the last step comes from market clearing in the goods market: $c_1^1(1) + c_1^2(1) = y_1^1(1)$. Doing the same for country 2 gives

$$P_2(1) = \frac{w_2^2(1) - (1+\tau_2)\frac{\bar{b}_1^2(2)}{1+\bar{r}_1(1)}\frac{1}{P_1(1)}}{c^2(1) - \frac{y_2^2(1)}{1+r_2(1)}} \tag{36}$$

$$= \frac{w_2^2(1)}{\tau_2\frac{\bar{b}_1^2(2)}{1+\bar{r}_1(1)}\frac{1}{P_1(1)} + y_2^2(1)\frac{r_2(1)}{1+r_2(1)}}. \tag{37}$$

Using (34) and (35) gives

$$\frac{(1-\tau_1)\frac{\bar{b}_1^1(2)}{1+\bar{r}_1(1)} + w_1^1(1)}{c^1(1) - \frac{y_1^1(1)}{1+r_1(1)}} = \frac{w_1^1(1) - \tau_1\frac{\bar{b}_1^1(2)}{1+\bar{r}_1(1)}}{y_1^1(1)}\frac{1+r_1(1)}{r_1(1)}$$

$$\frac{\bar{b}_1^1(2)}{1+\bar{r}_1(1)} = \frac{w_1^1(c^1(1) - y_1^1(1))}{\tau_1(c^1(1) - y_1^1(1)) + y_1^1(1)\frac{r_1(1)}{1+r_1(1)}}. \tag{38}$$

Using (35) and (38) gives

$$P_1(1) = \frac{w_1^1}{\tau_1(c^1(1) - y_1^1(1)) + y_1^1(1)\frac{r_1(1)}{1+r_1(1)}}. \tag{39}$$

Using (38) and (39), we get an expression for the real volume of trade in the bond market:

$$\frac{\bar{b}_1^1(2)}{1+\bar{r}_1(1)}\frac{1}{P_1(1)} = \frac{\bar{b}_1^2(2)}{1+\bar{r}_1(1)}\frac{1}{P_1(1)} = c^1(1) - y_1^1(1). \tag{40}$$

Substituting (40) into (37) gives

$$P_2(1) = \frac{w_2^2(1)}{\tau_2(c^1(1) - y_1^1(1)) + y_2^2(1)\frac{r_2(1)}{1+r_2(1)}}. \tag{41}$$

In the second period, the currency market clearing gives us $e_{21}(2)P_2(2)c_2^1(2) = P_1(2)c_1^2(2) - K_1(2)\bar{b}_1^2(2)$. From market clearing in the bond market delivery, we know that $K_1(2)\bar{b}_1^2(2) = D_1^1(2)$. Finally, the law of one price gives $P_1(2) = e_{21}(2)P_2(2)$ and market clearing $c_1^1(2) + c_1^2(2) = y_1^1(2)$. Using these, we can rearrange the period 2 budget constraint of the country 1 representative household as

$$\begin{aligned} P_1(2)c_1^1(2) + D_1^1(2) + e_{21}(2)P_2(2)c_2^1(2) &= w_1^1(2) + \frac{P_1(2)y_1^1(2)}{1+r_1(2)} \\ &\quad + T_1^1(2) \\ P_1(2)y_1^1(2)\frac{r_1(2)}{1+r_1(2)} &= w_1^1(2) + T_1^1(2) \\ P_1(2) &= \frac{w_1^1(2) + T_1^1(2)}{y_1^1(2)\frac{r_1(2)}{1+r_1(2)}} \qquad (42) \\ &= \frac{w_1^1(2) + T_1^1(2)}{y_1^1(2)\frac{r_1(2)}{1+r_1(2)}}. \qquad (43) \end{aligned}$$

Note that $\frac{1}{\phi}T_1^1(2) + w_1^1(2) = w_1^1(1)$. Also, $T_1^1(2) = \phi\tau_1\frac{\bar{b}_1^1(2)}{1+\bar{r}_1}(1 + r_1(1))$ and, using (38), becomes $T_1^1(2) = \phi\tau_1\frac{w_1^1(c^1(1)-y_1^1(1))(1+r_1(1))}{\tau_1(c^1(1)-y_1^1(1))+y_1^1(1)\frac{r_1(1)}{1+r_1(1)}}$. Therefore

$$
\begin{aligned}
w_1^1(2) + T_1^1(2) &= w_1^1(1) - T_1^1(2)\frac{1-\phi}{\phi} \\
&= w_1^1(1) - (1-\phi)\tau_1 \frac{w_1^1(c^1(1) - y_1^1(1))(1+r_1(1))}{\tau_1(c^1(1) - y_1^1(1)) + y_1^1(1)\frac{r_1(1)}{1+r_1(1)}} \\
&= w_1^1(1)\frac{\left\{\tau_1(c^1(1) - y_1^1(1))[1-(1-\phi)(1+r_1)] + y_1^1(1)\frac{r_1(1)}{1+r_1(1)}\right\}}{\tau_1(c^1(1) - y_1^1(1)) + y_1^1(1)\frac{r_1(1)}{1+r_1(1)}}.
\end{aligned} \tag{44}
$$

Substituting (44) into (43) gives

$$
\begin{aligned}
P_1(2) = {} & \frac{w_1^1(1)}{y_1^1(2)\frac{r_1(2)}{1+r_1(2)}} \\
& \times \frac{\left\{\tau_1(c^1(1) - y_1^1(1))[1-(1-\phi)(1+r_1)] + y_1^1(1)\frac{r_1(1)}{1+r_1(1)}\right\}}{\tau_1(c^1(1) - y_1^1(1)) + y_1^1(1)\frac{r_1(1)}{1+r_1(1)}}.
\end{aligned} \tag{45}
$$

The rate of inflation in country 1 is then the ratio given by (35) and (45):

$$
\frac{P_1(2)}{P_1(1)} = \frac{\tau_1(c^1(1) - y_1^1(1))[1-(1-\phi)(1+r_1)] + y_1^1(1)\frac{r_1(1)}{1+r_1(1)}}{y_1^1(2)\frac{r_1(2)}{1+r_1(2)}}. \tag{46}
$$

Now, using the expression for $T_1^1(2)$ obtained above, the budget constraint in the second period for the country 1 representative household becomes

$$
\begin{aligned}
D_1^1(2) &= w_1^1(2) + \frac{P_1(2)y_1^1(2)}{1+r_1(2)} + T_1^1(2) - P_1(2)c_1^1(2) - e_{21}(2)P_2(2)c_2^1(2) \\
&= w_1^1(2) + T_1^1(2) + P_1(2)\left[\frac{y_1^1(2)}{1+r_1(2)} - c^1(2)\right] \\
&= w_1^1(1)\frac{\left\{\tau_1(c^1(1) - y_1^1(1))[1-(1-\phi)(1+r_1)] + y_1^1(1)\frac{r_1(1)}{1+r_1(1)}\right\}}{\tau_1(c^1(1) - y_1^1(1)) + y_1^1(1)\frac{r_1(1)}{1+r_1(1)}} \\
&\quad + P_1(2)\left[\frac{y_1^1(2)}{1+r_1(2)} - c^1(2)\right]
\end{aligned}
$$

$$\frac{D_1^1(2)}{\frac{\bar{b}_1^1(2)}{1+\bar{r}_1(1)}} = \frac{w_1^1(1)\frac{\left\{\tau_1(c^1(1)-y_1^1(1))[1-(1-\phi)(1+r_1)]+y_1^1(1)\frac{r_1(1)}{1+r_1(1)}\right\}}{\tau_1(c^1(1)-y_1^1(1))+y_1^1(1)\frac{r_1(1)}{1+r_1(1)}} + P_1(2)[\frac{y_1^1(2)}{1+r_1(2)} - c^1(2)]}{\frac{w_1^1(c^1(1)-y_1^1(1))}{\tau_1(c^1(1)-y_1^1(1))+y_1^1(1)\frac{r_1(1)}{1+r_1(1)}}}$$

$$= \frac{w_1^1(1)\left\{\tau_1(c^1(1)-y_1^1(1))[1-(1-\phi)(1+r_1)] + y_1^1(1)\frac{r_1(1)}{1+r_1(1)}\right\}}{w_1^1(c^1(1)-y_1^1(1))}$$

$$+ \frac{P_1(2)[\frac{y_1^1(2)}{1+r_1(2)} - c^1(2)](\tau_1(c^1(1)-y_1^1(1)) + y_1^1(1)\frac{r_1(1)}{1+r_1(1)})}{w_1^1(c^1(1)-y_1^1(1))}$$

$$= \frac{\left\{\tau_1(c^1(1)-y_1^1(1))[1-(1-\phi)(1+r_1)] + y_1^1(1)\frac{r_1(1)}{1+r_1(1)}\right\} \times [y_1^1(2) - c^1(2)]}{y_1^1(2)\frac{r_1(2)}{1+r_1(2)}(c^1(1)-y_1^1(1))}, \quad (47)$$

where the expression for $\frac{\bar{b}_1^1(2)}{1+\bar{r}_1(1)}$ is obtained from (38) and the expression for $P_1(2)$ is from (43). Now turn to the first-order condition of the representative household of country 2 (31) for the long-term bond, noting that from above we have expressions for $\frac{P_1(2)}{P_1(1)}$ and $\frac{D_1^1(2)}{\frac{\bar{b}_1^1(2)}{1+\bar{r}_1(1)}}$ ((46) and (47), respectively).

$$\left\{\frac{c^2(1)}{c^2(2)}\right\}^{-\rho}(1+\tau_2)$$

$$= (1+\bar{r}_1(1))K_1(2)$$

$$= \frac{D_1^1(2)}{\frac{\bar{b}_1^1(2)}{1+\bar{r}_1(1)}}\frac{P_1(1)}{P_1(2)}$$

$$= \frac{\left\{\tau_1(c^1(1)-y_1^1(1))[1-(1-\phi)(1+r_1)] + y_1^1(1)\frac{r_1(1)}{1+r_1(1)}\right\} \times [y_1^1(2) - c^1(2)]}{y_1^1(2)\frac{r_1(2)}{1+r_1(2)}(c^1(1)-y_1^1(1))}$$

$$\times \frac{y_1^1(2)\frac{r_1(2)}{1+r_1(2)}}{\tau_1(c^1(1)-y_1^1(1))[1-(1-\phi)(1+r_1)] + y_1^1(1)\frac{r_1(1)}{1+r_1(1)}}$$

$$= \frac{y_1^1(2) - c^1(2)}{c^1(1) - y_1^1(1)}$$

$$= \frac{c^2(2) - y_2^2(2)}{y_2^2(1) - c^2(1)}$$

$$c^2(1)^{-\rho}(y_2^2(1) - c^2(1))(1 + \tau_2) = c^2(2)^{-\rho}(c^2(2) - y_2^2(2)). \qquad (48)$$

So the allocation in the first period is a function of the allocation in the second period and the tax on capital flows. Recall that the first-order condition makes the marginal rates of substitution between labor and consumption depend on the nominal interest rate and preference parameters, which are all data in the economy (30). As output is a linear function of labor supplied, then expression (48) can be written in terms of output or consumption in each period, preferences, and the tax rate.

The allocation in the second period is pinned down by the marginal penalty for default from the first-order conditions (29) and (27) for the representative household of country 1, from (30) for the country 2 household, and from market clearing in the goods market. The consumption/output of the country 2 household in period 1 is given by (48), and the period 1 allocation for the country 1 household is again given by (27) and market clearing in the goods market. As the capital inflow tax does not enter into this solution, we conclude that the tax rate on capital inflows does not affect the allocation and only the tax on capital outflows: τ_2.

Proof of Proposition 2

The allocational effects of an increase in the tax rate on capital flows will depend on (48), as the allocation in the second period is pinned down solely by the marginal punishment for default. The first-order condition (30) tells us that labor supplied, and hence output, is a decreasing function of consumption. Hence $c^2(1)^{-\rho}(y_2^2(1) - c^2(1))$ is a decreasing function of consumption. Therefore, increasing the tax rate on capital outflows will increase consumption and reduce labor supplied in the first period for the country 2 household, strictly increasing his utility. As the quantity produced by country 1 is decreasing and the quantity consumed is increasing, from market clearing in the goods market and first-order condition (27), the opposite must be occurring for the household of country 1. Hence the utility of consumption is falling for country 1: the allocation increasingly favors the exporter of capital.

Note that we have not considered the effect of the tax on the deadweight cost of default yet.

Proof of Propositions 3 and 4

To determine the effect on the deadweight loss, we combine the first-order conditions for bond trade of both households (28) and (31):

$$\frac{u'(c^2(1))}{u'(c^1(1))}\frac{1+\tau_2}{1-\tau_1} = K_1(2)\frac{u'(c^2(2))}{u'(c^1(2))}. \tag{49}$$

Differentiating (49) with respect to τ_1 and using the result that the allocation does not depend on τ_1, we get

$$\frac{\partial K_1(2)}{\partial \tau_1} = \frac{1+\tau_2}{(1-\tau_1)^2}\frac{u'(c^2(1))}{u'(c^1(1))}, \tag{50}$$

which is clearly strictly positive.

Differentiating (49) with respect to τ_2, we get

$$\frac{\partial K_1(2)}{\partial \tau_2} = K_1(2)\frac{1+\tau_2}{1-\tau_1}\left(\frac{1}{1+\tau_2} - \rho\left(\frac{\frac{\partial c^2(1)}{\tau_2}}{c^2(1)} - \frac{\frac{\partial c^1(1)}{\tau_2}}{c^1(1)}\right)\right). \tag{51}$$

Interpreting $\frac{\frac{\partial c^2(1)}{\tau_2}}{c^2(1)} = \epsilon^2(1)$ and $\frac{\frac{\partial c^1(1)}{\tau_2}}{c^1(1)} = \epsilon^1(1)$ as the elasticity of consumption with respect to the capital export tax rate, and using the results of proposition 2, we know that $\epsilon^2(1) > 0$ and $\epsilon^1(1) < 0$. We can now characterize the condition required for the delivery rate to increase with τ_2:

$$\frac{1}{\rho(1+\tau_2)} > \epsilon_1^2(1) - \epsilon_1^1(1). \tag{52}$$

We now turn to determining how the deadweight cost of default is affected by the tax rates. The deadweight loss of default is

$$-\frac{\lambda}{P_1(2)}\left[\bar{b}_1 - D\right] = -\lambda\frac{D}{P_1(2)}\left[1/K_1 - 1\right].$$

Differentiating this with respect to τ_i gives us

$$-\lambda \frac{\partial \frac{D_1^1(2)}{P_1(2)}}{\partial \tau_i}[1/K_1 - 1] - \lambda \frac{D_1^1(2)}{P_1(2)} \frac{\partial 1/K_1(2)}{\partial \tau_i}. \tag{53}$$

From the argument above, we know that (assuming the elasticity condition holds for the case of the capital outflow tax), since $\frac{\partial K_1(2)}{\partial \tau_i} > 0$ and $K_1(2) > 0$, then $\frac{\partial 1/K_1(2)}{\partial \tau_i} < 0$. Therefore $-\lambda \frac{D_1^1(2)}{P_1(2)} \frac{\partial 1/K_1(2)}{\partial \tau_2} > 0$. Finally, what remains is to determine $\frac{\partial \frac{D_1^1(2)}{P_1(2)}}{\partial \tau_2}$.

From the household 1 budget constraint of period 2 and the results of the proof from proposition 1, we know

$$\begin{aligned}
D_1^1(2) &= w_1^1(2) + T_1^1(2) + P_1(2)\left[\frac{y_1^1(2)}{1+r_1(2)} - c^1(2)\right] \\
\frac{D_1^1(2)}{P_1(2)} &= \frac{w_1^1(2) + T_1^1(2)}{P_1(2)} + \frac{y_1^1(2)}{1+r_1(2)} - c^1(2) \\
&= \frac{w_1^1(1) \frac{\left\{\tau_1(c^1(1)-y_1^1(1))[1-(1-\phi)(1+r_1)]+y_1^1(1)\frac{r_1(1)}{1+r_1(1)}\right\}}{\tau_1(c^1(1)-y_1^1(1))+y_1^1(1)\frac{r_1(1)}{1+r_1(1)}}}{\frac{w_1^1(1)}{y_1^1(2)\frac{r_1(2)}{1+r_1(2)}} \frac{\left\{\tau_1(c^1(1)-y_1^1(1))[1-(1-\phi)(1+r_1)]+y_1^1(1)\frac{r_1(1)}{1+r_1(1)}\right\}}{\tau_1(c^1(1)-y_1^1(1))+y_1^1(1)\frac{r_1(1)}{1+r_1(1)}}} \\
&\quad + \frac{y_1^1(2)}{1+r_1(2)} - c^1(2) \\
&= y_1^1(1) - c^1(2),
\end{aligned} \tag{54}$$

which depends only on period 2 variables and hence is not affected by either τ_1 or τ_2. This gives us our result that the deadweight loss of default falls when either a capital inflow or outflow tax is introduced.

As we showed in the previous proposition that the allocation is unaffected by the introduction of the tax on capital inflows, τ_1, and we have shown now that the deadweight loss of default falls when this tax is introduced, then this corresponds to a weak Pareto improvement.

Proof of Proposition 5

From the proof for proposition 1, we show that the allocation depends on τ_2 as well as preferences, productivity, and short-term interest rates only and not lump-sum transfers. Hence $T_1^1(2)$ and $T_2^2(2)$ do not affect the allocation of consumption or leisure. From equation (32) we see that the components of the deadweight cost of default are $\frac{D_1^1(2)}{P_1(2)}$ and $K_1(2)$. From equation (54) in this appendix (for the proof for proposition 3), we see that $\frac{D_1^1(2)}{P_1(2)}$ depends only on the allocation and hence is unaffected by the lump-sum transfer. The delivery rate also depends only on the allocation, from equation (49) in the proof for proposition 3. Hence, lump-sum transfers have no effect on either the allocation or the deadweight cost of default.

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