The Consequences of Bretton Woods' International Capital Controls and the High Value of Geopolitical Stability

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Abstract

This paper quantifies the positive and normative effects of international capital controls on global and regional economic activity under The Bretton Woods international financial system. A three region, open economy, DSGE capital flows accounting framework consisting of the U.S., Western Europe, and the Rest of the World, is developed to identify capital controls and quantify their impact. We find these controls had large positive and normative effects. Counterfactuals indicate world output would have been 6% higher had there been perfect capital mobility. We also robustly find these impediments to capital mobility raised welfare substantially in the rest of the world and modestly in Europe, at the expense of much lower welfare in the U.S. This finding raises the question of why the U.S. promoted these controls, given their impact on U.S. welfare. We interpret the large U.S. welfare loss as an estimate of the implicit value to the U.S. of preventing capital flight from other countries and thus promoting economic and political stability in ally and developing countries. This interpretation is consistent with the literature from that time that emphasized the U.S.'s deep interests in supporting governments perceived to be friendly towards the U.S. during a period of fascism and the beginning of the Cold War.

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1 Introduction

This paper quantifies the positive and normative impact of capital controls on the world economy under The Bretton Woods international financial system, which was in place from roughly 1949-1973. Bretton Woods was the most significant modern policy experiment to attempt to simultaneously manage international payments, international capital flows, and international currency values. Because of the uniqueness of Bretton Woods, there are thousands of studies of this system, with almost all focusing on monetary aspects of the system including the fixed exchange rates and the consequences of shifting to flexible rates following its' failure (see Bordo (1993, 2018)).

In contrast, this paper focuses on an important real aspect of the Bretton Woods system. We ask how much did Bretton Woods capital controls (i) impede the international flow of capital, (ii) where would capital have flown in the absence of those controls, and (iii) what was the impact of these controls on the world economy. We also evaluate why the United States—which was the primary designer of Bretton Woods— believed capital controls to be an essential part of Bretton Woods, and we provide estimates of the welfare implications of these capital controls.

Addressing these questions is challenging. As Obstfeld et. al. (2004) note, capital controls are extremely difficult to measure. In addition, several different types of controls were implemented, and the de facto application of controls may have differed considerably from their de jure specification. Moreover, Bretton Woods involved multiple, interrelated objectives and multidimensional policies, which means that general equilibrium considerations may be quantitatively important.

Given these challenges, this paper employs an open economy, general equilibrium capital flows accounting framework developed to quantify the effects of these multidimensional policies on the world economy. This approach is well-suited to study the consequences of Bretton Wood capital controls precisely because of multi-dimensional policies and objectives, and because the direct measurement of capital controls is extremely difficult to do.

We divide the world economy into three regions: the two major regions within the Bretton Woods agreement, (1) the U.S., and (2) western and northern Europe, and (3) the Rest of the World (ROW). The framework is a good fit for addressing this question because it accounts completely for observed levels of consumption, labor, investment, output, and capital flows in each of these three regions with a relatively small number of identified distortions. These include an international distortion that affects the cost of international financial transactions between regions, and which is observationally equivalent to a tax on foreign borrowing. This distortion affects region-specific capital flows and net exports, as developed in Ohanian, Restrepo-Echavarria, and Wright (2018). Other distortions include the efficiency, labor, capital, and government wedges as developed in Chari, Kehoe, and McGrattan (2006) and Cole and Ohanian (2002).

We focus on the international distortions since the Bretton Woods system required that countries

regulate international capital flows using capital controls. These distortions are used to analyze the quantitative importance of various factors and hypotheses that have been suggested within the literature. This capital flow accounting method facilitates the testing of specific hypotheses about how distortions change over time, and the implementation of general equilibrium counterfactual analyses.

We conduct counterfactuals to assess how world economic activity would have been different had countries not operated within the Bretton Woods system after the war. To do so, we eliminate the distortions on the international front, which we will argue reflect capital controls. We also evaluate the welfare implications of Bretton Woods for the U.S., Europe, and the ROW.

Our main findings are as follows. Bretton Woods capital controls were quantitatively very important by substantially impeding the flow of capital across countries. In their absence, we find that world output, and that the allocation of capital across countries would have been very different, with enormous capital flows out of the ROW and into the U.S. This would have increased world output by six percent.

We also find that these controls have very large welfare affects, with a perpetual consumption-equivalent welfare benefit of about 1.3 percent for Europe, and about 4.5 percent for the ROW. In contrast, we find that U.S. welfare was about 4.5 percent lower in consumption equivalent units under Bretton Woods.

This begs the question of why the U.S. had promoted these controls in the first place? We provide evidence that the U.S. viewed these controls as central for preserving and promoting economic and political stability in ally countries and in developing countries that the U.S. hoped would become allies. We therefore interpret the high cost of Bretton Woods controls as an estimate of the implicit value of preserving stability in friendly governments at a time of substantial hostilities related to fascism and communism.

The paper is organized as follows. Section 2 summarizes the capital flow accounting framework. Section 3 discusses the implementation. Section 4 presents the identified distortions. Section 5 shows the counterfactual exercises as well as welfare calculations. Section 6 discusses how history sheds light and supports our numerical results, and Section 7 concludes.

2 The model economy and identification of impediments to international capital mobility

In this section we develop a general equilibrium multi-region model in which we analyze the positive and normative effects of Bretton Woods' impediments to international capital mobility on the world economy. In particular we show how Bretton Woods exchange rate controls and international capital mobility impediments show up as a single distortion in one of the model's first order conditions,

and that we can separately identify the role of international capital mobility impediments from fixed exchange rate effects from this distorted first order condition.

We use the capital flow accounting framework developed in Ohanian, Restrepo-Echavarria and Wright (2018) and extend it to include traded and non-traded goods as in Backus and Smith (1993).

2.1 Model with traded and non-traded goods

Households Consider a world economy composed of three "countries" indexed by j, where $j = U$ stands for "United States," $j = E$ stands for "Europe," and $j = R$ stands for the "rest of the world." Time evolves discretely and is indexed by $t = 0, 1, ...$, so that N_{jt} denotes the population of country j at time t. Assume that at each state the economy has $J + 1$ goods, one single traded good and a non-traded good associated with each country J. The decisions of each country are made by a representative agent with preferences over total consumption C_{jt} and per capita hours worked h_{jt} ordered by

$$E_0 \left[\sum_{t=0}^{\infty} \beta^t \left\{ \ln \left(\frac{C_{jt}}{N_{jt}} \right) - \frac{\varphi}{1+\gamma} h_{jt}^{1+\gamma} \right\} N_{jt} \right],$$

where $C_{jt} = \left[\alpha X_{jt}^{\rho} + (1-\alpha) D_{jt}^{\rho} \right]^{1/\rho}$, and X_{jt} is the quantity of the traded good consumed by country j in period t and D_{jt} is the quantity of the non-traded good consumed by country j in period t. The parameters governing preferences—the discount factor β, the preference for leisure φ, and the Frisch elasticity of labor supply $1/\gamma$—are assumed common across countries; therefore, any cross-country differences in core preferences will hence be attributed to the distortions that we introduce next.

The problem of the representative household of country j is to choose a state-contingent stream of tradable consumption X_{jt}, hours worked h_{jt}, purchases of capital to be rented out next period K_{jt+1}, and a portfolio of state-contingent international bond holdings B_{jt+1} subject to a sequence of flow budget constraints for each state and date:

$$\begin{aligned} X_{jt} + P_{jt}^D D_{jt} + P_{jt}^K K_{jt+1} + E_t \left[q_{t+1} B_{jt+1} \right] \quad \leq \quad & \left(1 - \tau_{jt}^h\right) W_{jt} h_{jt} N_{jt} + \left(1 - \tau_{jt}^K\right) \left(r_{jt}^K + P_{jt}^{*K}\right) K_{jt} \\ & + \left(1 - \tau_{jt}^B + \Psi_{jt}\right) B_{jt} + T_{jt} + \Pi_{jt} + P_{jt}^D Y_{jt}^D, \end{aligned}$$

where initial capital K_{j0} and bonds B_{j0} are given. The traded good is produced by a firm using labor and capital, and there is an exogenous endowment of the non-traded good denoted by Y_{jt}^D with a corresponding price of P_{jt}^D, such that $Y_{jt}^D = D_{jt}$. Note that this implies that only the traded good can be used for investment. Furthermore, W_{jt} is the wage per hour worked, r_{jt}^K the rental rate of capital, P_{jt}^K the price of new capital goods, and P_{jt}^{*K} the price of old capital goods, which will differ from the price of new capital goods due to the presence of adjustment costs in capital. In this complete markets environment, the prices of state-contingent international bonds at time t that pay off in one state at $t + 1$ are composed of a risk-adjusted world price q_{t+1} multiplied by the probability of the state occurring, which allows us to write the expected value of the risk-adjusted expenditures on

bonds on the left-hand side of the flow budget constraint. Households also receive profits Π_{jt} from their ownership of domestic firms.

The τ's represent distortions that are isomorphic to taxes on factor payments and investment income. Specifically, τ^h is a distortion on domestic labor markets (or a tax on wage income), τ^K is a distortion on domestic capital markets (or a tax on income from domestic capital), while τ^B is a distortion on international capital markets that is isomorphic to a tax on income derived from international assets or, equivalently, a subsidy on the cost of paying for international liabilities, reflecting impediments to international capital mobility.

Any revenue from these taxes net of the level of government spending G_{jt} are assumed to be transferred in lump-sum fashion to or from households each period as T_{jt},

$$T_{jt} = \tau^h_{jt} W_{jt} h_{jt} N_{jt} + \tau^B_{jt} B_{jt} + \tau^K_{jt} \left(r^K_{jt} + P^{*K}_{jt} \right) K_{jt} - G_{jt}. \tag{1}$$

This implies that there is no government borrowing. As Ricardian equivalence holds in our model, this is without loss of generality.

Finally, Ψ_{jt} is a portfolio adjustment cost that we introduce in order to restore long-run stationarity in consumption, because even though there are complete markets, when we introduce a time-varying distortion on international capital markets, consumption can no longer be identified out of relative shares. We discuss this issue further in Subsection 2.3.

Note that the overall distortion on international capital markets is constituted by two terms. One term is τ^B which as stated above represents a distortion that is isomorphic to a tax on income derived from international assets, and a second term, Ψ, that is a portfolio adjustment cost. The portfolio adjustment cost is a mere technical necessity, and so τ^B, which represents the impediments to international capital mobility as it acts as a tax on the return to assets, is what we will be focusing our attention on when analyzing the effects of Bretton Woods.

Firms Each country is populated by two types of firms. The first type of firm hires labor and capital to produce the tradable consumption good using a standard Cobb-Douglas technology of the form $A_{jt} K^{\alpha}_{jt} \left(h_{jt} N_{jt} \right)^{1-\alpha}$, where A_{jt} is the level of aggregate productivity in the economy and α is the output elasticity of capital. This yields expressions for the equilibrium wage rate per hour and the rental rate on capital:

$$W_{jt} = (1-\alpha) \frac{Y_{jt}}{h_{jt} N_{jt}}, and \tag{2}$$

$$r^K_{jt} = \alpha \frac{Y_{jt}}{K_{jt}}. \tag{3}$$

The second type of firm produces new capital goods K_{jt+1} using I_{jt} units of investment (deferred consumption) and K_{jt} units of the old capital good. Their objective is to maximize profits $P_{jt}^K K_{jt+1} - I_{jt} - P_{jt}^{*K} K_{jt}$ subject to the capital production function (or capital accumulation equation) with convex adjustment costs ϕ of the form

$$K_{jt+1} = (1-\delta) K_{jt} + I_{jt} - \phi\left(\frac{I_{jt}}{K_{jt}}\right) K_{jt}.$$

Note that, although the capital good K_{jt+1} is to be used for production in period $t+1$, it is produced and sold in period t at price P_{jt}^K. This gives rise to first-order conditions:

$$P_{jt}^K = \frac{1}{1-\phi'\left(\frac{I_{jt}}{K_{jt}}\right)}, \tag{4}$$

$$P_{jt}^{*K} = P_{jt}^K\left(1-\delta-\phi\left(\frac{I_{jt}}{K_{jt}}\right)+\phi'\left(\frac{I_{jt}}{K_{jt}}\right)\frac{I_{jt}}{K_{jt}}\right), \tag{5}$$

and we assume that adjustment costs are of the quadratic form:

$$\phi\left(\frac{I_{jt}}{K_{jt}}\right) = \frac{\nu}{2}\left(\frac{I_{jt}}{K_{jt}} - \kappa\right)^2.$$

All production parameters—the output elasticity of capital α, the depreciation rate δ, and those governing adjustment costs ν and κ—are assumed constant across countries.

Growth and Uncertainty The world economy has grown substantially over the period under study. But this growth is not well represented by movements around a deterministic trend with a constant growth rate. Moreover, expectations of future growth in income drive a household's desire to save and invest and hence play a large role (in many cases, the dominant role) in determining capital flows in the presence of impediments to international capital mobility. Hence, it is not appropriate to simply apply the Hodrick-Prescott filter to the data and proceed with a detrended model, as might be done for a business cycle accounting analysis. As a consequence, we adopt a specification for the growth of the population and productivity level in each country that allows the data to speak to us about these expectations of future trends as we did in Ohanian, Restrepo-Echavarria, and Wright (2018).

We assume that there is a stochastic world trend for both population and productivity and associate this with growth in the United States (for similar approaches, see Canova (1998), Fernandez-Villaverde and Rubio-Ramirez (2007), and Cheremukhin and Restrepo-Echavarria (2014)). Specifically, we assume that the United States productivity and population evolve according to

$$\ln A_{Ut+1} = \ln A_{Ut} + \ln \pi_{ss} + \sigma_U^A \varepsilon_{Ut}^A,$$

$$\ln N_{Ut+1} = \ln N_{Ut} + \ln \eta_{ss} + \sigma_U^N \varepsilon_{Ut}^N,$$

where π_{ss} and η_{ss} are the growth rates in U.S. productivity and population that would occur in the deterministic steady-state of our model, such that $\pi_t = \frac{A_{Ut+1}}{A_{Ut}} = \pi_{ss} \exp\left(\sigma_U^A \varepsilon_{Ut}^A\right)$ and $\eta_t = \frac{N_{Ut+1}}{N_{Ut}} =$

$\eta_{ss} \exp\left(\sigma_U^N \varepsilon_{Ut}^N\right)$. In order to make our model of the world economy stationary, we scale by the level of effective labor in the United States $Z_t = A_{Ut}^{1/(1-\alpha)} N_{Ut}$. Note that our specification nests a constant growth rate as a special case.

Population and productivity levels in Europe and the Rest of the World are assumed to evolve relative to the U.S. trend in such a way that a non-degenerate long-run distribution of economic activity across countries is preserved. Specifically, for Europe and the Rest of the World we define relative productivity $a_{jt} = A_{jt}/A_{Ut}$ and relative population $n_{jt} = N_{jt}/N_{Ut}$ and assume that both a_{jt} and n_{jt} follow first-order autoregressive processes of the form

$$\begin{aligned} \ln a_{jt+1} &= \left(1-\rho_j^a\right) \ln a_{jss} + \rho_j^a \ln a_{jt} + \sigma_j^a \varepsilon_{jt+1}^a, \\ \ln n_{jt+1} &= \left(1-\rho_j^n\right) \ln n_{jss} + \rho_j^n \ln n_{jt} + \sigma_j^n \varepsilon_{jt+1}^n. \end{aligned}$$

This allows for long-lasting deviations from the world trend. We place no further restrictions on these processes, preferring to allow the data to speak by estimating their parameters directly.

The labor, capital, and international distortions (indexed by $m = h, K$, and B) for each country are also assumed to follow univariate first-order autoregressive processes of the form

$$\ln\left(1-\tau_{jt+1}^m\right) = \left(1-\rho_j^m\right) \ln\left(1-\tau_{jss}^m\right) + \rho_j^m \ln\left(1-\tau_{jt}^m\right) + \sigma_j^m \varepsilon_{jt+1}^m, \tag{6}$$

where τ_{jss}^m is the level the distortion would take on in the deterministic steady-state of our model and ρ_j^m governs the rate of mean reversion. The evolution of the level of government spending in each country G_{jt} is assumed to be such that the ratio of government spending to national income $g_{jt} = G_{jt}/Y_{jt}$ also follows a first-order autoregressive process:

$$\ln g_{jt+1} = \left(1-\rho_j^g\right) \ln g_{jss} + \rho_j^g \ln g_{jt} + \sigma_j^g \varepsilon_{jt+1}^g.$$

The parameters of all of these processes, with the exception of the steady-state of the international distortion to be discussed in Subsection 2.3, are estimated from, or calibrated to, match the data.

2.2 Identifying exchange rate effects from impediments to international capital mobility

The Euler equation for state-contingent international assets, which identifies the international capital markets distortion, is given by

$$\left(\frac{C_{jt+1}/N_{jt+1}}{C_{jt}/N_{jt}}\right)\left(\frac{P_{jt+1}}{P_{jt}}\right) = \frac{\beta}{q_{t+1}}\left(1-\tau_{jt}^B+\Psi_{jt}\right),$$

where P_j is the price aggregator for tradable and non-tradable goods, and is given by[1]

$$P_{jt} = \left[\psi^{\frac{1}{1-\rho}} + (1-\psi)^{\frac{1}{1-\rho}}\left(P_{jt}^D\right)^{-\frac{\rho}{1-\rho}}\right]^{-\frac{1-\rho}{\rho}}.$$

[1]The price aggregator is derived by substituting the demand for traded and no-traded goods in the definition for aggregate consumption.

Because the price of international state-contingent assets and discount factor are the same for all three regions, international capital market distortions $\left(1-\tau_{jt}^{B}+\Psi_{jt}\right)$ can only be identified for two, out of the three regions. This implies that normalizing the rest of the world international distortion to one, we get

$$\left(\frac{C_{jt+1}/N_{jt+1}}{C_{Rt+1}/N_{Rt+1}}\right)\left(\frac{C_{Rt}/N_{Rt}}{C_{jt}/N_{jt}}\right)\left(\frac{P_{jt+1}/P_{Rt+1}}{P_{jt}/P_{Rt}}\right)=\frac{\left(1-\tau_{jt}^{B}+\Psi_{jt}\right)}{\left(1-\tau_{Rt}^{B}+\Psi_{Rt}\right)}=\zeta_{jt+1}^{NTB}. \tag{7}$$

Note that in our model the real exchange rate can be defined as $Q_{jRt}=\frac{P_{jt}}{P_{Rt}}$. As such, international capital market distortions can be defined as the product of the growth rate of the aggregate relative consumption and the growth rate of the real exchange rate.

State contingent assets allow agents to smooth out consumption. Access to international financial markets, and hence, capital mobility affect an agent's ability to consume, and as such in our model the growth rate of relative consumption represents impediments to international capital mobility that change the incentives and/or opportunities to buy or sell foreign assets. As a result, we interpret our international capital market distortion ζ_{jt+1}^{B}, as being made up of two terms that are multiplicatively separable, the international capital mobility component and the exchange rate component:

$$\underbrace{\left(\frac{C_{jt+1}/N_{jt+1}}{C_{Rt+1}/N_{Rt+1}}\right)\left(\frac{C_{Rt}/N_{Rt}}{C_{jt}/N_{jt}}\right)}_{International\ capital\ controls}\quad\underbrace{\left(\frac{Q_{jRt+1}}{Q_{jRt}}\right)}_{Exchange\ rate\ effects}\quad=\zeta_{jt+1}^{NTB}. \tag{8}$$

Because we are interested in separately identifying the impediments to international capital mobility (first term in Equation 8) from the exchange rate effects (second term in Equation 8) in the overall international distortion, we need to know if the two terms are uncorrelated. We can corroborate this empirically because we have data on consumption, population, and real exchange rates for our three regions (see Section XX for the data and aggregation details), so we evaluate the two components and run a regression of the log of the international capital controls component on the log of the growth rate of the real exchange rate.

Table 1 shows the results of this regression. As we can see, the R-squared is roughly zero, evidence that the two terms are uncorrelated, hence, exchange rate effects do not explain the international capital controls that we identify through the growth rate of relative consumption.

In a model like the one described in Section 2.1, but without non-traded goods, where households maximize

$$E_0\left[\sum_{t=0}^{\infty}\beta^t\left\{\ln\left(\frac{C_{jt}}{N_{jt}}\right)-\frac{\varphi}{1+\gamma}h_{jt}^{1+\gamma}\right\}N_{jt}\right]$$

subject to

$$C_{jt}+P_{jt}^{K}K_{jt+1}+E_t\left[q_{t+1}B_{jt+1}\right]\quad\leq\quad\left(1-\tau_{jt}^{h}\right)W_{jt}h_{jt}N_{jt}+\left(1-\tau_{jt}^{K}\right)\left(r_{jt}^{K}+P_{jt}^{*K}\right)K_{jt}$$

Table 1: The International Capital Controls Component and the Exchange Rate Growth Rate

Dependent variable: log*(International capital controls component)*

	1950-2008	1950-1973	1973-2008
Exchange rate growth rate	0.036	0.000	-0.039
	(0.010)	(0.029)	(0.007)
Observations	824	306	503
Adj-R^2	0.027	0.000	0.058

Notes: Robust standard errors in parentheses.

$$+\left(1-\tau_{jt}^{B}+\Psi_{jt}\right)B_{jt}+T_{jt}+\Pi_{jt},$$

and C_{jt} is total tradable consumption, the Euler equations for state-contingent assets imply:

$$\underbrace{\left(\frac{C_{jt+1}/N_{jt+1}}{C_{Rt+1}/N_{Rt+1}}\right)\left(\frac{C_{Rt}/N_{Rt}}{C_{jt}/N_{jt}}\right)}_{International\,capital\,controls}=\frac{\left(1-\tau_{jt}^{B}+\Psi_{jt}\right)}{\left(1-\tau_{Rt}^{B}+\Psi_{Rt}\right)}=\zeta_{jt+1}^{B}. \tag{9}$$

In other words, the model without non-traded goods, isolates the variation in the international distortion generated by impediments to international capital mobility, given that ζ_{jt+1}^{B} is fully identified by the first term of Equation 8.

Based on the outcome of the regression showed in Table 1, and Equation 9, we argue we can abstract from having non-traded goods, to focus on the international capital control effects of Bretton Woods, without worrying about exchange rate effects.

In the model with just tradable goods, the first-order conditions for the household can be rearranged to find the optimal condition governing the labor supply,

$$\left(1-\tau_{jt}^{h}\right)W_{jt}\frac{N_{jt}}{C_{jt}}=\varphi h_{jt}^{\gamma}, \tag{10}$$

the Euler equation for domestic capital,

$$1=E_t\left[\beta\frac{C_{jt}/N_{jt}}{C_{jt+1}/N_{jt+1}}\left(1-\tau_{jt+1}^{K}\right)\frac{r_{jt+1}^{K}+P_{jt+1}^{*K}}{P_{jt}^{K}}\right], \tag{11}$$

and the Euler equation for state-contingent international assets,

$$\frac{C_{jt+1}/N_{jt+1}}{C_{jt}/N_{jt}}=\frac{\beta}{q_{t+1}}\left(1-\tau_{jt}^{B}+\Psi_{jt}\right), \tag{12}$$

as discussed above.

2.3 Achieving stationarity

Our model assumes that the world economy has complete markets. Complete markets are a natural benchmark, as there are many ways in which markets can be incomplete. It is also the natural approach

to modeling a world economy with very rich and complex asset trades—certainly more assets than can be accommodated in a tractable incomplete markets model. However, given our continuous state space, this means that each country has an infinite dimensional portfolio decision to make each period. In a contribution that may be of independent interest, we establish that the solution to a particular pseudo social planner's problem corresponds to the equilibrium of our complete markets economy and work directly on the pseudo social planner's problem. Appendix A describes in detail the mapping between the competitive equilibrium problem and the pseudo social planner's problem. As noted earlier, to obtain stationarity, we scale by the stochastic world trend Z_{t-1} to obtain an intensive form version of the model.

The large number of state variables (23) leads us to use perturbation methods. To do so, we make additional assumptions to ensure that the model has a unique non-degenerate deterministic steady-state (which serves as the point about which the approximation is taken). To see the need for these assumptions, note that we can take the Euler equation for state-contingent international assets and rearrange to obtain the first equality in

$$\frac{C_{jt+1}/N_{jt+1}}{C_{Rt+1}/N_{Rt+1}} = \frac{C_{jt}/N_{jt}}{C_{Rt}/N_{Rt}} \frac{1-\tau^B_{jt+1}+\Psi_{jt+1}}{1-\tau^B_{Rt+1}+\Psi_{Rt+1}} = \frac{C_{jt}/N_{jt}}{C_{Rt}/N_{Rt}} \zeta^B_{jt+1}. \tag{13}$$

This means we cannot separately identify each country's international capital markets distortion ζ^B_{jtj}, and so we normalize the rest of the world international distortion to one, $1-\tau^B_{Rt+1}+\Psi_{Rt+1}=1$, yielding the second equality. It also means that, if the steady-state of τ^B_{jt+1}, is not equal to zero, there is a long-run trend in relative aggregate consumption levels so that the deterministic steady-state distribution of consumption is degenerate (one country's share of consumption must converge to zero). Moreover, simply assuming that $\tau^B_{jt+1}=0$ for all j does not pin down a *unique* steady-state relative consumption level. Intuitively, the impediments to international capital mobility out of steady-state affect the accumulation of international assets, which in turn affect long-run consumption levels. In terms of equation (13), the *growth rate* of relative consumption is a first-order autoregressive process that converges to zero in the deterministic steady-state; the long-run *level* of relative consumption depends upon the entire sequence of realizations of the international distortion.

Analogous issues arise in multi-agent models with heterogeneous rates of time preference (see the conjecture of Ramsey (1928), the proof of Becker (1980), and the resolution of Uzawa (1968)) and in small open economy incomplete markets models. In the latter context, a suite of alternative resolutions of this issue have been proposed (see Schmitt-Grohe and Uribe (2003) for a survey and discussion). We use a variant of the portfolio adjustment cost approach, adapted to our general equilibrium complete markets setting. Specifically, for Europe and the United States, as was mentioned earlier, we assume that their international distortion can be decomposed into a pure tax on international investment income τ^B_{jt} and another term Ψ_{jt}, both of which the country takes as given:

$$\zeta^B_{jt} = 1-\tau^B_{jt}+\Psi_{jt}.$$

We refer to τ^B as a tax on international state-contingent assets and assume that it follows a first-order autoregressive process with the steady-state assumed to be zero:

$$\ln\left(1-\tau^B_{jt+1}\right) = \rho^B_j \ln\left(1-\tau^B_{jt}\right) + \sigma^B_j \varepsilon^B_{jt+1}. \tag{14}$$

The other term takes the form of a portfolio tax that is assumed, in equilibrium, to satisfy

$$\Psi_{jt} = \left(1-\tau^B_{jt}\right)\left[\left(\frac{C_{jt}/N_{jt}}{C_{Rt}/N_{Rt}}\frac{1}{\psi_{j0}}\right)^{-\psi_{j1}} - 1\right]. \tag{15}$$

This ensures that, in the deterministic steady-state, relative consumption levels are pinned down by ψ_{j0}, with mean reversion in relative consumption levels controlled by ψ_{jt} as

$$\ln\frac{C_{jt+1}/N_{jt+1}}{C_{Rt+1}/N_{Rt+1}} = \frac{\psi_{j1}}{1+\psi_{j1}}\ln\psi_{j0} + \frac{1}{1+\psi_{j1}}\ln\frac{C_{jt}/N_{jt}}{C_{Rt}/N_{Rt}} + \frac{1}{1+\psi_{j1}}\ln\left(1-\tau^B_{jt+1}\right). \tag{16}$$

We refer to this as a portfolio tax because in steady-state, relative consumption levels map one-for-one into net foreign asset positions. Once again, these parameters are identified from the data, meaning that we allow the data to estimate the long-run net foreign asset position of each country.

Under these assumptions on the portfolio tax, there exists a unique non-degenerate deterministic steady-state. We proceed by taking a first-order log-linear approximation of the pseudo social planner's problem around this point.

3 Implementation

The model described in the previous section has been designed to exactly replicate data on the national income and product account expenditure aggregates. In this sense, the model can be used as an accounting framework for observed data. In this section, we describe how the model uses these data to identify the different distortions. We then briefly describe our data sources, with a more detailed discussion available in Appendix B. To recover realizations of the domestic capital market distortions, we must compute the equilibrium of the model in order to determine expectations of future returns to capital, and so we also describe our solution method. A small number of structural parameters governing preferences and production are calibrated. Some distortions can be recovered, and the parameters governing their evolution estimated, without solving the model. The remaining parameters of the model are estimated using maximum likelihood estimation.

3.1 Using the data to measure distortions

Realizations of the domestic labor, and capital distortions, as well as international capital market distortions can all be measured by feeding data on the national income and accounting expenditure aggregates through the optimality conditions of households and firms combined with the equilibrium

conditions of the model. Realizations of the domestic labor and international distortions can be computed directly from first-order conditions without knowing the solution of the model. The domestic capital market distortion, on the other hand, requires the computation of expectations about future capital returns and hence requires both estimating and solving the model.

To see this, note that under our assumption of complete markets, the overall international distortion, ζ^B_{jt+1}, can be recovered from data on the growth in relative consumption levels, as shown in equation (13). Estimation of equation (16) serves to both decompose ζ^B_{jt+1} into the international tax τ^B_{jt+1} and the portfolio adjustment cost Ψ_{jt+1} and estimate the parameters governing the evolution of both. Note that under the assumptions of our model, the residual in this equation—the international distortion—follows an autoregressive process; relative consumption does not follow a simple first-order autoregressive process. Nonetheless, all that is needed to estimate the process governing the international distortion and the parameters of the portfolio adjustment cost is data on the growth in relative consumption levels. This can be done without solving the entire model.

The domestic labor market distortion can also be recovered, and its evolution process estimated, outside of the model. Specifically, using the optimal labor supply condition for the household (10) and the optimal employment decision of the firm (2), we obtain

$$1-\tau^h_{jt} = \frac{\varphi}{1-\alpha} h^{\gamma}_{jt} \frac{h_{jt}N_{jt}}{Y_{jt}} \frac{C_{jt}}{N_{jt}}. \tag{17}$$

That is, using data on consumption, population, hours worked, and output, and given values for the production and preference parameters, we can recover realizations of the labor distortion without solving the model, and use them to estimate its stochastic process. Note that it is not possible to separately identify the level of the labor distortion from the preference for leisure parameter φ, which in principle could also vary across countries. Hence, in what follows, we normalize the leisure parameter to 1 for all countries, and we focus on changes in the levels of these distortions over time, and not on cross-country differences in their levels.

Lastly, the domestic capital distortion is determined from the Euler equation for the household (11), the optimal capital decision of the consumer good firm (3), and the optimality conditions of the capital good firm (4) and (5). Denoting by $i_{jt+1} = I_{jt+1}/K_{jt+1}$ the ratio of investment to the capital stock, we obtain the domestic capital distortion from

$$1 = E_t \left[\beta \frac{C_{jt+1}/N_{jt+1}}{C_{jt}/N_{jt}} \left(1-\tau^K_{jt+1}\right) \frac{\alpha \frac{Y_{jt+1}}{K_{jt+1}} + \frac{1-\delta-\phi(i_{jt+1})+\phi'(i_{jt+1})i_{jt+1}}{1-\phi'(i_{jt+1})}}{\frac{1}{1-\phi'(i_{jt})}} \right]. \tag{18}$$

Note that it is impossible to separately identify the level of the domestic capital distortion from the level of the discount factor, and hence we focus on changes in the levels of these distortions, and not the levels themselves, below. Unlike the labor and international distortions, this requires computing an expectation, which in turn requires the solution of the model and estimation of the processes governing the evolution of all exogenous variables. Moreover, it also requires a value for the initial

capital stock from which data on investment can be used to derive the entire sequence of capital stocks, which we estimate along with all other parameters in the model. We describe the solution and estimation of the model next.

3.2 Estimation

As discussed in the previous subsection, to recover our wedges we need data on the main national accounts expenditure aggregates—output Y_{jt}, consumption C_{jt}, investment I_{jt}, and net exports NX_{jt}—along with data on population N_{jt} and hours worked h_{jt}, for each of our three "countries." We use the data set we constructed in Ohanian, Restrepo-Echavarria, and Wright (2018).[2]

We solve the model numerically by taking a first-order log-linear approximation of the model around its deterministic steady-state, which is well defined under our assumptions on the portfolio tax. After imposing symmetry in the preference and production parameters across countries, we must assign values to 68 parameters. In this subsection, we describe how some parameters are calibrated to standard values in the literature and others are estimated by maximum likelihood using the Kalman filter. For the welfare calculations of Section 5 we use a second-order approximation instead of a first-order.

The parameters governing preferences and production are assumed constant across countries, so that any differences across countries are attributed to distortions. Of these common parameters (collected in Table 1), six are calibrated to standard values, while a seventh is a normalization. Specifically, we set the output elasticity of capital in the Cobb-Douglas production function α to 0.36, the discount factor β to 0.96, and the depreciation rate δ to 7 percent per year. These are all standard values. The curvature for the disutility of labor γ is set to 1.5, which implies a Frisch elasticity of labor supply of two-thirds. This is within the range typically estimated using micro data on the labor supply intensive margin, a little higher than estimates using micro data on the extensive margin, but smaller than estimates typically found using macro data (see the surveys by Pencavel (1987), Keane (2011), and Reichling and Whalen (2012)). As is evident from equation (17), we cannot separately identify the household's preference for leisure φ from the long-run labor distortion τ^h_{jss}, so we normalize φ to 1; this means that we are cautious in interpreting the estimated level of the labor distortion.

In the investment adjustment cost function, the parameter κ is set such that adjustment costs are zero in steady-state, or $\kappa = (\delta + z_{ss} - 1)$. The adjustment cost scale parameter ν is chosen to generate a particular value for the elasticity of the price of capital with respect to the investment-capital ratio, which is equal to $\nu\kappa$. Bernanke, Gertler, and Gilchrist (1999) use a value of 0.25 for this elasticity for the United States and argue the range of plausible values is from 0 to 0.5. We use 0.5 as our benchmark.

[2] See paper for details.

Table 2: Common Parameter Values

Parameter	Notation	Value
Preferences		
Discount Factor	β	0.96
Frisch Elasticity of Labor Supply	$1/\gamma$	2/3
Preference for Leisure	φ	1
Production		
Output Elasticity of Capital	α	0.36
Depreciation Rate	δ	0.07
Adjustment Cost Size	ν	5.5
Adjustment Cost Reference Level	κ	0.09

The remaining parameters govern the evolution of population, productivity, government spending; the domestic labor, capital, and international distortions; the portfolio tax; and the initial levels of capital in each country. For the estimation we impose the assumption that the world economy grows at 2 percent per year in the long run, or $z_{ss} = \pi_{ss}^{1/(1-\alpha)}\eta_{ss} = 1.02$.

As our model is non-stationary, it is estimated using the *growth rates* of our data. To ensure that our estimated model produces *levels* of hours worked, capital, and productivity that are consistent with the data, we set the steady-state labor distortion to match the sample average level of hours worked, set the steady-state of the domestic capital distortion to match capital-to-output ratios from our benchmark capital series, and estimate the steady-states and persistence of the productivity processes from our benchmark productivity series. All other parameters are then estimated using maximum likelihood.

The linearized equations of the model combined with the linearized measurement equations form a state-space representation of the model. We apply the Kalman filter to compute the likelihood of the data given the model and to obtain the paths of the distortions. Table 3 shows the estimated parameters.

4 Market distortions and Bretton Woods' impediments to international capital mobility

In this section, we report the recovered values for the efficiency, domestic labor and capital, and international distortions.

The distortions introduced into the model can represent tax distortions, they may stand in for

Table 3: Country Specific Parameter Values

Process	Region	Steady State	Persistence	Standard Deviation
Population	United States	η_{ss} =0.84	ρ_U^n =1	σ_U^n =0.003
	Europe	n_{Ess} =0.77	ρ_E^n =0.99	σ_E^n =0.002
	Rest of World	n_{Rss} =0.82	ρ_R^n =0.98	σ_R^N =0.003
Productivity	United States	π_{ss} =1.01	ρ_π =1	σ_π =0.08
	Europe	a_{Ess} =0.74	ρ_E^a =0.99	σ_E^a =0.02
	Rest of World	a_{Rss} =0.52	ρ_R^a =0.99	σ_R^a =0.03
Government Distortion	United States	g_{Uss} =0.18	ρ_U^g =0.94	σ_U^g =0.03
	Europe	g_{Ess} =0.20	ρ_E^g =0.20	σ_E^g =0.03
	Rest of World	g_{Rss} =0.13	ρ_R^g =0.13	σ_R^g =0.10
Domestic Labor Market Distortion	United States	τ_{Uss}^h =1.93	ρ_U^h =0.99	σ_U^h =0.04
	Europe	τ_{Ess}^h =1.91	ρ_E^h =0.99	σ_E^h =0.03
	Rest of World	τ_{Rss}^h =1.79	ρ_R^h =0.99	σ_R^h =0.02
Domestic Capital Market Distortion	United States	τ_{Uss}^k =0.94	ρ_U^K =0.99	σ_U^K =0.03
	Europe	τ_{Ess}^k =0.94	ρ_U^h =0.99	σ_U^K =0.27
	Rest of World	τ_{Rss}^k =0.98	ρ_R^h =0.99	σ_R^K =0.01
International Distortion	United States	τ_{Uss}^B =0	ρ_U^B =0.93	σ_U^B =0.02
	Europe	τ_{Ess}^B =0	ρ_E^B =0.93	σ_E^B =0.01
Portfolio Tax	United States	ψ_{U0} = -0.08	$1-\psi_{U1}$ =0.94	—
	Europe	ψ_{E0} = -0.04	$1-\psi_{E1}$ =0.97	—

Note: Appendix C contains more details on the estimation procedures.

non-tax distortions, other equilibrium frictions (that are efficient and hence non-distortionary), other forms of model misspecification, or some combination of the above. In other words, the recovered distortions may be reduced-form representations of diverse structural phenomena, rather than true primitives of the model. Moreover, a structural distortion in one factor market may be recovered as a reduced-form distortion affecting another factor market or even the level of productivity/efficiency. We view this as a virtue of the approach, as it pinpoints the precise margins—the allocation of time between market and non-market activities, or the allocation of resources between consumption and investment at home and abroad—that drive observed capital flows in a way that can be informative about large classes of structural models.

4.1 Domestic efficiency, labor, and capital market distortions

Efficiency and capital flows Our estimates of efficiency (or total factor productivity) across the three regions (A_{jt}) are depicted in Figure 1. This figure shows that unlike what was expected, the world economy grew substantially during this period. Specifically, we can see that during the Bretton Woods era productivity in the United States grew 1.84%, in Europe it grew 2.7% and in the rest of the world it grew 3.6%. At the same time, if we look at output growth we can see that it was 3.7% for the United States, 4.6% for Europe and 7.4% for the rest of the world.

This tells us that prior to 1973, capital should have flown in larger quantities to the rest of the world, then to Europe and finally to the United States. However, Figure 2 shows that during this period capital flows were small, and that if anything, capital flew in larger quantities to the United States rather than into Europe.

In order to account for this discrepancy, there must exist offsetting incentives in either domestic or international capital markets, or in domestic labor markets.

Domestic labor market distortions Figure 3 reports our estimate of labor market distortions τ^h (right panel) and per capita hours worked (left panel). Recall that labor market distortions are identified off of the relationship among consumption, wages, and hours worked in equation (10). Bearing in mind the caveat that the level of the recovered distortion cannot be separately identified from preference parameters that could vary across countries, under our normalization a distortion that is greater than zero is interpreted as a tax on labor income and reflects employment levels lower than predicted by the model with a distortion that is equal to zero; a number less than zero identifies relatively high employment, which is interpreted as a subsidy to labor. A value of 0.4 denotes a 40 percent tax on wage income.

To interpret this distortion, note that it reflects various factors that affect the relationship between the household's marginal rate of substitution between consumption and leisure and the marginal prod-

Figure 1: Total Factor Productivity

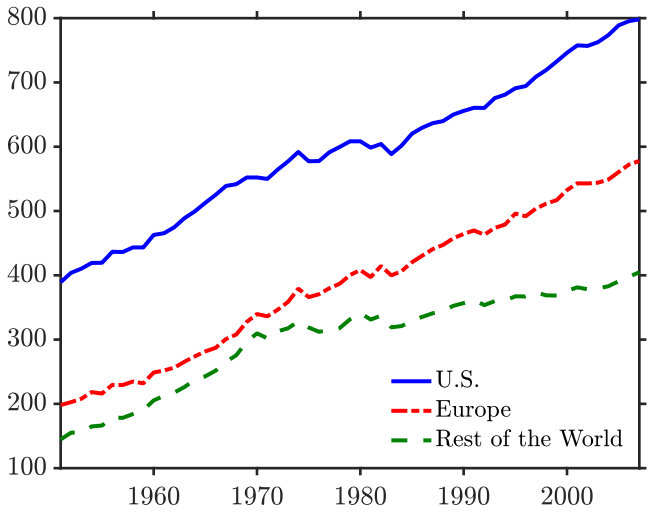


Figure 2: Capital Flows (Net-Exports %GDP)

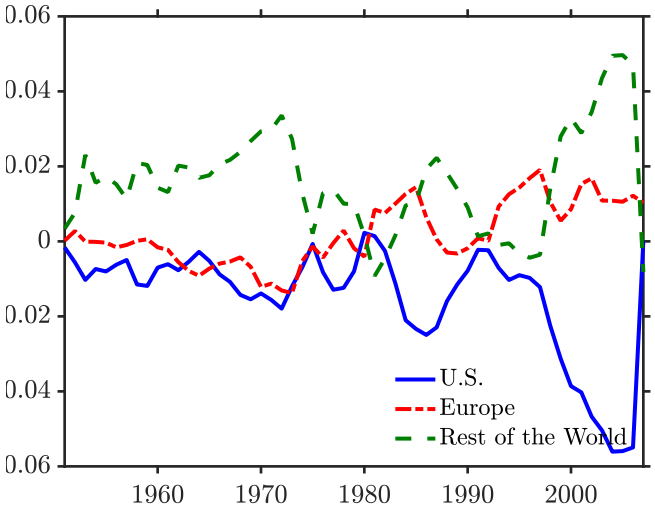
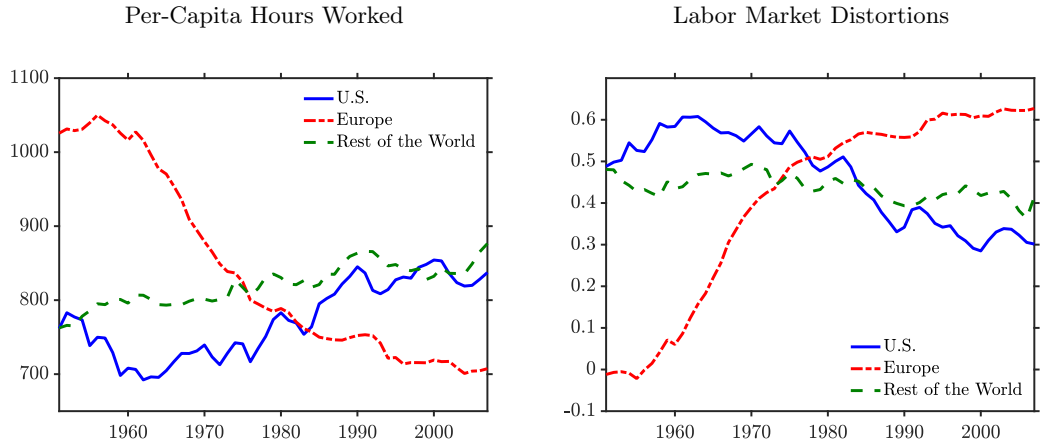


Figure 3: Hours Worked and Labor Market Distortions



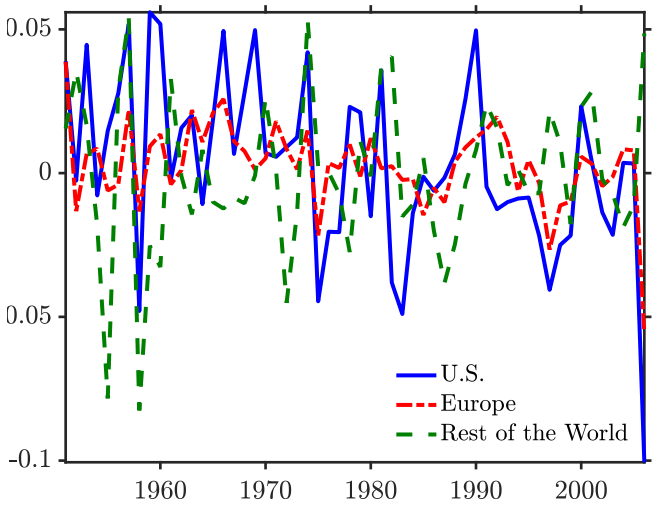
uct of labor. These may include forces that can be affected by policy, such as labor and consumption taxes (Chari, Kehoe, and McGrattan (2007) and Ohanian, Raffo, and Rogerson (2008)), employment protection laws and other restrictions on hiring or firing workers (Cole and Ohanian (2015)), unemployment benefits (Cole and Ohanian (2002)), and limitations on product market competition that increase firm monopoly power (Chari, Kehoe, and McGrattan (2007)), as well as search and matching frictions (Cheremukhin and Restrepo-Echavarria (2014)) that form part of the "technology" of the economy.

Studies of taxes on labor income and consumption in European countries coincide closely with the European labor wedge. Prescott (2002) and Ohanian, Raffo, and Rogerson (2008) report that in most European countries consumption and labor taxes rose substantially between 1950 and the mid-1980s and then were roughly stable on average after that. This closely mimics the pattern of our labor market distortion for Europe that shows an increase until the mid-1970s and little movement thereafter.

In summary, our method recovered quantitatively large movements in distortions to labor markets that coincide with important policy changes affecting labor taxes and labor market regulations.

Domestic capital market distortions Figure 4 presents our estimates of domestic capital market distortions τ^K. This distortion is identified off of the Euler equation (11) and thus reflects the difference between returns to investment estimated from the marginal product of capital and the return to savings estimated from the growth rate of consumption. Bearing in mind our caveat about the recovered levels of this distortion, under our normalization a value of 0.05 is equivalent to a 5 percent tax on capital income. As can be seen from the figure, the volatility of the capital wedge is decreasing across time, and its value is pretty constant around zero. In fact, the volatility of this wedge before 1973 is 18%,

Figure 4: Domestic Capital Market Distortions



54%, 153% higher for the U.S., Europe and the rest of the world, respectively, as compared with its volatility between 1973 and 2006.

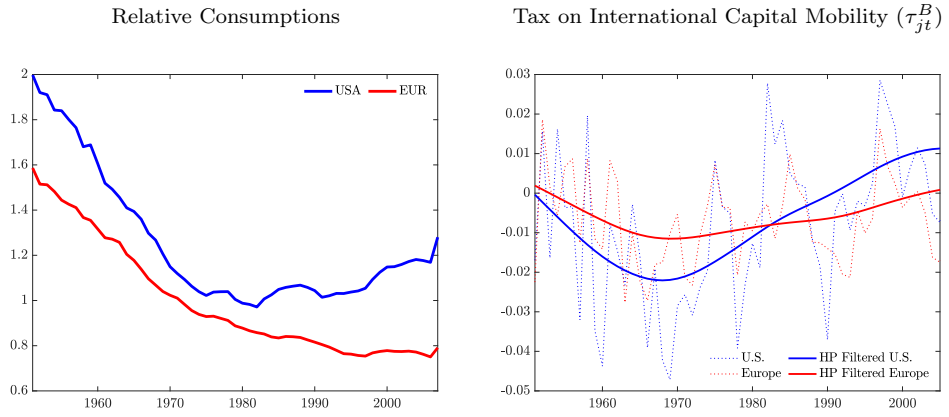
4.2 Impediments to International Capital Mobility

The evolution of impediments to international capital mobility τ^B is depicted in the right panel of Figure 5. Since all distortions are relative to the rest of the world, the figure depicts only Europe and the U.S. A key contribution to the accounting literature is that this distortion is identified off of *relative* consumption *growth* rates from the Euler equation for international asset purchases (12). As a consequence, the distortion is quite volatile, and so, in addition to the recovered distortion (the dotted lines), we also plot its Hodrick-Prescott trend (solid line) in order to highlight its medium-term movements. The left panel of the figure depicts the consumption for the U.S. and Europe relative to the rest of the world.

In particular, note the very steep decline in U.S. consumption relative to the ROW. Given preferences for smooth consumption, this figure suggests that U.S. households would have preferred a less steep drop in relative consumption than what actually occurred. We will see that the international distortion is critical for understanding this pattern, and that in its absence, a lot of capital would have flowed into the U.S. from the ROW to facilitate a much smoother U.S. consumption profile over time.

In the figure for τ^B a value below zero represents a tax on international borrowing (impediments to international capital inflows), while a value above zero represents a tax on international savings

Figure 5: Relative Consumptions and International Capital Market Distortions



(impediments to international capital outflows).

What is relevant from the figure, is that during the Bretton Woods period, both the U.S. and Europe where facing a distortion that is isomorphic to a tax on international borrowing relative to the rest of the world; which was preventing capital inflows into the two regions, just as intended by the Bretton Woods agreement.

To this point, it is important to note that the sign of the international distortion is different during the Bretton Woods era and after. In other words, one can see that prior to 1973 the United States and Europe were facing a tax on foreign borrowing and later on it switches to a tax on foreign borrowing or very close to zero.

We argue that the international distortion captures the impediments to international capital mobility implemented during the Bretton Woods era, and that as such, we can use our model to conduct experiments where we remove those impediments, and see what would have happened to fundamentals if Bretton Woods hadn't been in place.

Apart from knowing that the sign of the distortion is in line with what was intended when the agreement was instituted—to prevent massive capital outflows from the rest of the world and Europe into the U.S.—it is also important to see if our model driven distortion reflects the actual policies that where implemented by the different countries to control capital flows. To this end in Appendix D we show plots of τ^{*B} for the United States as well as for the main European countries, together with the years in which specific policies to impede international capital flows where instituted. As can be seen from those plots, our recovered distortion lines up remarkably well with the different policies that were actually implemented across countries, allowing us to interpret our international distortion in a structural manner, and argue that it captures the impediments to international capital mobility introduced by the Bretton Woods agreement.

In the following section, we show what would have happened to capital flows, consumption, hours worked, investment etc. as well as welfare in the absence of these capital controls. In other words we show a counterfactual exercise to see what would have happened to the world economy over time if the Bretton Woods agreement had never been signed by setting $\tau^{*B} = 0$.

5 The effects of Bretton Woods on the world economy and welfare

In this section we assess the effect of Bretton Woods as a capital control system, by running a counterfactual exercise where we shut down the international distortions for the U.S. and Europe, $\tau^{*B} = 0$, and re-solve the model so that agent expectations reflect the assumptions of the counterfactual experiment.

Because the tax on international capital mobility is directly identified off of relative consumption, when we set it to zero $\tau^{*B} = 0$, this implies a particular counterfactual path for consumption. And that path of consumption will determine the behavior of other fundamentals. Figure 6 shows this path.

Figure 6: Counterfactual Relative Consumption

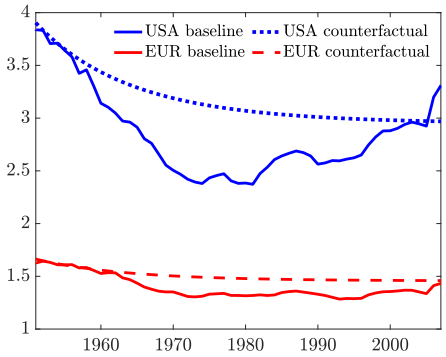
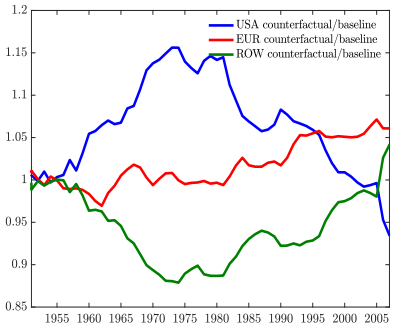
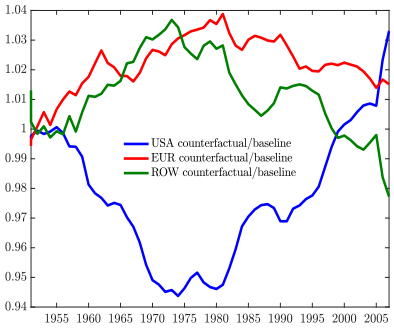


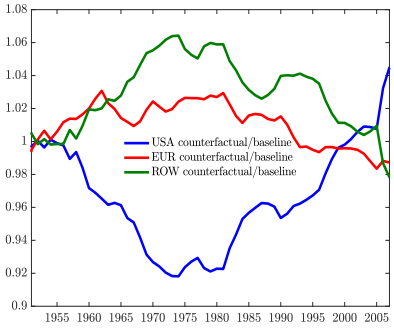
Figure 7: The World Without Bretton Woods



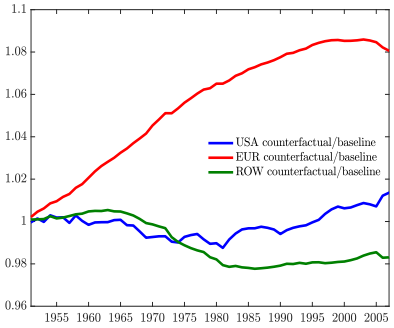
(a) Consumption



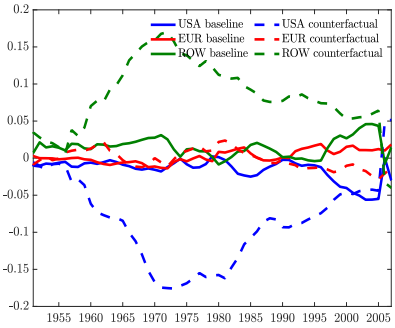
(b) Output



(c) Hours Worked



(d) Capital



(e) Net Exports/GDP

Note that the path followed by consumption under the counterfactual both for the U.S. and Europe, implies a higher consumption than under the benchmark for both regions. In the model, a "country" can achieve higher consumption by either increasing production, or by importing it (capital inflows),

Table 4: Welfare Effects of Bretton Woods

Region	Consumption Equivalent
U.S.	-4.44%
Europe	1.33%
Rest fo the World	4.54%

and the way they achieve that increase will be determined by the behavior of the other distortions that are still in place in the domestic markets.

Figure 7 shows the results of the counterfactual. We can see from Figure 7 that capital would have flown out of the rest of the world, and in much smaller amounts out of Europe, and into the United States. Right around 1970, capital inflows to the United States, would have reached about 18% of GDP. These capital inflows would have resulted in lower hours worked and higher consumption for the U.S.

Something that is important to notice, is that even though Europe has an international wedge with a fairly similar behavior to that of the U.S., when we remove it, there are no capital inflows to Europe (while there are to the U.S.). The difference relies on the labor wedge. As shown in the right panel of Figure 3, Europe has a labor wedge that is strongly increasing during the Bretton Woods era, reflecting an important increase in labor income taxes. As such, and due to the complementarity between labor and capital, the labor wedge prevents capital from flowing into Europe as there is not enough labor available to accompany capital and increase production. This result is consistent with what we have found in our previous research (see Ohanian, Restrepo-Echavarria, and Wright (2018)).

We find that these controls have very large welfare affects. Table 4 shows the welfare effects of Bretton Woods from a consumption equivalent perspective. As we can see, Europe had a perpetual consumption-equivalent welfare benefit of about 1.3 percent, and the ROW had one of around 4.5 percent. In contrast, we find that U.S. welfare was about 4.5 percent lower in consumption equivalent units under Bretton Woods. This begs the question of why the U.S. had promoted these controls in the first place!

6 Why did the U.S. implement capital controls?

Bretton Woods' goal was to support international economic and political stability through regulations that governed international trade, payments, and currency values. This followed one of the most unstable thirty-year periods in modern history, a three-decade span that included two world wars, a

pandemic, the Great Depression, and trade wars.

This section focuses on the U.S.'s goals to support economic reconstruction and international economic growth, promote stability of ally governments, and protect against future hostilities. We will show that the two major architects of Bretton Woods, Harry Dexter White of the U.S. and Keynes were very concerned about international capital flows that could endanger these goals, and that capital controls were implemented with these concerns in mind.

The evidence presented here will aid us in interpreting our welfare results that indicate the U.S. would have been significantly better off had Bretton Woods capital controls not been adopted. This raises the question of why the U.S. wanted these controls in the first place, given that this distortion impeded the flow of capital and higher welfare for the U.S.

The evidence suggests that the U.S. was willing to adopt distorting policies that significantly depressed U.S. welfare within a standard, open economy growth model, to promote broader international economic and political stability goals. The evidence shows that the U.S. was very concerned about capital flight, and (i) how international capital movements could damage economic and political stability in other countries, (ii) that developing countries were particularly vulnerable to capital flight, and (iii) that foreign capital would likely come to the United States. These historical perspectives are consistent with our model findings.

We interpret our welfare estimates as representing the perceived benefit of implementing capital controls as a means of preserving economic and political stability in ally and developing countries. We find that this perceived value is very large, and perhaps plausibly so, given the literature's views about U.S. ambitious foreign policy goals. These estimates thus provide the first quantification within a world, general equilibrium framework of U.S. international policy choices relating to the economic and political health of other countries.

Economic Views of Capital Controls in the 1940s The key concern for both White and Keynes was that capital flows that could destabilize a country by draining it of investment funds, which in turn could weaken the country's economy and political stability. They viewed capital controls being useful for several reasons, including the economic reconstruction of ally countries after the war, the desire to support developing countries and keep capital in those economies, and the desire to keep unaligned countries from politically aligning with axis countries, which were viewed as the major hostile countries at that time, and from the Soviet Union once the Cold War had begun around 1950.

White described the essence of capital controls as follows:

> [A capital control cooperation provision's] acceptance would go a long way toward solving one of the very troublesome problems in international economic relations, and would remove one of the most potent disturbing factors of monetary stability. Flights of capital,

> motivated either by prospect of speculative exchange gain, or desire to avoid inflation, or evade taxes or influence legislation, frequently take place especially during disturbed periods. Almost every country, at one time or another, exercises control over the inflow and outflow of investments, but without the cooperation of other countries such control is difficult, expensive, and subject to considerable evasion.

Capital control implementation was based on White's and Keynes's views on capital flows during the 1920s and 1930s. Both White and Keynes agreed that capital flows during this period were "speculative", and that capital flight had exacerbated crises, and were often driven by speculative fear and not necessarily fundamentals. They believed that capital flows needed to be controlled during periods of instability and recovery, such as the reconstruction period after World War II, though Keynes viewed controls as being a permanent requisite.

A primary goal of capital controls was promoting the reconstruction of devastated countries and the economic development of poor nations. White viewed capital controls as protecting these countries from capital flight, motivated either by fundamentals, such as taxes, or by speculation[3]:

> Even more harmful than exchange disturbances is the steady drain of capital from a country that needs the capital but is unable for one reason or another to offer sufficient monetary return to keep its capital at home. The assumption that capital serves a country best by flowing to countries which offer most attractive terms is valid only under circumstances that are not always present.

For both White and Keynes, the interwar period contained several episodes of what both considered to be destabilizing capital flows, including the French capital flight in 1925 and 1926, the 1931 Austrian banking panic, related panics in Germany and in the U.S. This led White to write as follows[4]:

> There has been too easy an acceptance of the view that an enlightened trade and monetary policy requires complete abandonment of controls over international economic transactions. There is a tendency to regard foreign exchange controls, or any interference with the free movement of funds and of goods as, ipso facto, bad. This view is both unrealistic and unsound. It ignores the fact that there are situations in which many countries frequently find themselves, and which all countries occasionally meet, that make inevitable the adoption of controls of one character or another. There are times when it is in the best economic interests of a country to impose restrictions on movements of capital, and on movements of goods. There are periods in a country's history when failure to impose exchange controls,

[3] International Monetary Fund. (1996). The White Plan. In IMF History Volume 3 (1945-1965): Twenty Years of International Monetary Cooperation Volume III: Documents USA: INTERNATIONAL MONETARY FUND.

[4] International Monetary Fund. (1996). The White Plan. In IMF History Volume 3 (1945-1965): Twenty Years of International Monetary Cooperation Volume III: Documents. USA: INTERNATIONAL MONETARY FUND.

or import or export controls, have led to serious economic and political disruption.

American concerns with capital flight from developing countries predates Bretton Woods and influenced the Bretton Woods agreement. In 1939 American Treasury officials and Latin American officials actively worked on the creation of an Inter-American Bank (IAB) to halt capital flight from Latin America. Assistant Secretary of State Adolf Berle believed capital outflows from Latin America to the U.S. were largely responsible for the lack of capital in Latin America, and White was concerned about the rapid increase in Latin American capital coming into the U.S. in the 1930s (see Helleiner (2014), "International Development and the North-South Dialogue of Bretton Woods", Forgotten foundations of Bretton Woods: International development and the making of the postwar order. Cornell University Press).

By the early 1940s, the U.S. was actively promoting capital controls in Latin American countries, reflecting the extreme volatility these countries experienced in which agricultural production was a primary income source. The view was that open markets and limited regulations may be best for highly developed economies, but not for developing economies, which often were highly open economies that exhibited large output fluctuations outside of their control. Robert Triffin wrote[5]:

> We often lose sight of the fact that the general attitude taken in this country with respect to exchange control may be related to the peculiar circumstances of our own economy and does not take into consideration the fundamentally different characteristics of other economies, more dependent on international transactions and subject to violent disruptions associated with quasi monoculture. In other words, we tend to generalize and give universal validity to rigid principles derived from familiarity with conditions specific to the United States or at least to highly developed and well balanced economies.

International Policy Restrictions to Counteract Nazi and Soviet Influences The U.S. worried more broadly about Latin America, specifically Nazi influence. Helleiner describes that White wrote that the U.S. would need to support Latin America, given that Latin America was being targeted by the Nazis. Helleiner writes[6]:

> "White argued 'Latin America will gradually succumb to the organized economic and ideological campaign now being waged by aggressor nations. A bold program of financial assistance to Latin America that could be an important part of our international political program of peace, security and encouragement of democracy.' In addition, White argued

[5] Helleiner, E. (2014). "International Development and the North-South Dialogue of Bretton Woods", Forgotten foundations of Bretton Woods: International development and the making of the postwar order. Cornell University Press, p. 143-144.

[6] Helleiner, E. (2014). Forgotten foundations of Bretton Woods: International development and the making of the postwar order. Cornell University Press, p. 43.

> 'Latin America presents a remarkable opportunity for economic development. Only capital and technical skill are needed to develop the area so that it could provide for a much larger population, for a higher standard of living and a greatly expanded foreign trade."

More broadly, Helleiner (2014) argues[7]:

> What explains the US interest in promoting international development? Particularly important was the strategic goal of offsetting the Nazi threat. By offering to back the development aspirations of Southern (Latin American) governments, US officials helped secure alliances and provide a wider moral purpose to the Allied cause in the war, particularly at a time when fascist (and communist) ideals provided alternative routes to development from the preferred US model.

By 1950, the Nazi influence was over, but the Cold War had begun with the Soviet Union. Eichengreen (2019) (Eichengreen, B. (2019). Globalizing capital: a history of the international monetary system. Princeton University Press, p. 113) notes that even stricter capital controls were implemented in Europe at that time, with the view that these controls would support European reconstruction. This was an even more pressing matter, given that the USSR was so close to free Europe.

Where would capital flow? Based on previous experiences of massive capital inflows to the U.S. during the Great Depression, and the relative health of the U.S. economy as World War II ended, it was natural to expect that the U.S. would be the source for these flows after the war. Broughton (2009), who researched the history of the IMF, describes how in 1935 White advised Treasury Secretary Morgenthau that taxing foreign purchases of U.S. assets would be a way to limit capital inflows, as White viewed these inflows as a potential problem should investors withdraw those funds quickly. In 1938, White advised taxation again as capital inflows continued from France. Boughton, J. M. (2009). American in the shadows: Harry Dexter White and the design of the International Monetary Fund. In American Power and Policy (pp. 6-23). Palgrave Macmillan, London.

Taken together, the political and historical literature indicates that the U.S. viewed capital controls as a tool to promote economic and political stability in ally and developing countries as a way of keeping capital at home, which in turn would support investment and stability. The U.S. had strong political motives for supporting allies and preventing unaligned countries from becoming aligned with hostile governments. Interpreting the model's international financing wedge up to 1973 as reflecting capital controls provides an estimate of the impact of these controls, which is very large. This appears to be consistent with the very ambitious and important goals of U.S. foreign policy during World War II and its aftermath.

[7] Helleiner, E. (2014). Forgotten foundations of Bretton Woods: International development and the making of the postwar order. Cornell University Press, p. 12.

7 Final remarks

Within the literature, capital controls are a remarkably overlooked feature of the Bretton Woods system. This paper quantified the positive and normative impact of those controls within an open economy, general equilibrium accounting framework that allows us to identify the effect of the controls using NIPA-level data, and without dealing with the very difficult issues associated with trying to directly measure these controls.

Capital controls had very large, distorting effects on world capital flows, preventing a considerable amount of capital leaving the ROW for the U.S. and reducing world output through this misallocation. While these controls raised welfare for Europe and the ROW, they substantially depressed welfare for the U.S.

This raises an important question: why was the U.S. willing to implement a policy that would be so distorting and depressing for themselves, while supporting Europe and the ROW? We find this is not surprising, given the U.S.'s broader goals of preserving political and economic stability in ally and developing countries. The U.S. had a strong interest in keeping these countries, many of which were fragile after the war, economically sound and politically friendly.

The historical literature around that time documents that Harry Dexter White, the main U.S. architect of Bretton Woods, viewed capital controls as an important tool that would prevent capital flight that otherwise would damage these economies, and that those economies, both allies and developing countries, needed to grow and prosper.

The U.S. was chronically engaged in expensive military conflicts, beginning with the Axis powers during World War II, and continuing with the Soviet Union through the Cold War after 1950, including the Korean War and the Vietnam War, in an attempt to create a largely democratic world that was aligned with U.S. economic and political interests. These findings show that one cost of trying to achieve that vision – capital controls – was very high.

More broadly, this opens a new avenue for research that integrates open economy general equilibrium models with political economy and global conflict. Among other possible lines of inquiry, this research could provide a new perspective on U.S. policy adoption since World War II.

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APPENDIX

Appendix A: Model Solution and Computation

In this appendix we provide further details on the formulation, analysis, and solution of our benchmark competitive equilibrium model of the world economy. We begin by describing the pseudo social planners problem that we use to compute equilibria, and prove its equivalence with our competitive equilibrium problem. Given our stochastic trend, the model as formulated is not stationary. We next show how we transform both problems into intensive form problems that are stationary. We then discuss how we implement interventions in the pseudo social planners problem so that initial wealth in the competitive equilibrium problem stays constant. Finally, we discuss the balanced growth path of the deterministic version of our model or, equivalently, the steady state of the deterministic intensive form model.

The Pseudo Social Planners Problem

Consider a social planner whose problem is to choose state, date, and country contingent sequences of consumption, capital, and hours worked to maximize:

$$E_0\left[\sum_j \chi_{jt}^C \sum_{t=0}^{\infty} \beta^t \left\{\ln\left(\frac{C_{jt}}{N_{jt}}\right) - \chi_{jt}^I \chi_{jt}^H \frac{\varphi}{1+\gamma}\left(\frac{h_{jt}N_{jt}}{N_{jt}}\right)^{1+\gamma}\right\} N_{jt}\right],$$

subject to a world resource constraint for each state and date

$$\begin{aligned} & \sum_j \left\{C_{jt} + \chi_{jt}^I X_{jt} + G_{jt}\right\} \\ = & \sum_j \chi_{jt}^I Y_{jt} + T_t^{PSPP} \\ = & \sum_j \chi_{jt}^I A_{jt} K_{jt}^{\alpha} \left(h_{jt}N_{jt}\right)^{1-\alpha} + T_t^{PSPP}, \end{aligned}$$

capital evolution equations for each country j of the form

$$K_{jt+1} = (1-\delta) K_{jt} + X_{jt} - \phi\left(\frac{X_{jt}}{K_{jt}}\right) K_{jt},$$

an exogenous path for the series of additive shocks to the resource constraint T^{PSPP} (which the social planner takes as given, but in equilibrium satisfy $T_t^{PSPP} = \sum_j \chi_{jt}^I \left(X_{jt} - Y_{jt}\right)$), and exogenous paths of population, productivity, and the social planner's "wedges" χ_{jt}^I, χ_{jt}^H, and χ_{jt}^C to be described next.

For χ_{jt}^H we assume the process is given by

$$\ln \chi_{jt+1}^H = \left(1-\rho_j^h\right) \ln \chi_{jSS}^H + \rho_j^H \ln \chi_{jt}^H + \sigma_j^H \varepsilon_{jt+1}^H, \tag{19}$$

and link the process for this wedge to the processes for the competitive equilibrium wedge through the parameter restrictions

$$\begin{aligned}\chi^H_{jSS} &= 1/\left(1-\tau^h_{jSS}\right),\\ \rho^H_j &= \rho^h_j,\\ \sigma^H_j &= \sigma^h_j.\end{aligned}$$

For the social planners consumption wedge, we normalize $\chi^C_{Rt} = \chi^C_{RSS} = 1$, while for $j = A, L$ we require

$$\ln \chi^C_{jt+1} = \left(1-\rho^C_j\right)\ln \chi^C_{jSS} + \rho^C_j \ln \chi^C_{jt} + \varepsilon^C_{jt+1},$$

with the process for ε^C_{jt} assumed to be autoregressive and of the form

$$\varepsilon^C_{jt+1} = \rho^{\varepsilon^C}_j \varepsilon^C_{jt} + \sigma^{\varepsilon^C}_j \epsilon^{\varepsilon^C}_{jt+1},$$

with $\epsilon^{\varepsilon^C}_{jt+1}$ assumed standard normal. To ensure consistency with our competitive equilibrium problem we impose the parameter restrictions

$$\begin{aligned}1-\rho^C_j &= \frac{\psi_{j1}}{1+\psi_{j1}},\\ \chi^C_{jSS} &= \psi_{j0},\\ \rho^{\varepsilon^C}_j &= \frac{\rho^B_j}{1+\psi_{j1}},\\ \sigma^{\varepsilon^C}_j &= \frac{\sigma^B_j}{1+\psi_{j1}}.\end{aligned}$$

For the investment wedge, we assume that it's growth rate is related to past growth rates of itself, and to contemporaneous and lagged growth rates of the consumption wedge

$$\ln\left(\frac{\chi^I_{jt+1}}{\chi^I_{jt}}\right) = \left(1-\rho^I_j\right)\ln\left(1+g^{\chi^I}_{jSS}\right) - \ln\left(\frac{\chi^C_{jt+1}}{\chi^C_{jt}}\right) + \rho^I_j \ln\left(\frac{\chi^I_{jt}}{\chi^I_{jt-1}}\frac{\chi^C_{jt}}{\chi^C_{jt-1}}\right) + \sigma^{\chi^I}_j \varepsilon^I_{jt+1},$$

and impose parameter restrictions linking it to the evolution of the capital wedge in the competitive equilibrium problem.

$$\begin{aligned}\rho^I_j &= \rho^K_j,\\ 1+g^{\chi^I}_{jSS} &= 1-\tau^K_{jSS}\\ \sigma^{\chi^I}_j &= \sigma^K_j.\end{aligned} \tag{20}$$

Note that, compared to the competitive equilibrium problem, the formulation of this problem, and the specification of the wedges, is non-standard. As just one example, the investment wedge χ^I now appears in the objective function *and* multiplies *both* the production function *and* investment in the resource constraint. This specification is necessary to recover the competitive equilibrium allocations.

The is quite intuitive: the investment wedge χ^I must multiply both output and investment in the resource constraint in order to replicate the capital wedge, which is modeled as a tax on the gross return to capital inclusive of the value of capital, but this causes it to enter the planners optimality condition for labor. The addition of the investment wedge as a multiplier on leisure ensures that the investment wedge cancels when determining optimal labor supply. As another example, the error term in the social planners consumption wedge is autoregressive. As yet another example, we impose a very precise relationship between the investment wedge and the consumption wedge. As a result of the unusual nature of this formulation, we work with the competitive equilibrium benchmark in the paper, instead of directly introducing the social planning problem.

Under a restriction on the growth of the world economy (so that the expected summation in the objective function is finite), this problem is well defined. It is also convex. Hence, the necessary and sufficient conditions for an optimum include

$$C_{jt} \quad : \quad \beta^t \chi^C_{jt} \frac{N_{jt}}{C_{jt}} = \lambda_t^{PSPP}, \tag{21}$$

$$h_{jt} \quad : \quad \beta^t \chi^C_{jt} \chi^H_{jt} \psi h_{jt}^{\gamma} = \lambda_t^{PSPP} (1-\alpha) \frac{Y_{jt}}{h_{jt} N_{jt}} \tag{22}$$

$$\begin{aligned} K_{jt+1} \quad : \quad \mu_{jt}^{PSPP} = E \Bigg[& \lambda_{t+1}^{PSPP} \chi^I_{jt+1} \alpha \frac{Y_{jt+1}}{K_{jt+1}} \\ & + \mu_{jt+1}^{PSPP} \left(1 - \delta - \phi \left(\frac{X_{jt+1}}{K_{jt+1}} \right) + \phi' \left(\frac{X_{jt+1}}{K_{jt+1}} \right) \frac{X_{jt+1}}{K_{jt+1}} \right) \Bigg] \end{aligned} \tag{23}$$

$$X_{jt} \quad : \quad \lambda_t^{PSPP} \chi^I_{jt} = \mu_{jt}^{PSPP} \left(1 - \phi' \left(\frac{X_{jt}}{K_{jt}} \right) \right) \tag{24}$$

where λ_t^{PSPP} is the multiplier on the resource constraint at time t and μ_{jt}^{PSPP} the one of the capital evolution equation in country j at time t.

To establish the legitimacy of using the pseudo social planner to find a solution to the competitive equilibrium problem, it is sufficient to show that a solution to these necessary and sufficient conditions is also a solution to the necessary conditions for the competitive equilibrium problem. We do this next.

Equivalence Between the Solution of the Pseudo Social Planner's Problem and the Competitive Equilibrium

To establish the legitimacy of using the pseudo social planner's problem (PSPP) to find a solution to the competitive equilibrium problem (CEP), we need to show that the solution to the necessary and sufficient conditions for an optimum of the PSPP is also a solution to the necessary conditions for the competitive equilibrium problem. For this, it is sufficient to exhibit both the prices and the Lagrange multipliers that ensure that the optimality conditions from the CEP are satisfied.

Consider the first order condition (FOC) of the PSPP with respect to consumption (21). The

corresponding FOC of the households problem from the CEP is

$$\beta^t \frac{N_{jt}}{C_{jt}} = \lambda_{jt}^{HH},$$

and so the two conditions are equivalent iff

$$\lambda_{jt}^{HH} = \frac{\lambda_t^{PSPP}}{\chi_{jt}^C}. \tag{25}$$

Likewise, the FOC of the PSPP with respect to hours (22) can be compared with the corresponding FOC of the households problem from the CEP

$$\beta^t \psi h_{jt}^{\gamma} = \lambda_{jt}^{HH} \left(1 - \tau_{jt}^h\right) W_{jt}.$$

Hence, the two conditions are equivalent iff

$$\lambda_{jt}^{HH} \left(1 - \tau_{jt}^h\right) W_{jt} = \frac{\lambda_t^{PSPP}}{\chi_{jt}^C} \frac{1}{\chi_{jt}^H} (1 - \alpha) \frac{Y_{jt}}{h_{jt} N_{jt}}.$$

But imposing (25), we can see that the conditions will be equivalent if

$$W_{jt} = (1 - \alpha) \frac{Y_{jt}}{h_{jt} N_{jt}}, \tag{26}$$

$$1 - \tau_{jt}^h = \frac{1}{\chi_{jt}^H}. \tag{27}$$

Note that (26) implies that the FOC in hours for the firm producing the consumption good in the CEP is now satisfied. Moreover, given assumption (19), the derived process for $1 - \tau_{jt}^h$ satisfied the law of motion (6) from the CEP because

$$\ln \chi_{jt+1}^H = \left(1 - \rho_j^h\right) \ln \chi_{jSS}^H + \rho_j^H \ln \chi_{jt}^H + \sigma_j^H \varepsilon_{jt+1}^H,$$

becomes

$$\ln \left(1 - \tau_{jt+1}^h\right) = \left(1 - \rho_j^h\right) \ln \left(1 - \tau_{jSS}^h\right) + \rho_j^h \ln \left(1 - \tau_{jt}^h\right) + \sigma_j^h \varepsilon_{jt+1}^h,$$

under our assumptions on parameters above with $\varepsilon_{jt+1}^H = -\varepsilon_{jt+1}^h$.

The FOCs of the PSPP in consumption for country j and the rest of the world can be combined to yield

$$\frac{C_{jt}/N_{jt}}{C_{Rt}/N_{Rt}} = \frac{\chi_{jt}^C}{\chi_{Rt}^C}.$$

Under our normalization and parameter restrictions, this implies

$$\ln \frac{C_{jt+1}/N_{jt+1}}{C_{Rt+1}/N_{Rt+1}} = \frac{\psi_{j1}}{1 + \psi_{j1}} \ln \psi_{j0} + \frac{1}{1 + \psi_{j1}} \ln \frac{C_{jt}/N_{jt}}{C_{Rt}/N_{Rt}} + \varepsilon_{jt+1}^C,$$

which is precisely equation (16) from the CEP problem with $\varepsilon_{jt+1}^C = \ln \left(1 - \tau_{jt+1}^{*B}\right)$.

The FOC with respect to capital from the PSPP (23) combined with the FOC with respect to investment (24) can be rearranged to yield

$$\frac{\lambda_t^{PSPP}\chi_{jt}^I}{1-\phi'\left(\frac{X_{jt}}{K_{jt}}\right)} = E_t\left[\lambda_{t+1}^{PSPP}\chi_{jt+1}^I\left(\alpha\frac{Y_{jt+1}}{K_{jt+1}} + \frac{1-\delta-\phi\left(\frac{X_{jt+1}}{K_{jt+1}}\right)+\phi'\left(\frac{X_{jt+1}}{K_{jt+1}}\right)\frac{X_{jt+1}}{K_{jt+1}}}{1-\phi'\left(\frac{X_{jt+1}}{K_{jt+1}}\right)}\right)\right].$$

Comparing this with the FOC in capital from the households problem

$$\lambda_{jt}^{HH}P_{jt}^K = E_t\left[\lambda_{jt+1}^{HH}\left(1-\tau_{jt+1}^K\right)\left(r_{jt+1}^K + P_{jt+1}^{*K}\right)\right],$$

we can see that the two will be equivalent if

$$\begin{aligned}
r_{jt+1}^K &= \alpha\frac{Y_{jt+1}}{K_{jt+1}}, \\
P_{jt}^K &= \frac{1}{1-\phi'\left(\frac{X_{jt}}{K_{jt}}\right)}, \\
P_{jt+1}^{*K} &= \frac{1-\delta-\phi\left(\frac{X_{jt+1}}{K_{jt+1}}\right)+\phi'\left(\frac{X_{jt+1}}{K_{jt+1}}\right)\frac{X_{jt+1}}{K_{jt+1}}}{1-\phi'\left(\frac{X_{jt+1}}{K_{jt+1}}\right)}, \\
1-\tau_{jt+1}^K &= \frac{\chi_{jt+1}^C}{\chi_{jt}^C}\frac{\chi_{jt+1}^I}{\chi_{jt}^I},
\end{aligned} \tag{28}$$

where in the last line we substituted from (25). The first of these conditions is simply the FOC in capital for the firm producing the consumption good in the CEP, while the second and third are the optimality conditions for the firm producing the capital good.

The fourth line gives us the relationship between the consumption and investment wedges in the PSPP and the capital wedge from the CEP. This is straightforward to impose in our analysis; for any process for the growth of the PSPP consumption wedge, we simply implicitly assume whatever process for the growth of the PSPP investment wedge necessary to generate a first order autoregressive process for the product of its growth rate with that of the consumption wedge. To see that the conditions presented above are sufficient to ensure that this is true, note that under this restriction we have

$$\ln\left(1-\tau_{jt+1}^K\right) = \ln\left(\chi_{jt+1}^I/\chi_{jt}^I\right) + \ln\left(\chi_{jt+1}^C/\chi_{jt}^C\right),$$

so that after substituting for (28) and imposing the restrictions in (20) we obtain the evolution equation for the capital wedge in the CEP

$$\ln\left(1-\tau_{jt+1}^K\right) = \left(1-\rho_j^K\right)\ln\left(1-\tau_{jSS}^K\right) + \rho_j^K\ln\left(1-\tau_{jt}^K\right) + \sigma_j^K\varepsilon_{jt+1}^K.$$

Lastly, note that the resource constraint of the PSPP is equal to the sum of the budget constraints of the CE problem after imposing market clearing in bonds. Or, conversely, substituting for the allocations, prices and transfers in the CEP budget constraints from the PSPP problem, we can deduce the implied sequences of foreign bond holdings.

The Intensive Form Problem

Recall that, as discussed in Section 2.3 of the text, the world economy is assumed to follow a stochastic trend identified with the rest of the world's level of effective labor $Z_t = A_{Rt}^{1/(1-\alpha)} N_{Rt}$. As the trend possesses a unit root, to make the model stationary we will work with first differences of this trend $z_{t+1} = Z_{t+1}/Z_t$ and scale all variables by the level of effective labor in the previous period Z_{t-1}. We also define

$$\begin{aligned} \pi_{t+1} &= \frac{A_{Rt+1}}{A_{Rt}}, \\ \eta_{t+1} &= \frac{N_{Rt+1}}{N_{Rt}}, \end{aligned}$$

so that

$$z_{t+1} = \frac{Z_{t+1}}{Z_t} = \frac{A_{Rt+1}^{1/(1-\alpha)} N_{Rt+1}}{A_{Rt}^{1/(1-\alpha)} N_{Rt}} = \pi_{t+1}^{1/(1-\alpha)} \eta_{t+1}.$$

For notational simplicity it also helps to define $a_{Rt} = n_{Rt} = 1$ for all t in all states.

This section outlines this process and derives the resulting intensive form competitive equilibrium. We also derive the intensive form social planning problem that is the basis for our numerical algorithm and estimation. In the next section, we use the intensive form versions of both problems to establish that solutions to the pseudo social planner's problem are also competitive equilibria.

Competitive Equilibrium Problem

Recall that the problem of country j is to maximize

$$E_0 \left[\sum_{t=0}^{\infty} \beta^t \left\{ \ln\left(\frac{C_{jt}}{N_{jt}}\right) - \frac{\psi}{1+\gamma} h_{jt}^{1+\gamma} \right\} N_{jt} \right],$$

subject to a flow budget constraint for each state and date

$$\begin{aligned} C_{jt} + P_{jt}^K K_{jt+1} + E_t \left[q_{t+1} B_{jt+1} \right] \leq & \left(1 - \tau_{jt}^h\right) W_{jt} h_{jt} N_{jt} + \left(1 - \tau_{jt}^B + \Psi_{jt}\right) B_{jt} + T_{jt} \\ & + \left(1 - \tau_{jt}^K\right) \left(r_{jt}^K + P_{jt}^{*K}\right) K_{jt}, \end{aligned}$$

where, from the perspective of the country, Ψ_{jt} is a fixed sequence of interest penalties (analogous to a debt elastic interest rate that is not internalized) and where P_{jt}^K is the price of new capital goods, and P_{jt}^{*K} is the price of old capital goods.

Substituting for the evolution of the exogenous states and scaling by Z_{t-1}, and denoting all scaled variables by lower case, yields for the household's objective function

$$E_0 \left[\sum_{t=0}^{\infty} \beta^t \left(\prod_{s=0}^{t} \eta_s \right) \left\{ \ln\left(\frac{C_{jt}}{N_{jt}}\right) - \frac{\psi}{1+\gamma} h_{jt}^{1+\gamma} \right\} n_{jt} N_{R0} \right],$$

which is an affine transformation of

$$E_0\left[\sum_{t=0}^{\infty}\beta^t\left(\prod_{s=0}^{t}\eta_s\right)\left\{\ln\left(c_{jt}\right)-\frac{\psi}{1+\gamma}h_{jt}^{1+\gamma}\right\}n_{jt}\right].$$

For the household budget constraint we get

$$\begin{aligned}c_{jt}+P_{jt}^{K}z_tk_{jt+1}+z_tE_t\left[q_{t+1}b_{jt+1}\right] &\leq \left(1-\tau_{jt}^{h}\right)\frac{W_{jt}h_{jt}N_{jt}}{A_{Rt-1}^{1/(1-\alpha)}N_{Rt-1}}+\left(1-\tau_{jt}^{B}+\Psi_{jt}\right)b_{jt}+t_{jt}\\ &\quad+\left(1-\tau_{jt}^{K}\right)\left(r_{jt}^{K}+P_{jt}^{*K}\right)k_{jt}.\end{aligned}$$

Recall that there are two types of firm in this economy. The first produces the final consumption good. Optimization for these firms implies that

$$\begin{aligned}W_{jt} &= \left(1-\alpha\right)A_{jt}\left(\frac{K_{jt}}{h_{jt}N_{jt}}\right)^{\alpha},\\ r_{jt}^{K} &= \alpha A_{jt}\left(\frac{K_{jt}}{h_{jt}N_{jt}}\right)^{-(1-\alpha)}.\end{aligned}$$

Noting that

$$\begin{aligned}W_{jt} &= \left(1-\alpha\right)A_{jt}\left(\frac{K_{jt}}{h_{jt}N_{jt}}\right)^{\alpha}\\ &= \left(1-\alpha\right)a_{jt}A_{Rt}\left(\frac{K_{jt}}{h_{tj}n_{jt}N_{Rt}}\right)^{\alpha},\end{aligned}$$

we let

$$\begin{aligned}w_{jt} &= \frac{W_{jt}}{A_{Rt-1}^{1/(1-\alpha)}}=\left(1-\alpha\right)a_{jt}\left(\frac{K_{jt}}{h_{tj}n_{jt}A_{Rt-1}^{1/(1-\alpha)}N_{Rt}}\right)^{\alpha}\\ &= \left(1-\alpha\right)a_{jt}\pi_t\left(\frac{k_{jt}}{h_{jt}n_{jt}\eta_t}\right)^{\alpha}.\end{aligned}$$

But note that for the return to capital

$$\begin{aligned}r_{jt}^{K} &= \alpha A_{jt}\left(\frac{K_{jt}}{h_{jt}N_{jt}}\right)^{-(1-\alpha)}\\ &= \alpha a_{jt}A_{Rt}\left(\frac{K_{jt}}{h_{jt}n_{jt}N_{Rt}}\right)^{-(1-\alpha)}\\ &= \alpha a_{jt}A_{Rt}\left(\frac{K_{jt}}{h_{jt}n_{jt}A_{Rt-1}^{1/(1-\alpha)}N_{Rt-1}}\frac{A_{Rt-1}^{1/(1-\alpha)}N_{Rt-1}}{N_{Rt}}\right)^{-(1-\alpha)}\\ &= \alpha a_{jt}\pi_t\left(\frac{k_{jt}}{h_{jt}n_{jt}\eta_t}\right)^{-(1-\alpha)},\end{aligned}$$

so that no scaling of capital returns is required.

The second type of firm produces new capital goods z_tk_{jt+1} using x_{jt} units of deferred consumption and k_{jt} units of the old capital good. Their objective function is

$$P_{jt}^{K}z_tk_{jt+1}-x_{jt}-P_{jt}^{*K}k_{jt}.$$

Assuming a capital accumulation equation with adjustment costs of the form

$$z_t k_{jt+1} = (1-\delta) k_{jt} + x_{jt} - \phi\left(\frac{x_{jt}}{k_{jt}}\right) k_{jt},$$

we get that the firms problem is to choose x_{jt} and k_{jt} to maximize

$$P_{jt}^K \left[(1-\delta) k_{jt} + x_{jt} - \phi\left(\frac{x_{jt}}{k_{jt}}\right) k_{jt}\right] - x_{jt} - P_{jt}^{*K} k_{jt}.$$

The FOC in x implies

$$P_{jt}^K = \frac{1}{1-\phi'\left(\frac{x_{jt}}{k_{jt}}\right)},$$

while the one in k yields

$$P_{jt}^{*K} = P_{jt}^K \left(1 - \delta - \phi\left(\frac{x_{jt}}{k_{jt}}\right) + \phi'\left(\frac{x_{jt}}{k_{jt}}\right)\frac{x_{jt}}{k_{jt}}\right).$$

The first order conditions of the household's intensive form problem are

$$\begin{aligned}
c_{jt} &: \beta^t \left(\prod_{s=0}^{t} \eta_s\right) n_{jt} \frac{1}{c_{jt}} = \lambda_{jt}^{CE}, \\
h_{jt} &: \beta^t \left(\prod_{s=0}^{t} \eta_s\right) n_{jt} \psi h_{jt}^{\gamma} = \lambda_{jt}^{CE} \left(1 - \tau_{jt}^h\right) w_{jt} n_{jt} \eta_t, \\
k_{jt+1} &: 1 = E\left[\frac{\lambda_{jt+1}^{CE}}{\lambda_{jt}^{CE}} \left(1 - \tau_{jt+1}^K\right) \frac{r_{jt+1}^K + P_{jt+1}^{*K}}{P_{jt}^K z_t}\right], \\
b_{jt+1} &: z_t q_{t+1} \lambda_{jt}^{CE} = \lambda_{jt+1}^{CE} \left[\left(1 - \tau_{jt+1}^B + \Psi_{jt+1}\right)\right],
\end{aligned}$$

where λ_{jt}^{CE} is the multiplier on the budget constraint.

If transfers rebate all "tax revenues" beyond that required to finance government expenditure, then in equilibrium we have

$$c_{jt} + z_t k_{jt+1} + z_t E_t\left[q_{t+1} b_{jt+1}\right] + g_{jt} = w_{jt} h_{jt} n_{jt} \eta_t + \left(r_{jt}^K + 1 - \delta\right) k_{jt} - \phi\left(\frac{x_{jt}}{k_{jt}}\right) k_{jt} + b_{jt}.$$

From the labor-leisure condition we get

$$\psi h_{jt}^{\gamma} = \frac{1}{c_{jt}} \left(1 - \tau_{jt}^h\right) w_{jt} n_{jt} \eta_t.$$

From the Euler equation in physical capital we get

$$1 = E\left[\frac{\lambda_{jt+1}^{CE}}{\lambda_{jt}^{CE}} \left(1 - \tau_{jt+1}^K\right) \frac{r_{jt+1}^K + \left(1 - \delta - \phi\left(\frac{x_{jt+1}}{k_{jt+1}}\right) + \phi'\left(\frac{x_{jt+1}}{k_{jt+1}}\right)\frac{x_{jt+1}}{k_{jt+1}}\right) / \left(1 - \phi'\left(\frac{x_{jt+1}}{k_{jt+1}}\right)\right)}{z_t \left(1 - \phi'\left(\frac{x_{jt}}{k_{jt}}\right)\right)^{-1}}\right].$$

After substituting for λ^{CE} we obtain

$$1 = E\left[\beta \eta_{t+1} \frac{c_{jt}}{c_{jt+1}} \frac{n_{jt+1}}{n_{jt}} \left(1 - \tau_{jt+1}^K\right) \frac{r_{jt+1}^K + \left(1 - \delta - \phi\left(\frac{x_{jt+1}}{k_{jt+1}}\right) + \phi'\left(\frac{x_{jt+1}}{k_{jt+1}}\right)\frac{x_{jt+1}}{k_{jt+1}}\right) / \left(1 - \phi'\left(\frac{x_{jt+1}}{k_{jt+1}}\right)\right)}{z_t \left(1 - \phi'\left(\frac{x_{jt}}{k_{jt}}\right)\right)^{-1}}\right].$$

Lastly, from the Euler equation in foreign assets, we obtain

$$z_t q_{t+1} \frac{n_{jt}}{c_{jt}} = \beta \eta_t \frac{n_{jt+1}}{c_{jt+1}} \left(1 - \tau_{jt}^B + + \Psi_{jt}\right).$$

Pseudo Social Planners Problem

Following an analogous process for the pseudo social planner's problem introduced above, the intensive form pseudo social planners objective function becomes

$$\begin{aligned} & E_0\left[\sum_j \chi_{jt}^C \sum_{t=0}^{\infty} \beta^t \left\{\ln\left(\frac{C_{jt}}{N_{jt}}\right) - \chi_{jt}^I \chi_{jt}^H \frac{\psi}{1+\gamma} h_{jt}^{1+\gamma}\right\} n_{jt} N_{Rt}\right] \\ = \quad & E_0\left[\sum_j \chi_{jt}^C \sum_{t=0}^{\infty} \beta^t \left(\prod_{s=0}^{t} \eta_s\right) \left\{\ln\left(\frac{C_{jt}}{N_{jt}}\right) - \chi_{jt}^I \chi_{jt}^H \frac{\psi}{1+\gamma} h_{jt}^{1+\gamma}\right\} n_{jt} N_{R0}\right], \end{aligned}$$

which is equivalent to maximizing

$$E_0\left[\sum_{t=0}^{\infty} \beta^t \left(\prod_{s=0}^{t} \eta_s\right) \sum_j \chi_{jt}^C \left\{\ln\left(c_{jt}\right) - \chi_{jt}^I \chi_{jt}^H \frac{\psi}{1+\gamma} h_{jt}^{1+\gamma}\right\} n_{jt}\right].$$

The resource constraint becomes

$$\begin{aligned} & \sum_j \left\{c_{jt} + \chi_{jt}^I x_{jt} + g_{jt}\right\} \\ = \quad & \sum_j \chi_{jt}^I y_{jt} + t_t^{SP} \\ = \quad & \sum_j \chi_{jt}^I a_{jt} \pi_t k_{jt}^{\alpha} \left(h_{jt} n_{jt} \eta_t\right)^{1-\alpha} + t_t^{SP}, \end{aligned}$$

while the capital evolution equation is

$$z_t k_{jt+1} = \left(1-\delta\right) k_{jt} + x_{jt} - \phi\left(\frac{x_{jt}}{k_{jt}}\right) k_{jt}.$$

The first order conditions of this problem are

$$\begin{aligned} c_{jt} \quad : \quad & \beta^t \left(\prod_{s=0}^{t} \eta_s\right) \chi_{jt}^C \frac{1}{c_{jt}} n_{jt} = \lambda_t^{SP}, \\ h_{jt} \quad : \quad & \beta^t \left(\prod_{s=0}^{t} \eta_s\right) \chi_{jt}^C \chi_{jt}^I \chi_{jt}^H \psi h_{jt}^{\gamma} n_{jt} = \lambda_t^{SP} \left(1-\alpha\right) \chi_{jt}^I a_{jt} \pi_t n_{jt} \eta_t k_{jt}^{\alpha} \left(h_{jt} n_{jt} \eta_t\right)^{-\alpha} \\ k_{jt+1} \quad : \quad & \mu_{jt}^{SP} z_t = E\left[\lambda_{t+1}^{SP} \chi_{jt+1}^I \alpha a_{jt+1} \pi_{t+1} k_{jt+1}^{\alpha-1} \left(h_{jt+1} n_{jt+1} \eta_{t+1}\right)^{1-\alpha} + \right. \\ & \left. \mu_{jt+1}^{SP} \left(1 - \delta - \phi\left(\frac{x_{jt+1}}{k_{jt+1}}\right) + \phi'\left(\frac{x_{jt+1}}{k_{jt+1}}\right) \frac{x_{jt+1}}{k_{jt+1}}\right)\right], \\ x_{jt} \quad : \quad & \lambda_t^{SP} \chi_{jt}^I = \mu_{jt}^{SP} \left(1 - \phi'\left(\frac{x_{jt}}{k_{jt}}\right)\right), \end{aligned}$$

where λ_t^{SP} is the multiplier on the resource constraint at time t and μ_{jt}^{SP} the one of the capital evolution equation in country j at time t. We can rearrange these, after substituting for λ_t^{SP}, to get

$$\begin{aligned} 1 \quad = \quad & E\left[\beta \eta_{t+1} \frac{c_{jt}}{c_{jt+1}} \frac{n_{jt}}{n_{jt+1}} \frac{\chi_{t+1}^C}{\chi_t^C} \frac{\chi_{jt+1}^I}{\chi_{jt}^I} \times \right. \\ & \left. \frac{\alpha a_{jt+1} \pi_{t+1} k_{jt+1}^{\alpha-1} \left(h_{jt+1} n_{jt+1} \eta_{t+1}\right)^{1-\alpha} + \left(1 - \delta - \phi\left(\frac{x_{jt+1}}{k_{jt+1}}\right) + \phi'\left(\frac{x_{jt+1}}{k_{jt+1}}\right) \frac{x_{jt+1}}{k_{jt+1}}\right) / \left(1 - \phi'\left(\frac{x_{jt+1}}{k_{jt+1}}\right)\right)}{z_t \left(1 - \phi'\left(\frac{x_{jt}}{k_{jt}}\right)\right)}\right]. \end{aligned}$$

Imposing the "equilibrium" restriction on the wedges and additive shock yields

$$\sum_j \left\{ c_{jt} + z_t k_{jt+1} - (1-\delta) k_t - \phi\left(\frac{x_{jt}}{k_{jt}}\right) k_{jt} + g_{jt} \right\} = \sum_j a_{jt}\pi_t k_{jt}^{\alpha} \left(h_{jt} n_{jt} \eta_t\right)^{1-\alpha}.$$

The Equivalence of Interventions in the Competitive Equilibrium and Pseudo Social Planner's Problems

In the paper, we aim to quantify the contributions of the different wedges to capital flows by conducting a particular set of interventions. Specifically, we set the wedge in question equal to its average level, and then track how capital flows evolve under this intervention. In the competitive equilibrium problem, this change would occur for a given level of initial wealth or net foreign assets. However, as we use a pseudo social planners problem to solve and estimate the equilibrium, and simulate the effect of an intervention, we need to change the level of the Pareto weight (the social planning analog of initial wealth) or, equivalently, the initial level of the pseudo social planner's international wedge, so as to keep wealth in the competitive equilibrium problem constant. This is done by allowing the initial values of the pseudo social planner's international wedge (equivalently, the planner's Pareto weight) to jump to the level required to keep net foreign assets constant.

To see how we do this, note that in the competitive equilibrium problem at the beginning of period t after the resolution of uncertainty, the $j'th$ country's net foreign asset position is given by the number B_{jt}. From the resource constraint we know that

$$B_{jt} = -NX_{jt} + E_t\left[q_{t,t+1} B_{jt+1}\right].$$

We also know, from the Euler equation in bonds, that for $j = ROW$ (with no taxes)

$$\frac{1}{C_{jt}} N_{jt} q_{t,t+1} = \beta \frac{1}{C_{jt+1}} N_{jt+1}.$$

Substituting gives

$$\begin{aligned} B_{jt} &= -NX_{jt} + E_t\left[\beta \frac{C_{Rt}}{C_{Rt+1}} \frac{N_{Rt+1}}{N_{Rt}} B_{jt+1}\right] \\ &= -NX_{jt} + E_t\left[\beta \frac{C_{Rt}}{C_{Rt+1}} \eta_{t+1} B_{jt+1}\right]. \end{aligned}$$

The intensive form analog is then

$$\frac{B_{jt}}{Z_{t-1}} = -\frac{NX_{jt}}{Z_{t-1}} + E_t\left[\beta \frac{C_{Rt}/Z_{t-1}}{C_{Rt+1}/Z_t} \frac{Z_{t-1}}{Z_t} \eta_{t+1} \frac{B_{jt+1}}{Z_t} \frac{Z_t}{Z_{t-1}}\right],$$

so that

$$b_{jt} = -nx_{jt} + E_t\left[\beta \frac{c_{Rt}}{c_{Rt+1}} \eta_{t+1} b_{jt+1}\right],$$

which after recursively substituting becomes

$$\begin{aligned} b_{jt} &= -E_t\left\{nx_{jt} + \beta\eta_{t+1}\frac{c_{Rt}}{c_{Rt+1}}nx_{jt+1} + \beta^2\eta_{t+1}\eta_{t+2}\frac{c_{Rt}}{c_{Rt+2}}nx_{jt+2} + ...\right\} \\ &= -E_t\left\{\sum_{s=0}^{\infty}\beta^s\left(\prod_{r=1}^{s}\eta_{t+r}\right)nx_{jt+s}\right\}, \end{aligned} \tag{29}$$

where

$$\prod_{s=0}^{1}\eta_{t+r} = 1.$$

In solving the pseudo social planners problem, we compute the solution for net foreign assets as a function of the state (which includes the pseudo social planner's international wedge) using equation (29), which allows us to numerically vary the level of the social planner's international wedge in order to keep net foreign assets constant.

The Balanced Growth Path of the Deterministic Model

In this section we derive the balanced growth path of our model or, equivalently, the steady state of the intensive form version of our model. We then use this derivation to go into further detail about why we needed to add the portfolio adjustment costs in order to establish the existence of a non-degenerate balanced growth path for our model. Lastly, we use the derivation to show why the labor wedge has little role on the balanced growth path of the model, even though it matters a great deal along the transition to this balanced growth path, and hence why analyses based on steady state relations will tend to understate the importance of the labor wedge in determining capital flows.

As noted in the text, which can be easily verified from the resource constraint of the economy, along the balanced growth path the growth rates of consumption, investment, capital, output, government spending and net exports for all countries are all equal to the long run growth rate of effective labor, or

$$z_{ss} = \eta_{ss}\pi_{ss}^{\frac{1}{1-\alpha}}.$$

From the household's optimality condition in the accumulation of international assets, we can see that on the balanced growth path the price of these assets satisfies

$$\frac{1}{1+r_{ss}^W} \equiv q_{ss} = \beta\frac{\eta_{ss}}{z_{ss}} = \beta\pi_{ss}^{\frac{-1}{1-\alpha}},$$

where we have defined r_{ss}^W to be the steady state world interest rate. That is, as usual, the world interest rate increases in the discount rate (decreases in the discount factor) and increases in the rate of growth of productivity.

As far as country specific levels of variables, the steady state level of government spending relative to output is given by assumption as g_{jss}. Steady state investment relative to capital is determined

from the capital accumulation equation to be

$$\left(\frac{X_j}{K_j}\right)_{ss} = \delta + z_{ss} - 1,$$

where we have imposed the fact that adjustment costs are zero on the balanced growth path (or steady state), and where we have written the subscript "ss" outside of the parentheses to denote the fact that the ratio of investment to capital is constant on the balanced growth path, but the levels of investment and capital themselves are not. Hence, investment relative to output is given by

$$\left(\frac{X_j}{Y_j}\right)_{ss} = (\delta + z_{ss} - 1)\left(\frac{K_j}{Y_j}\right)_{ss},$$

and so will be pinned down once we know the steady state output to capital ratio.

From the Euler equation in capital, imposing steady state, we have

$$1 + r^W_{ss} = \left(1 - \tau^K_{jss}\right)\left(\alpha\left(\frac{Y_j}{K_j}\right)_{ss} + 1 - \delta\right)$$

which pins down the capital to output ratio as

$$\frac{K_{jss}}{Y_{jss}} = \alpha \frac{1}{\frac{1+r^W_{ss}}{1-\tau^K_{jss}} - (1-\delta)}.$$

All that remains is to pin down is consumption, hours, net exports and net foreign assets on the balanced growth path. It turns out that all of this can be done once we have the level of net foreign assets relative to output. Given $(B_j/Y_j)_{ss}$ we have that

$$\left(\frac{B_j}{Y_j}\right)_{ss}(1 - qz_{ss}) = -\left(\frac{NX_j}{Y_j}\right)_{ss}.$$

This simply states that the level of net exports in steady state is equal to the growth adjusted world interest rate on net foreign assets.

As an aside, it is worthwhile to note that, since net foreign assets are growing on the balanced growth path, the current account—in a deterministic model, this is equal to the change in the level of net foreign assets—is not zero on the balanced growth path. Given our timing convention, the ratio of the current account CA to output is given by

$$\left(\frac{CA_j}{Y_j}\right)_{ss} = \left(\frac{B'_j - B_j}{Y_j}\right)_{ss} = (z_{ss} - 1)\left(\frac{B_j}{Y_j}\right)_{ss} = \frac{1 - z_{ss}}{1 - qz_{ss}}\left(\frac{NX_j}{Y_j}\right)_{ss}.$$

Given the ratio of net exports to output, we can back out the ratio of consumption to output from the resource constraint of a country

$$\left(\frac{C_j}{Y_j}\right)_{ss} = 1 - \left(\frac{X_j}{Y_j}\right)_{ss} - g_{jss} - \left(\frac{NX_j}{Y_j}\right)_{ss}.$$

The level of hours per person (which is constant on the balanced growth path) is then pinned down by the first order condition in hours

$$h_{jss} = \left(\frac{1 - \tau^h_{jss}}{\psi} \left(\frac{Y_j}{C_j} \right)_{ss} \right)^{1/(1+\gamma)}.$$

What determines the level of net foreign assets relative to output on the balanced growth path? In a complete markets model without wedges, this would be pinned down by initial conditions. In an incomplete markets model, in general, this level would not be pinned down at all, but would instead vary forever with the sequence of shocks that hit the economy. This is why the model does not possess a unique steady state: if the shocks are all set to zero after some date T, and the economy jumped immediately to the balance growth path, the level of net foreign assets that had been accumulated up until that time period, scaled by output, would persist forever after. This is why we, and all of the literature up until this point, has adopted some mechanism for pinning down the long run level of net foreign assets relative to output. Our specification of a tax on deviations of net foreign assets from a benchmark allows us to estimate the balanced growth path of assets from the data.

It is also worth pointing out that, as constructed above, the labor wedge had no impact on the balanced growth path except for determining the level of hours worked relative to consumption. This is a little misleading; in general, realizations of the labor wedge will affect the economy on the transition to steady state and hence will affect the accumulation of net foreign assets. However, analysis of capital flows from the balanced growth perspective, that ignores the transition path, will find no role for the labor wedge to impact long run capital flows.

Appendix B: Data and Methods

As noted in the text, to recover our wedges we need data on the main national accounts expenditure aggregates—output Y_{jt}, consumption C_{jt}, investment X_{jt}, government spending G_{jt}, and net exports NX_{jt}—along with data on population N_{jt} and hours worked h_{jt}, for each of our three "countries" or regions. In this Appendix, we describe our data sources, data aggregation techniques, and sample definitions, and provide plots of the raw data used in our analysis. A data file will be made available after the paper has been accepted for publication. We then go on to discuss our estimation method in greater detail than provided in the text.

Sample Definition

The rest of the world is defined to be the aggregate of Japan, Korea, Taiwan, Hong Kong, Singapore, Canada, Australia, New Zealand, Iceland, Argentina, Brazil, Chile, Colombia, Mexico, Peru, Venezuela, Costa Rica.

Europe is the aggregate of Austria, Belgium, Denmark, Luxembourg, France, Germany, Greece, Italy, Netherlands, Norway, Portugal, Sweden, Switzerland, Turkey and the Unted Kingdom.

General Data Sources

Data were obtained from a number of sources (this is also described in Ohanian and Wright (2008)). Briefly, where available, data from the Organization for Economic Cooperation and Development's *Annual National Accounts* (OECD) was used for its member countries. For other countries, data from the World Bank's *World Development Indicators* (WDI) was our primary source. Data prior to 1960 is often scarce; our primary source was the World Bank's *World Tables of Economic and Social Indicators* (WTESI). The Groningen Growth and Development Center's (GGDC) was a valuable source of hours worked data. Taiwanese data came from the National Bureau of Statistics of China. More specifics are provided in the country specific notes below.

For the purpose of comparing our model generated estimates of the level of productivity and capital stocks to the data, we use the estimate of capital stocks in 1950 from Nehru and Dhareshwar (1993) combined with the perpetual inventory method to construct a reference series for the capital stock and the implied level of productivity.

Data Aggregation, Manipulation and Cleaning

All national accounts data were transformed to constant 2000 U.S. dollar prices. Data were aggregated by summation for each region. Net exports for the rest of the world were constructed to ensure that

the world trade balance with itself was zero, and any statistical discrepancy for a region was added to government spending.

Our measure of output is gross domestic product. Hence, net exports do not include net exports of factor services, and correspond to the trade balance (and not the current account balance). Where available, our measure of investment was gross capital expenditure. When this was not available, we used data on gross fixed capital expenditure.

For some countries and variables, data was missing for a small number of years. More details on these cases are presented in the country specific notes below; in general, missing data was filled in by assuming that data for the missing country evolved in the same way as the rest of the regional aggregate.

Country Specific Notes on Data

Next, we add a series of country specific notes on data sources and construction. These notes focus on details about missing data that are specific to each country, and on any other issues with country specific data.

Asia

1. Hong Kong. NIPA and population data from 1960 to 2007 is from the WDI. NIPA and population data from 1950 to 1960 is from WTESI. Hours data was from GGDC. Inventory investment was not available prior to 1965 and so gross fixed capital expenditure was used instead.

2. Japan. NIPA and population data from 1960 to 2007 is from the OECD. NIPA and population data from 1950 to 1960 is from WTESI. Hours data was from GGDC. Inventory investment was not available prior to 1960 and so gross fixed capital expenditure was used instead. Hours data was missing for 1950 and were imputed using trends in the data for other Asian countries.

3. South Korea. NIPA and population data from 1960 to 2007 is from the WDI. NIPA and population data from 1950 to 1960 is from WTESI. Hours data from 1963 to 2007 was from GGDC; no hours data are available prior to 1963. Inventory investment was not available prior to 1960 and so gross fixed capital expenditure was used instead.

4. Singapore. Official NIPA data for Singapore first becomes available in 1960 and was taken from the WDI. Prior to 1960, NIPA estimates derived from colonial data were obtained from Sugimoto (2011). Hours worked data were taken from GGDC from 1960. Prior to 1960, we computed total hours worked from data on the employment and hours worked of laborers, shop assistants, shop clerks and industrial clerks in both public and private sector establishments as tabulated

in the *Annual Report of the Labour Department* for the Colony of Singapore (1950-1956) and State of Singapore (1957-1960).

5. Taiwan. NIPA data for Taiwan begins in 1951 and comes from the National Bureau of Statistics of China. Hours worked data comes from GGDC starting in 1960. Population, and hours worked data prior to 1960, come from the Penn World Tables v.9.0.

Latin America

1. Argentina. NIPA and population data from 1960 to 2007 is from the WDI. NIPA and population data from 1950 to 1960 is from WTESI. Hours data was from GGDC. Inventory investment was not available prior to 1960, and for some years after 1979, and so gross fixed capital expenditure was used instead.

2. Brazil. NIPA and population data from 1960 to 2007 is from the WDI. NIPA and population data from 1950 to 1960 is from WTESI. Hours data was from GGDC. Inventory investment was not available prior to 1960 and so gross fixed capital expenditure was used instead.

3. Chile. NIPA and population data from 1960 to 2007 is from the WDI. NIPA and population data from 1950 to 1960 is from WTESI. Hours data was from GGDC.

4. Colombia. NIPA and population data from 1960 to 2007 is from the WDI. NIPA and population data from 1950 to 1960 is from WTESI. Hours data was from GGDC. Inventory investment was not available prior to 1960 and so gross fixed capital expenditure was used instead.

5. Mexico. NIPA and population data from 1960 to 2007 is from the WDI. NIPA and population data from 1950 to 1960 is from WTESI. Hours data was from GGDC. Inventory investment was not available prior to 1960 and so gross fixed capital expenditure was used instead.

6. Peru. NIPA and population data from 1960 to 2007 is from the WDI. NIPA and population data from 1950 to 1960 is from WTESI. Hours data was from GGDC. Inventory investment was not available prior to 1960 and so gross fixed capital expenditure was used instead.

Rest of the World

We end up with an aggregate of 22 advanced economies from North America, Europe and Australasia. The specific list of countries is: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, and the United States of America.

1. Australia. NIPA and population data are from the OECD. Hours worked were taken from GGDC back until 1953, and extended back to 1950 using the series in Butlin (1977).

2. Austria. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
3. Belgium. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
4. Canada. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
5. Denmark. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
6. Finland. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
7. France. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
8. Germany. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
9. Greece. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
10. Iceland. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
11. Ireland. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
12. Italy. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
13. Luxembourg. NIPA and population data are from the OECD. Hours worked were taken from GGDC back until 1958.
14. Netherlands. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
15. New Zealand. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
16. Norway. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
17. Portugal. NIPA and population data are from the OECD. Hours worked were taken from GGDC back until 1956.
18. Spain. NIPA and population data are from the OECD. Hours worked were taken from GGDC back until 1954.
19. Sweden. NIPA and population data are from the OECD. Hours worked were taken from GGDC back until 1959.
20. Switzerland. NIPA and population data are from the OECD. Hours worked were taken from GGDC.

21. United Kingdom. NIPA and population data are from the OECD. Hours worked were taken from GGDC.

22. The United States of America. NIPA and population data are from the OECD. Hours worked were taken from GGDC.

Appendix C: Conceptual Issues About Measuring Capital Flows

In the paper, we use net exports of goods and services as our measure of international capital flows. This is a common approach, although some researchers studying capital flows in more recent decades have focused on the current account as a measure of capital flows (which includes income from net exports of factor services, otherwise known as net factor income). In this appendix, we discuss the reasons for our approach in more detail.

In brief, there are several reasons for our approach: (1) net factor income is poorly measured; (2) balance of payments data is limited by its focus on transactions data and its inconsistent treatment of transfers such as debt restructuring, which matter a lot for Latin America in the middle of our sample; (3) balance of payments data is not available for many countries prior to 1970 and has sometimes severe measurement issues; and (4) there is no unique mapping from model outcomes to implications for the balance of payments, although there is a unique mapping of net exports. We elaborate on these reasons in detail below.

First, on data availability, it is important to note that data on net factor income (the difference between net exports and the current account balance) are often not available, particularly before 1970. For example, Alfaro, Kalemli-Ozcan, and Volosovych (2014), who conduct the most exhaustive study of data on international capital flows that we know of, focus most of their analysis on the period after 1980, for which the most data are available for 156 countries. Their "1970" sample covers only 46 countries and includes only a limited subset of the variables contained in their wider analysis. This means that these data do not speak to a key period of interest: the decades leading up to 1970.

Second, on the issue of data reliability, it is important to note that even when these data are available, they are subject to significant measurement error. As a number of people have pointed out, including the International Monetary Fund itself, according to their data the world often runs a large current account deficit with itself. Until recently, this deficit was almost entirely concentrated in the net factor income component of the current account. Moreover, the error has often been extremely large, peaking at around 5 percent of world imports in 1982 (see Marquez and Workman (2000)).

Third, at a deeper level, our focus on net exports data (and not data on the current account or on the capital account) is driven by issues related to the way the balance of payments is constructed. Conceptually, a country's net foreign asset position can change for roughly three reasons. First, it may change because of a transaction in which assets change hands or income is paid. Second, it may change due to capital gains and valuation effects. Third, it may change due to a gift or transfer, such as foreign aid, a nationalization or expropriation, or due to debt forgiveness and restructuring.

The way the balance of payments is constructed, it is designed to capture transactions. It is explicitly *not* designed to capture the effect of valuation changes on a country's net foreign asset position (this has, in and of itself, led to a significant debate about how to interpret data on the balance

of payments and data on net foreign assets; see the issues raised by Lane and Milesi Ferretti (2001, 2005, and 2007); Tille (2003); Higgins, Klitgaard, and Tille (2005) and Gourinchas and Rey (2007)). In addition, its ability to capture transfers such as sovereign default depends on whether the country has adopted accrual accounting standards (in which case, a debt restructuring is paired with an artificial accounting transaction) and whether it is believed that accrual accounting standards are adequate for this purpose (Sandleris and Wright (2013) and others have argued that, when a country defaults on its debts, it is better to use cash accounting concepts in evaluating their balance of payments). As a result of all these concerns, amplified by the fact that the asset structure of international finance has changed over time to emphasize more derivative securities and valuation effects have become more important in an era of floating exchange rates, confidence in the reliability and backwards comparability of balance of payments data is low, even in the absence of the measurement error noted above. The issues are well summarized by Alfaro, Kalemli-Ozcan, and Volosovych (2014) who write:

> There are substantial country differences in terms of time coverage, missing, unreported, or misreported data, in particular for developing countries. Some countries do not report data for all forms of capital flows. Outflows data tend to be misreported in most countries and, as the result, captured in the errors and omissions item.
>
> Unfortunately, it is hard to verify whether the data are really missing as opposed to simply being zero. Due to the debt crisis of the 1980s there are several measurement problems related to different methodologies of recording non-payments, rescheduling, debt forgiveness and reductions.

Fourth, on the issue of mapping models to data, it has been known for a long time that a given model of international capital markets can be mapped into data on the balance of payments in different ways depending on which of many alternative equivalent asset structures is used. For example, in a complete markets framework, it may be possible to decentralize the equilibrium allocations using Arrow securities, Arrow-Debreu securities, a portfolio of equities and debt, or a combination of debt and derivative securities and so on. Each will typically have different implications for the balance of payments. A model with only Arrow or Arrow-Debreu securities has many assets experiencing a 100 percent capital loss each period, with one asset experiencing a large capital gain. In principle, these capital gains would not be recorded in the balance of payments at all. With only Arrow-Debreu securities, no transactions occur after the first initial period. With Arrow securities, a portfolio of new securities is bought every period. Again, these can have very different implications for the balance of payments. Likewise, the equilibrium will look different if it is decentralized with a mixture of debt and equity or with financial derivatives.

As a consequence, it is has become traditional in the literature to (1) work with models that either have a very limited asset structure (such as with bonds only or a bond and one equity), which misses much of the richness of the international asset trade but can give precise predictions for the

balance of payments, or (2) to work with complete market models to focus on allocations—such as net exports—which are invariant across different decentralizations. A particularly strong statement of this position is provided by Backus, Kehoe, and Kydland (1994). This is the approach we have adopted in this paper.

Moreover, even when a particular stand is taken on the asset structure in the model, it is not always obvious how best to map the model to the data. This might be more easily understood in the model of this paper, under the assumption that the asset structure is one in which the world trades Arrow securities each period (the assumption made in the text).

To begin, we can start by looking at the change in a country's net foreign asset position from one period to the next. If the current account in the data was constructed to include valuation effects, this would be the natural measure of the current account in the model. However, even with this simple concept, we can measure the change at different points within the period by looking at either start or end-of-period levels.

The start-of-period definition is

$$CA^1_{jt} = B_{jt+1} - B_{jt},$$

so that, recalling also that

$$B_{jt} = -NX_{jt} + E_t\left[q_{t+1}B_{jt+1}\right],$$

we can write the current account as

$$CA^1_{jt} = NX_{jt} + B_{jt+1} - E_t\left[q_{t+1}B_{jt+1}\right],$$

where the two terms after net exports correspond to net factor income (which can be thought of as earned between t and $t+1$),

$$NFI_{jt} = B_{jt+1} - E_t\left[q_{t+1}B_{jt+1}\right].$$

The end-of-period definition is

$$\begin{aligned} CA^2_{jt} &= E_t\left[q_{t+1}B_{jt+1}\right] - E_{t-1}\left[q_tB_{jt}\right] \\ &= NX_{jt} + B_{jt} - E_{t-1}\left[q_tB_{jt}\right]. \end{aligned}$$

This differs from the previous version in that it adds net factor income between periods $t-1$ and t to net exports in period t, as opposed to income earned between t and $t+1$.

As noted previously, current accounts are not measured this way in practice. Specifically, the current account does not include the capital gains or losses on foreign assets. One could try to compute a model analog of net factor income exclusive of capital gains and losses in the model. One way to do this, although far from the only way, would be to define the model in terms of the expected profits and losses from the country's net foreign asset position:

$$NII_{jt} = E_{t-1}\left[B_{jt}\left(1 - q_t\right)\right].$$

Intuitively, if we define the interest rate between $t-1$ and t as satisfying

$$q_t = \frac{1}{1+r_t}$$

so that

$$1 - q_t = \frac{r_t}{1+r_t},$$

we get

$$B_{jt}\left(1-q_t\right) = r_t \frac{B_{jt}}{1+r_t}.$$

This leads to an alternative measure of the current account, designed to more-closely mimic that available in the data, or

$$CA^3_{jt} = NX_{jt} + E_{t-1}\left[\frac{r_t}{1+r_t} B_{jt}\right].$$

A fourth alternative would be to try to measure net foreign investment income using an average (or expected) interest rate. For example, we might define an average interest rate $\bar{r}_t$ from

$$\bar{q}_t = E_{t-1}\left[q_t\right]$$

as

$$1 + \bar{r}_t = 1/\bar{q}_t.$$

Then we have a fourth measure of the current account:

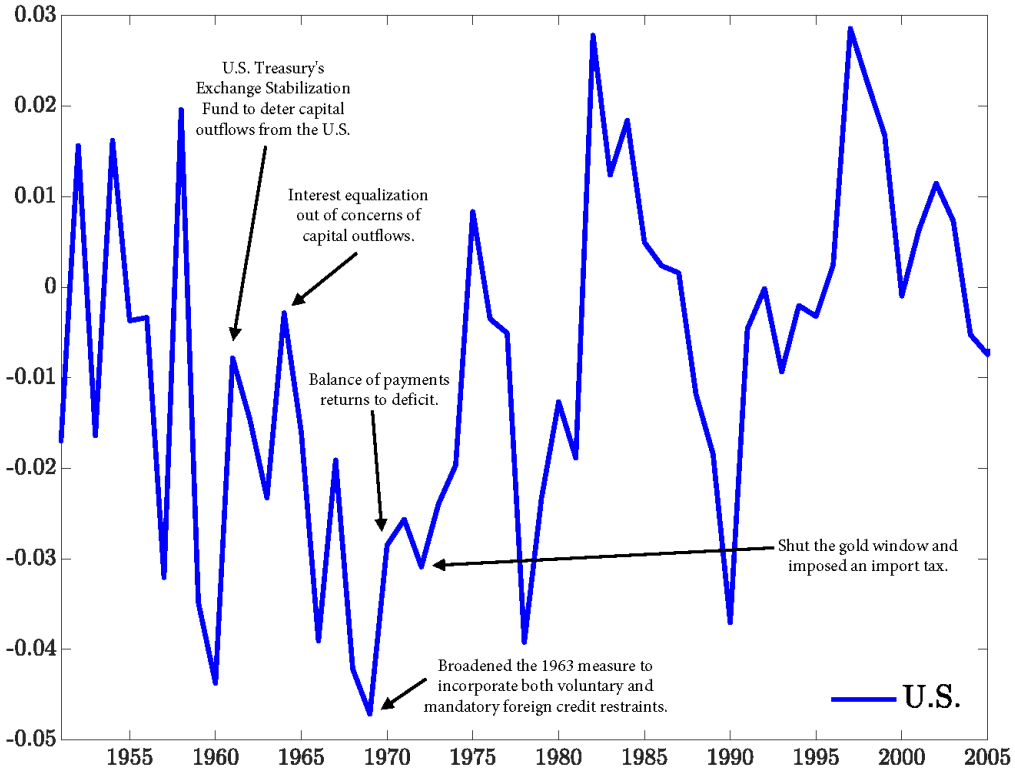
$$CA^4_{jt} = NX_{jt} + \frac{\bar{r}_t}{1+\bar{r}_t} B_{jt}.$$

In summary, in the context of a complete markets model where multiple decentralizations are possible, even when attention is restricted to a decentralization using Arrow securities alone, there are multiple plausible ways of mapping model outputs into the analog of the current account measured in the data.

Appendix D: Capital Controls in the United States and Europe

United States

Figure 8: Tax on international capital mobility and Capital Controls Implemented in the United States



- **1961:** U.S. Treasury's Exchange Stabilization Fund was created to deter capital outflows from the U.S. In the model, deterring these outflows from the U.S. is equivalent to a relative increase in τ^{*B}. As we see in the data, τ^{*B} rises from -0.044 to -0.008.

- **1963:** Interest equalization was implemented out of concerns of capital outflows. This policy, which was intended to decrease capital outflows, is equivalent to a relative increase in τ^{*B}. In the data, τ^{*B} rises from -0.023 to -0.003.

- **1970:** Broadened the 1963 measure to incorporate both voluntary and mandatory foreign credit restraints. These constrains to capital outflows are equivalent to a relative increase in τ^{*B} in

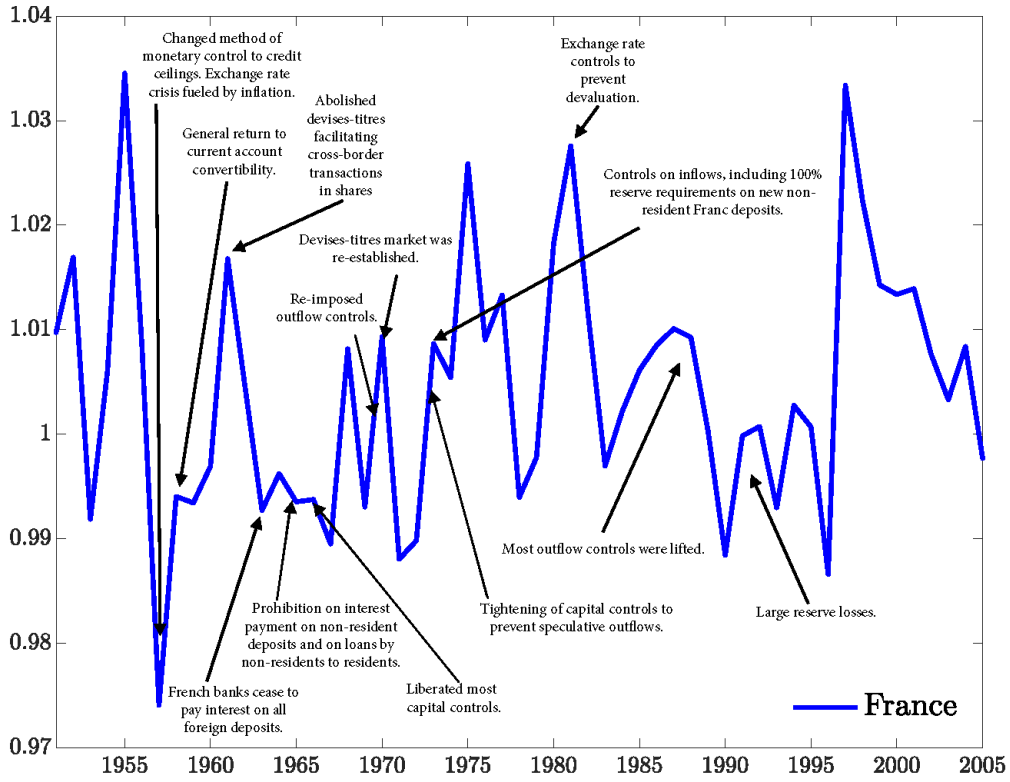
the model. As we see in the data, τ^{*B} rises from -0.047 to -0.028.

- **1970:** Balance of payments returns to deficit, which in our model is equivalent to a relative increase in τ^{*B}. As we see in the data, τ^{*B} rises from -0.028 to -0.026.

- **1971:** Shut the gold window and imposed an import tax. This tax deters capital outflows and is equivalent in the model to a relative increase in τ^{*B}. The data show an increase in τ^{*B} from -0.031 to 0.008.

France

Figure 9: Tax on international capital mobility and Capital Controls Implemented in France



- **1957:** Changed method of monetary control to credit ceilings. Exchange rate crisis fueled by inflation. These factors would lead to capital outflows, and are equivalent in the model to a relative decrease in τ^{*B}. As we see in the data, τ^{*B} falls from -0.044 to -0.008.

- **1958:** General return to current account convertibility. In the model, facilitating capital outflows is equivalent to a relative increase in τ^{*B}. As we see in the data, τ^{*B} increases from -0.044 to -0.008.

- **1962:** Abolished devises-titres, facilitating cross-border transactions in shares. This policy deters capital outflows, and is equivalent to a relative increase in τ^{*B}. As we see in the data, τ^{*B} increases from -0.044 to -0.008.

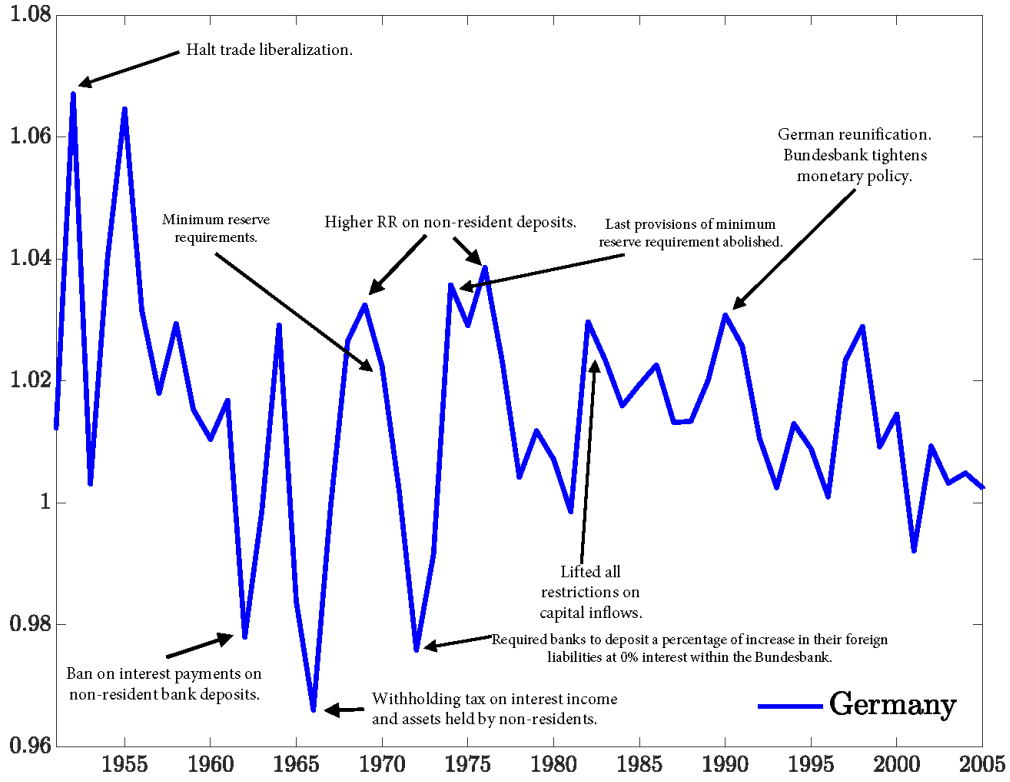
- **1963:** French banks cease to pay interest on all foreign deposits. This policy incentivizes capital

outflows from France and is equivalent to a relative decrease in τ^{*B}. As we see in the data, τ^{*B} falls from -0.044 to -0.008.

- **1965*:** Prohibition on interest payment on non-resident deposits and on loans by non-residents to residents. This prohibition deters capital inflows and would be equivalent in the model to a relative decrease in τ^{*B}. As we see in the data, τ^{*B} falls from -0.044 to -0.008.
- **1966*:** Liberated most capital controls.
- **1968*:** Re-imposed outflow controls
- **1969*:** Devises-titres market was re-established
- **1973*:** Tightening of capital controls to prevent speculative outflows
- **1974:** Controls on inflows, including 100% reserve requirements on new non-resident Franc deposits
- **1982:** Exchange rate controls to prevent devaluation
- **1986:** Most outflow controls were lifted
- **1992:** Large reserve losses

Germany

Figure 10: Tax on international capital mobility and Capital Controls Implemented in Germany

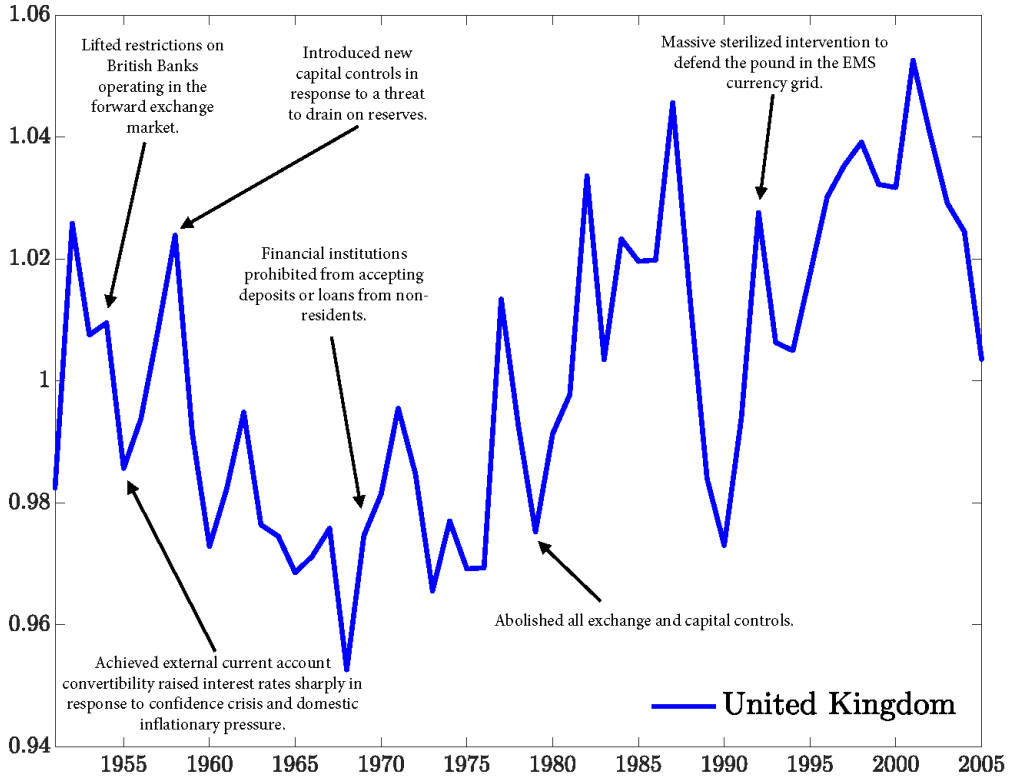


- **1951:** Halt trade liberalization
- **1960:** Ban on interest payments on non-resident bank deposits
- **1965:** Withholding tax on interest income and assets held by non-residents
- **1968:** Higher RR on non-resident deposits
- **1970:** Minimum reserve requirements
- **1972:** Required banks to deposit a percentage of increase in their foreign liabilities at 0% interest within the Bundesbank
- **1974*:** Last provisions of minimum reserve requirement abolished
- **1977:** Higher RR on non-resident deposits

- **1981*:** Lifted all restrictions on capital inflows
- **1990:** German reunification; Bundesbank tightens monetary policy

United Kingdom

Figure 11: Tax on international capital mobility and Capital Controls Implemented in the United Kingdom



- **1954:** Lifted restrictions on British Banks operating in the forward exchange market
- **1955:** Achieved external current account convertibility; raised interest rates sharply in response to confidence crisis and domestic inflationary pressure
- **1957:** Introduced new capital controls in response to a threat to drain on reserves
- **1971:** Financial institutions prohibited from accepting deposits or loans from non-residents
- **1979:** Abolished all exchange and capital controls
- **1992:** Massive sterilized intervention to defend the pound in the EMS currency grid