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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 and thereafter. 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 by restricting international capital flows. Counterfactual analyses show world output would have been 0.6% higher had there been perfect capital mobility, and that 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 key question of why the U.S. promoted these controls within the system? We interpret the large U.S. welfare loss as an estimate of the implicit value to the U.S. of keeping capital in ally and developing countries, and thus promoting global political stability within these countries, including European and Latin American countries. This interpretation is consistent with the literature from that time that emphasized the U.S.'s interests in supporting U.S. -friendly governments in the face of communism and fascism.

Keywords: Bretton Woods, International Payments, Capital Flows.

JEL Codes: E21, E65, F21, F33, F38, F41, J20.

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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) and thereafter. 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 (i) how much did Bretton Woods capital controls impede the international flow of capital, (ii) where would capital have gone 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 for the U.S., Europe, and the Rest of the World.

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 at the same time, which complicates capturing the effect of controls into a single measure, and the de facto application of controls may have differed considerably from their de jure specification. In addition, Bretton Woods involved multiple, interrelated objectives and multidimensional policies, which suggests that general equilibrium considerations will be important in evaluating the impact of these controls.

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 between 1950 and 2010. This approach is well-suited to study the consequences of Bretton Woods' 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 works as an accounting framework by capturing the observed levels of consumption, labor, investment, output, and capital flows in each of these three regions with a relatively small number of identified distortions that are measured off of the model's first order conditions. These include an international distortion that affects the cost of international financial transactions between regions, and acts as a capital control. This distortion affects region-specific capital flows and net exports, as developed in Ohanian, Restrepo-Echavarria, and Wright (2018). Other distortions include the efficiency, domestic labor and capital, and government

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. This capital flow accounting method facilitates the testing of specific hypotheses about how distortions change over time and analyzing their general equilibrium effects.

We conduct positive and normative counterfactual analyses to assess how world economic activity would have been different had countries not operated within the Bretton Woods system after the war.

Our counterfactual eliminates the identified distortions affecting international borrowing and lending during Bretton Woods and afterwards. Our thought experiment is that had a free system of international capital controls been implemented during Bretton Woods, similar to the system in place during the "Golden Age" of capital flows around the late 19th and early 20th century, then that free system would have been in place for the full postwar period. We view the identified distortions as capital controls or related regulations/taxes that change the incentives and/or the opportunities to borrow and lend abroad. We also evaluate the welfare implications of removing capital controls for the three regions.

Our main findings are as follows. capital controls were quantitatively 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 large capital flows moving out of the ROW and into the U.S. This would have increased world output by about one 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 when impediments to international capital flows are removed.

This finding of a large US welfare loss 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 capital controls to the U.S. as an estimate of the implicit value of promoting stability in friendly governments at a time of substantial hostilities related to fascism and communism at that time.

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. 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).

We show how Bretton Woods exchange rate controls and international capital mobility impediments arise 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 on capital flows from fixed exchange rate effects from this distorted first order condition.

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 $t = 0, 1, \dots$, so that N_{jt} denotes the population of country j at time t . There are $J + 1$ physical 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 $C_{jt} = [\alpha X_{jt}^\rho + (1 - \alpha) D_{jt}^\rho]^{1/\rho}$, 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 representative household of country j chooses a state-contingent stream of tradable consumption X_{jt} , hours worked h_{jt} , purchases of capital to be rented out the following period $K_{j,t+1}$, and a portfolio of state-contingent international bond holdings $B_{j,t+1}$ subject to a sequence of flow budget constraints for each state and date:

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

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. 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 country-specific distortions that are isomorphic to taxes on factor payments and investment income. Specifically, τ^h is a distortion on domestic labor markets, τ^K is a distortion on domestic capital markets, while τ^B is a distortion on international capital markets.

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

$$T_{jt} = \tau_{jt}^h W_{jt} h_{jt} N_{jt} + \tau_{jt}^B B_{jt} + \tau_{jt}^K (r_{jt}^K + P_{jt}^{*K}) K_{jt} - G_{jt}. \quad (1)$$

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.

Throughout the rest of the paper we will focus our attention primarily on τ^B .

Firms Each country is populated by two types of competitive firms. The first hires labor and capital to produce the tradable consumption good using a standard Cobb-Douglas technology of the form $A_{jt} K_{jt}^\alpha (h_{jt} N_{jt})^{1-\alpha}$, 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:

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

and

$$r_{jt}^K = \alpha \frac{Y_{jt}}{K_{jt}}. \quad (3)$$

The second 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. They 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:

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

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

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 constant and the same across countries.

Growth and Uncertainty The world economy has grown substantially over the period under study. However, this growth has fluctuated considerably across regions and over time. While the U.S. has had fairly stable growth since World War II, growth in Europe and the ROW has been more volatile. Both of these regions initially grew faster than the U.S. after World War II, but growth slowed considerably, particularly in the ROW, around the 1970s. Capturing these region and country-specific growth dynamics is important because expectations of future income growth 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 filter the data and proceed with a detrended model, as is frequently done in the business cycle literature. Instead, 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

$$\begin{aligned} \ln A_{Ut+1} &= \ln A_{Ut} + \ln \pi_{ss} + \sigma_U^A \varepsilon_{Ut}^A, \\ \ln N_{Ut+1} &= \ln N_{Ut} + \ln \eta_{ss} + \sigma_U^N \varepsilon_{Ut}^N, \end{aligned}$$

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 $\pi_t = \frac{A_{Ut+1}}{A_{Ut}} = \pi_{ss} \exp(\sigma_U^A \varepsilon_{Ut}^A)$ and $\eta_t = \frac{N_{Ut+1}}{N_{Ut}} =$

$\eta_{ss} \exp(\sigma_U^N \varepsilon_{U_t}^N)$. In order to make our model of the world economy stationary, we scale by the level of effective labor in the United States $Z_t = A_{U_t}^{1/(1-\alpha)} N_{U_t}$. 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 $a_{jt} = A_{jt}/A_{U_t}$ and relative population $n_{jt} = N_{jt}/N_{U_t}$ and assume that both a_{jt} and n_{jt} follow first-order autoregressive processes of the form

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

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

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

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:

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

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

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

where P_j is the price aggregator for tradable and non-tradable goods, and is given by¹

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

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

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

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 aggregate relative consumption and the growth rate of the real exchange rate:

$$\underbrace{\left(\frac{C_{jt+1}/N_{jt+1}}{C_{Rt+1}/N_{Rt+1}} \right) \left(\frac{C_{Rt}/N_{Rt}}{C_{jt}/N_{jt}} \right)}_{\text{Relative Consumption Growth Rate}} \underbrace{\left(\frac{Q_{jRt+1}}{Q_{jRt}} \right)}_{\text{Exchange rate effects}} = \zeta_{jt+1}^{NTB}. \quad (8)$$

Note that the international capital market distortion (ζ_{jt+1}^{NTB}) consists of two terms that are multiplicatively separable; the growth rate of relative consumption, and the growth rate of the real exchange rate. Because we want to separately identify any effects coming from impediments to international capital mobility from those coming from exchange rates, we proceed as follows. We first examine the potential quantitative importance of the exchange rate component in this equation (the second term in Equation 8) by since if this component is quantitatively irrelevant, then we can ignore 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 Appendix B for the data and aggregation details), so we evaluate the two components and run a regression of the log of the relative consumption growth rate 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 are just noise and do not explain 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

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

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

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

<i>Dependent variable: $\log(\text{International capital controls component})$</i>			
	1950-2008	1950-1973	1973-2008
Exchange rate growth rate	0.036 (0.010)	0.000 (0.029)	-0.039 (0.007)
Observations	824	306	503
Adj- R^2	0.027	0.000	0.058

Notes: Robust standard errors in parentheses.

subject to

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

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

$$\left(\frac{C_{jt+1}/N_{jt+1}}{C_{Rt+1}/N_{Rt+1}} \right) \left(\frac{C_{Rt}/N_{Rt}}{C_{jt}/N_{jt}} \right) = (1 - \tau_{jt+1}^B + \Psi_{jt+1}) = \zeta_{jt+1}^B. \quad (9)$$

In other words, the model without non-traded goods, isolates the variation in the international distortion generated by relative consumption growth rates, 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 that we can abstract from having non-traded goods, such that the international distortion is fully identified by the growth rate of relative consumption, without worrying about exchange rate effects.

Furthermore, we know that 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. In our model the growth rate of relative consumption is directly determined by the international capital market distortion ζ_{jt+1}^B , which changes the incentives and/or opportunities to buy or sell foreign assets.

We are well aware that this distortion may arise due to miss-specification of the model, other equilibrium frictions (that are efficient and hence non-distortionary), it can reflect taxes or non-tax distortions, or some combination of the above, and that in principle it can be micro-founded in several different ways that need not be related to international capital markets. However, we are going to take a stand and argue that τ^B represents impediments to international capital mobility (capital controls). To defend this stand, we will later on in Section 4 show that our recovered τ^B 's for the U.S. and different countries is Europe line up remarkably well with different policies that were implemented in those countries to control capital flows, and that as such we can give a structural interpretation to

them. So from now on we will refer to τ^B as capital controls or impediments to international capital mobility.

Finally, 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,

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

the Euler equation for domestic capital,

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

and the Euler equation for state-contingent international assets,

$$\frac{C_{jt+1}/N_{jt+1}}{C_{jt}/N_{jt}} = \frac{\beta}{q_{t+1}} (1 - \tau_{jt+1}^B + \Psi_{jt+1}). \quad (12)$$

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 without non-traded goods presented above 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, take equation (9). It means that if the steady-state of τ_{jt+1}^B , is not equal to zero then 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 $\tau_{jt+1}^B = 0$ 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 (9), 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, we assume that their international distortion can be decomposed into a term that represents capital controls τ_{jt}^B and an adjustment cost term Ψ_{jt} , both of which the country takes as given:

$$\zeta_{jt}^B = 1 - \tau_{jt}^B + \Psi_{jt}.$$

We assume that τ^B follows a first-order autoregressive process with the steady-state assumed to be zero:

$$\ln(1 - \tau_{jt+1}^B) = \rho_j^B \ln(1 - \tau_{jt}^B) + \sigma_j^B \varepsilon_{jt+1}^B. \quad (13)$$

The adjustment cost term, which can be positive or negative, is assumed in equilibrium, to satisfy

$$\Psi_{jt} = (1 - \tau_{jt}^B) \left[\left(\frac{C_{jt}/N_{jt}}{C_{Rt}/N_{Rt}} \frac{1}{\psi_{j0}} \right)^{-\psi_{j1}} - 1 \right]. \quad (14)$$

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

$$\ln \frac{C_{jt+1}/N_{jt+1}}{C_{Rt+1}/N_{Rt+1}} = \frac{\psi_{j1}}{1 + \psi_{j1}} \ln \psi_{j0} + \frac{1}{1 + \psi_{j1}} \ln \frac{C_{jt}/N_{jt}}{C_{Rt}/N_{Rt}} + \frac{1}{1 + \psi_{j1}} \ln(1 - \tau_{jt+1}^B). \quad (15)$$

The portfolio adjustment cost can be positive or negative 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 estimate the long-run net foreign asset position of each country from the data.

Under these assumptions on the portfolio adjustment cost, there exists a unique non-degenerate deterministic steady-state. This will allow us to take 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. This means the model can be used as an accounting framework for the variables in observed data. This section describes how the model

uses these data to identify the different distortions. It also summarizes the sources of the data, with a detailed data discussion in Appendix B.

To recover the empirical 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_{jt+1}^B , can be recovered from the growth in relative consumption levels, as shown in equation (9). Estimation of equation (15) serves to both decompose ζ_{jt+1}^B into τ_{jt+1}^B 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 first-order autoregressive process, but rather an ARMA(1,1) 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 the parameters of its stochastic process can be 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

$$1 - \tau_{jt}^h = \frac{\varphi}{1 - \alpha} h_{jt}^\gamma \frac{h_{jt} N_{jt}}{Y_{jt}} \frac{C_{jt}}{N_{jt}}. \quad (16)$$

Specifically, given 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

$$1 = E_t \left[\beta \frac{C_{jt+1}/N_{jt+1}}{C_{jt}/N_{jt}} (1 - \tau_{jt+1}^K) \frac{\alpha \frac{Y_{jt+1}}{K_{jt+1}} + \frac{1 - \delta - \phi(i_{jt+1}) + \phi'(i_{jt+1})i_{jt+1}}{1 - \phi'(i_{jt+1})}}{\frac{1}{1 - \phi'(i_{jt})}} \right]. \quad (17)$$

Note that it is impossible to separately identify the level of the domestic capital distortion from the level of the discount factor. We therefore focus on changes in the levels of these distortions. 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. We also estimate the initial capital stock of each country.

3.2 Data, Model Solution, and Model Estimation

Recovering the wedges requires national accounts data, including output Y_{jt} , consumption C_{jt} , investment I_{jt} , and net exports NX_{jt} , and requires data on population N_{jt} and hours worked h_{jt} , for each of our three "regions." We use the dataset constructed in Ohanian, Restrepo-Echavarria, and Wright (2018).

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. This section describes 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.

The empirical values of the portfolio adjustment cost are constructed using relative consumption growth rates across regions, and thus do not depend on any other model features.

The parameters governing preferences and production are assumed constant across countries. 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 value strikes a balance between the estimates within the literatures that study labor supply decisions using micro data on the intensive margin, using micro data on the extensive margin, and using aggregate data (see the surveys by Pencavel

Table 2: Common Parameter Values

Parameter	Notation	Value
<i>Preferences</i>		
Discount Factor	β	0.96
Frisch Elasticity of Labor Supply	$1/\gamma$	2/3
Preference for Leisure	φ	1
<i>Production</i>		
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

(1987), Keane (2011), and Reichling and Whalen (2012)). As is evident from equation (16), we cannot separately identify the household’s preference for leisure φ from the long-run labor distortion τ_{jss}^h , so we normalize φ to 1. We therefore focus on analyzing changes in this wedge over time, rather than its level.

As is standard in the investment adjustment cost literature, 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 value for the elasticity of the price of capital with respect to the investment-capital ratio, $\nu\kappa$. 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.

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.

We assume a steady state growth path in which the world economy grows at 2 percent per year: $z_{ss} = \pi_{ss}^{1/(1-\alpha)} \eta_{ss} = 1.02$.

Since the model is non-stationary, it is estimated using the *growth rates* of the data. To ensure that the 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 use the Kalman filter to compute the likelihood and to

Table 3: Country Specific Parameter Values

Process	Region	Steady State	Persistence	Standard Deviation
Population	United States	$\eta_{ss}=0.84$	$\rho_U^n=1$	$\sigma_U^n=0.003$
	Europe	$n_{Ess}=0.77$	$\rho_E^n=0.99$	$\sigma_E^n=0.002$
	Rest of World	$n_{Rss}=0.82$	$\rho_R^n=0.98$	$\sigma_R^n=0.003$
Productivity	United States	$\pi_{ss}=1.01$	$\rho_\pi=1$	$\sigma_\pi=0.08$
	Europe	$a_{Ess}=0.74$	$\rho_E^a=0.99$	$\sigma_E^a=0.02$
	Rest of World	$a_{Rss}=0.52$	$\rho_R^a=0.99$	$\sigma_R^a=0.03$
Government Distortion	United States	$g_{Uss}=0.18$	$\rho_U^g=0.94$	$\sigma_U^g=0.03$
	Europe	$g_{Ess}=0.20$	$\rho_E^g=0.20$	$\sigma_E^g=0.03$
	Rest of World	$g_{Rss}=0.13$	$\rho_R^g=0.13$	$\sigma_R^g=0.10$
Domestic Labor Market Distortion	United States	$\tau_{Uss}^h=1.93$	$\rho_U^h=0.99$	$\sigma_U^h=0.04$
	Europe	$\tau_{Ess}^h=1.91$	$\rho_E^h=0.99$	$\sigma_E^h=0.03$
	Rest of World	$\tau_{Rss}^h=1.79$	$\rho_R^h=0.99$	$\sigma_R^h=0.02$
Domestic Capital Market Distortion	United States	$\tau_{Uss}^k=0.94$	$\rho_U^K=0.99$	$\sigma_U^K=0.03$
	Europe	$\tau_{Ess}^k=0.94$	$\rho_E^h=0.99$	$\sigma_U^K=0.27$
	Rest of World	$\tau_{Rss}^k=0.98$	$\rho_R^h=0.99$	$\sigma_R^K=0.01$
International Distortion	United States	$\tau_{Uss}^B=0$	$\rho_U^B=0.93$	$\sigma_U^B=0.02$
	Europe	$\tau_{Ess}^B=0$	$\rho_E^B=0.93$	$\sigma_E^B=0.01$
Portfolio Tax	United States	$\psi_{U0}=1.95$	$1-\psi_{U1}=0.94$	—
	Europe	$\psi_{E0}=1.46$	$1-\psi_{E1}=0.97$	—

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

obtain the paths of the wedges. Table 3 shows the estimated parameters.

4 Quantified Distortions and Bretton Woods' Impediments to International Capital Mobility

This section presents the values for the efficiency, domestic labor and capital, and international distortions.

The distortions introduced into the model may stand for taxes, 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

Figure 1: Total Factor Productivity

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 Productivity, and domestic labor and capital market distortions

Productivity and capital flows Our estimates of total factor productivity across the three regions (A_{jt}) are depicted in Figure 1. This figure shows that the world economy grew rapidly, particularly during the Bretton Woods era. During Bretton Woods, 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%. Bretton Woods was also a period of extremely rapid real output growth, with 3.7% for the United States, 4.6% for Europe and 7.4% for the rest of the world.

These productivity and output growth patterns highlight a very dynamic and rapidly evolving world economy with large differences in growth rates across regions. These large differences suggest strong incentives to move capital to the rest of the world, where growth was highest. In sharp contrast, Figure 2 shows that during this period capital flows were very small, and that capital moved in larger quantities to the United States, the region with the slowest growth rate.

We will see below that very large international capital market distortions during Bretton Woods account for the very small volumes of capital flows during this period, and the surprising directions

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

of the flows that did occur. Other distortions affect these flows through general equilibrium channels, and are also important for understanding patterns in labor and investment.

Domestic labor market distortions Figure 3 reports the estimated labor market distortions τ^h (right panel) and per capita hours worked (left panel). Recall that labor market distortions are identified from the first order condition relating consumption, the marginal product of labor, and hours worked in Equation 10. Recalling the normalization of the leisure preference parameter, a value of the labor wedge that is greater than zero is equivalent to a tax on labor income, and reflects employment levels lower than predicted by the model with a distortion that is equal to zero; a value less than zero identifies relatively high employment, which is interpreted as a subsidy to labor. Note that a value of 0.4, for example, denotes a 40 percent tax rate on labor 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 product 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

Figure 3: Hours Worked and Labor Market Distortions

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 recovers quantitatively large movements in distortions to labor markets that plausibly 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. 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 23%, 62%, and 139% higher for the U.S., Europe and the rest of the world, respectively, as compared with its volatility between 1973 and 2006.

4.2 International Capital Market Distortions

The evolution of impediments to international capital mobility τ^B is depicted in the right panel of Figure 5. Since these distortions are constructed as relative to the rest of the world, the figure shows

Figure 4: Domestic Capital Market Distortions

those for 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) to highlight longer-term movements. The left panel of the figure shows consumption for the U.S. and Europe relative to the rest of the world, and the middle panel shows the relative per-capita consumption growth for the U.S..

The most striking feature of this graph is the very steep decline in U.S. consumption relative to the ROW. This rapid change in relative consumption is puzzling, given standard consumption-smoothing motives, which suggest that both the U.S. and the ROW would have benefited from a much less extreme pattern in consumption than what occurred. Absent impediments to intertemporal trade, it is reasonable to presume that both could have been better off. We will see that capital controls are critical for understanding this pattern, and that in their 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, preventing such a prolonged and persistent negative relative consumption for the U.S. as shown in the middle panel of Figure 5.

If we think of capital controls as having a re-distributive effect on consumption, as dictated by Equation 9, then higher values of τ^B imply that the U.S./Europe is worse off relative to the ROW, because their consumption is growing less than that of the rest of the world. This explains the positive values for τ^B that we observe in the right panel of Figure 5, as both the U.S. and Europe's consumption relative to the ROW is declining for the better first part of the period. As relative consumption growth

Figure 5: Relative Consumption and International Capital Market Distortions

for country j improves, then τ_j^B goes down.

This means that a decreasing or low τ^B encourages capital inflows and deters capital outflows, and an increasing or high τ^B discourages capital inflows and encourages capital outflows.

The figure shows that during the Bretton Woods period, both the U.S. and Europe faced capital controls that were on average preventing capital from flowing into their countries, while after 1973 τ_j^B goes down on average, changing to a negative sign, particularly in the U.S., easing out the deterrence of capital inflows and coinciding with capital flowing back in to the U.S. (see Figure 2).

Note that these capital controls are on the entire flow, and not just on the return, so they provided a significant incentive to both the U.S. and Europe to not borrow and bring in capital from developing countries, which is consistent with the Bretton Woods goal of keeping capital within developing economies to preserve economic and political stability.

We have argued throughout that we can interpret the distortions to international capital markets embedded in our model as impediments to international capital mobility. To make this case, we now assess the plausibility of our estimates of τ_j^B , by comparing them with actual policy changes affecting international capital flows at the country level. To do so we recover the τ^B 's for the U.S. and the three biggest Western European countries (U.K., France, and Germany), and identify the major policy changes aimed at affecting international capital flows at the country level. We find that our model measure of capital controls (τ^B) lines up remarkably well with the actual policies that were instituted in these countries to put capital controls in place. The rest of the section shows and discusses these results.

United States Figure 6 shows τ_U^B between 1950 and 2007. This corresponds to the dotted line in the right hand panel of Figure 5. In 1961 the U.S. Treasury's Exchange Stabilization Fund was created to deter capital outflows. The implementation of this policy coincides with a low peak in

τ_U^B which as discussed earlier reflects a deterrence of capital outflows. In the same way in 1963, an interest equalization was implemented out of concerns of capital outflows, and again it coincides with a low peak in our measure of capital controls.

In 1969, a policy that broadened the 1963 interest equalization measure, to incorporate both voluntary and mandatory foreign credit restraints, trying to discourage capital inflows, was implemented. This measure coincides with a high peak of our empirical measure which also reflects a deterrence of capital inflows. In the same way in 1971, the gold window was shut down and an import tax was imposed, again coinciding with a high peak of our empirical measure which has the same meaning as the one intended by the policy.

Figure 6: Estimated versus Implemented Capital Controls in the United States

France Figure 7 shows the recovered τ^B for France alone. In 1957 they changed the method of monetary control to credit ceilings, as they experienced an exchange rate and inflation crisis, with inflation rising to a 10 percent annual rate by late 1957. This policy was intended to prevent capital inflows by putting a cap on borrowing. This policy corresponds to a high peak in our empirical analog

which has the same type of capital control implication. In 1962 they abolished the policy of "devises-titres", which facilitated cross-border financial transactions in order to deter capital outflows. This corresponds to a low peak in our empirical estimate which also reflects a discouragement of capital outflows. In 1963 french banks cease to pay interest on all foreign deposits. This policy discourages capital inflows and happens at the time of a high peak in our empirical measure. In 1965 they prohibit interest payments on non-resident deposits and on loans by non-residents to residents, with the aim to deter capital inflows, and this policy once more coincides with a high peak of our empirical measure which also means that the model identifies a distortion that discourages capital inflows.

In 1968/69, France re-imposes outflow controls (after having liberated most capital controls in 1966), and in our model our estimate of capital controls is going down which reflects a discouragement of capital outflows. In 1969 the "devises-titres" market was re-established, making cross-border financial transactions more complicated. This in principal might encourage capital outflows but in our model 1969/70 corresponds to a low peak in τ^B which reflects impediments to capital outflows. However, its important to have in mind that our measure of capital controls reflects the net effect of all the policies that were implemented at the time, and in this particular case explicit outflow controls were re-imposed in 1968, which means that the effect of those might be stronger than that of the re-establishment of the "devises-titres" market.

In 1973 there was a tightening of capital controls to prevent speculative capital outflows, and this correctly lines up with a decrease in our τ^B . In 1974 controls on inflows, including 100% reserve requirements on new non-resident Franc deposits are implemented, causing a slight increase in τ^B . In 1982 exchange rate controls are put in place to prevent devaluation of the Franc, and as such in our model it corresponds to a low peak in our measure of capital controls which deters capital outflows. Finally in 1986 most outflow controls were lifted and this coincides with an increase for the following years in our τ^B .

Figure 7: Estimated versus Implemented Capital Controls in France

Germany Figure 8 compares the estimated versus the observed capital controls that we could find for Germany. In 1960 they imposed a Ban on interest payments on non-resident bank deposits, discouraging capital inflows, and in our empirical measure there is a positive peak reflecting the same type of measure. In 1965 they implement a measure to withhold a tax on interest income and assets held by non-residents, again deterring capital inflows. This corresponds to a very high τ^B produced by our model which also represents a deterrence of capital inflows. In 1981 they lifted all restrictions on capital inflows, which coincides with a peak in our τ^B .

In 1968 and 1977 they impose a higher reserve requirement on non-resident deposits and in 1972 they required banks to deposit a percentage of increase in their foreign liabilities at 0% interest within the Bundesbank. These are all policies that deter capital inflows, but our model did not identify them as such.

Figure 8: Estimated versus Implemented Capital Controls in Germany

United Kingdom Figure 9 compares our empirical estimate of τ^B with the policies implemented in the United Kingdom to impede international capital mobility. In 1954 they lifted restrictions on British Banks operating in the forward exchange market. In 1955 they achieved external current account convertibility; raised interest rates sharply in response to confidence crisis and domestic inflationary pressure. In 1957 they introduced new capital controls in response to a threat to drain on reserves, which would be aimed at preventing capital outflows, and it coincides with a low peak in our τ^B . In 1971 financial institutions are prohibited from accepting deposits or loans from non-residents. This is a direct ban on both inflows (deposits) and outflows (loans), so it is impossible to tell in which direction our empirical measure should move. Same as in 1979 when they abolished all exchange and capital controls, it may or may not be a wash and there is no way of knowing.

Figure 9: Estimated versus Implemented Capital Controls in the United Kingdom

To conclude, with very few exceptions, our model estimates of the impediments to international capital mobility or capital controls, line up remarkably well with the actual policies that were implemented by the most important countries in our sample. Because of this we believe that our estimated τ^B 's are a good measure of capital controls and as such we can use them to run counterfactual experiments to better understand the effects of these controls on fundamentals during and after the Bretton Woods era.

In the following section, we show what would have happened to capital flows, consumption, hours worked, investment and welfare in the absence of these capital controls and all capital market imperfections that were implemented during and after Bretton Woods. In other words we show a counterfactual exercise to see what would have happened to the world economy over time by setting $\tau^B = 0$.

5 The impact of Capital Controls and imperfections on the world economy and welfare

In this section we assess the effect of Bretton Woods as a capital control system, and international capital market impediments after Bretton Woods, by running a counterfactual exercise where we shut down the international distortions for the U.S. and Europe, by setting $\tau^B = 0$, and re-solve the model so that agent expectations reflect the assumptions of the counterfactual experiment. This experiment thus quantifies what would have happened had a perfectly open system of international borrowing and lending been in place after World War II. Our thought experiment here is to presume that had a free system been in place after World War II, it would have remained throughout the postwar period.

This experiment studies the positive and normative effects of the counterfactual of having perfect capital mobility between 1950-2010 among these three regions. Our thought experiment is to consider Bretton Woods as the source of international capital market imperfections, as identified by the international distortion, between 1950 and 1973. We also remove these distortions afterwards, so the experiment represents what would have happened had there been no distortions to international capital flows during this 60 year period.

Because our capital controls measure is directly identified off of relative consumption, when we set it to zero, this implies a particular path for consumption under the counterfactual. Figure 10 shows this path.

Figure 10: Counterfactual Relative Consumption

Figure 11: The World Without Bretton Woods

(a) Consumption

(b) Output

(c) Hours Worked

(d) Capital

(e) Net Exports/GDP

Note that the path of consumption under the counterfactual both for the U.S. and Europe implies higher consumption than under the benchmark for both regions (with the exception of the first decade in Europe). In the model, a region or country can achieve higher consumption by either increasing

production, or by importing resources (capital inflows). The way they achieve that increase will be determined by the behavior of the other distortions that remain in domestic markets.

Figure 11 shows the results of the counterfactual. We can see that capital would have moved 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 distortion 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 labor market distortions. As shown in the right panel of Figure 3, Europe has a labor market friction 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 market distortion prevents capital from flowing into Europe as labor is scarce, which in turn depresses the productivity of capital. This result is consistent with what we have found in our previous work (see Ohanian, Restrepo-Echavarria, and Wright (2018)).

We find that these controls have very large welfare affects. Table 4 shows the welfare effects of the impediments to international capital flows that were instituted during and after the Bretton Woods era from a consumption equivalent perspective. Europe had a perpetual consumption-equivalent welfare benefit of about 1.3 percent, and the ROW had about 4.5 percent higher welfare in consumption-equivalent units. In contrast, we find that U.S. welfare was about 4.5 percent lower in consumption equivalent units under Bretton Woods.

To understand why setting the international wedge terms to zero raises U.S. welfare, but reduces ROW welfare, recall that in the pseudo-social planner's problem the negative of the international distortions ($-\tau_j^B$) are approximately equal to the innovation in the planner's Pareto weight. Thus, reducing $-\tau_U^B$ corresponds to an increase in the planner's Pareto weight for the U.S., which shifts resources from the ROW to the U.S., resulting in higher U.S. consumption and lower US labor supply, and lower ROW consumption and higher ROW labor supply.

The positive innovation to the US Pareto weight in the pseudo planner's problem is equivalent to a wealth transfer from the ROW to the US in the decentralized economy.

The U.S. is significantly worse off under Bretton Woods. This begs the question of why the U.S. had promoted these controls in the first place, which we discuss in the following section.

Table 4: Welfare Effects of Bretton Woods

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

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 speculation²:

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

²International 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](#).

banking panic, related panics in Germany and in the U.S. This led White to write as follows³:

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, 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 wrote⁴:

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

³International 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.

⁴Helleiner, 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.

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 writes⁵:

“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 ‘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) argues⁶:

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

⁵Helleiner, E. (2014). *Forgotten foundations of Bretton Woods: International development and the making of the postwar order*. Cornell University Press, p. 43.

⁶Helleiner, E. (2014). *Forgotten foundations of Bretton Woods: International development and the making of the postwar order*. Cornell University Press, p. 12.

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 Summary and Conclusion

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 extremely difficult challenges associated with trying to directly measure these controls.

We find that 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. 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 appears to be not in its' best interest, and instead chose to support Europe and the ROW? We find this anomaly is consistent with the the U.S.'s broader goals of preserving political and economic stability in ally (Western and Northern Europe, Australia, New Zealand, Canada) and developing countries (Asia, Latin America). Having just fought World War II, and anticipating the probability of future military involvements, the US 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 may damage allied and developing countries.

This suggests viewing capital controls as an investment in maintaining US foreign interests and geopolitical stability. This view aligns with the expensive military involvements after World War II, including the Korean War, the Vietnam War, the Cold War, and smaller interventions in Latin

America and the Middle East.

More broadly, these findings 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. international economic policies since World War II.

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APPENDIX

Appendix A: Model Solution and Computation

In this appendix 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

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

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 $T_t^{PSPP} = \sum_j \chi_{jt}^I (X_{jt} - Y_{jt})$), 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

$$\ln \chi_{jt+1}^H = (1 - \rho_j^h) \ln \chi_{jSS}^H + \rho_j^h \ln \chi_{jt}^H + \sigma_j^H \varepsilon_{jt+1}^H, \quad (18)$$

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

$$\chi_{jSS}^H = 1 / (1 - \tau_{jSS}^h),$$

$$\begin{aligned}\rho_j^H &= \rho_j^h, \\ \sigma_j^H &= \sigma_j^h.\end{aligned}$$

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

$$\ln \chi_{jt+1}^C = (1 - \rho_j^C) \ln \chi_{jSS}^C + \rho_j^C \ln \chi_{jt}^C + \varepsilon_{jt+1}^C,$$

with the process for ε_{jt}^C assumed to be autoregressive and of the form

$$\varepsilon_{jt+1}^C = \rho_j^{\varepsilon^C} \varepsilon_{jt}^C + \sigma_j^{\varepsilon^C} \epsilon_{jt+1}^{\varepsilon^C},$$

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

$$\begin{aligned}1 - \rho_j^C &= \frac{\psi_{j1}}{1 + \psi_{j1}}, \\ \chi_{jSS}^C &= \psi_{j0}, \\ \rho_j^{\varepsilon^C} &= \frac{\rho_j^B}{1 + \psi_{j1}}, \\ \sigma_j^{\varepsilon^C} &= \frac{\sigma_j^B}{1 + \psi_{j1}}.\end{aligned}$$

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

$$\ln \left(\frac{\chi_{jt+1}^I}{\chi_{jt}^I} \right) = (1 - \rho_j^I) \ln \left(1 + g_{jSS}^I \right) - \ln \left(\frac{\chi_{jt+1}^C}{\chi_{jt}^C} \right) + \rho_j^I \ln \left(\frac{\chi_{jt}^I}{\chi_{jt-1}^I} \frac{\chi_{jt}^C}{\chi_{jt-1}^C} \right) + \sigma_j^{\chi^I} \varepsilon_{jt+1}^I,$$

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

$$\begin{aligned}\rho_j^I &= \rho_j^K, \\ 1 + g_{jSS}^I &= 1 - \tau_{jSS}^K \\ \sigma_j^{\chi^I} &= \sigma_j^K.\end{aligned} \tag{19}$$

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. This 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

$$C_{jt} : \beta^t \chi_{jt}^C \frac{N_{jt}}{C_{jt}} = \lambda_t^{PSPP}, \quad (20)$$

$$h_{jt} : \beta^t \chi_{jt}^C \chi_{jt}^H \psi h_{jt}^\gamma = \lambda_t^{PSPP} (1 - \alpha) \frac{Y_{jt}}{h_{jt} N_{jt}} \quad (21)$$

$$K_{jt+1} : \mu_{jt}^{PSPP} = E \left[\lambda_{t+1}^{PSPP} \chi_{jt+1}^I \alpha \frac{Y_{jt+1}}{K_{jt+1}} + \mu_{jt+1}^{PSPP} \left(1 - \delta - \phi \left(\frac{X_{jt+1}}{K_{jt+1}} \right) + \phi' \left(\frac{X_{jt+1}}{K_{jt+1}} \right) \frac{X_{jt+1}}{K_{jt+1}} \right) \right] \quad (22)$$

$$X_{jt} : \lambda_t^{PSPP} \chi_{jt}^I = \mu_{jt}^{PSPP} \left(1 - \phi' \left(\frac{X_{jt}}{K_{jt}} \right) \right) \quad (23)$$

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 (20). 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

$$\lambda_{jt}^{HH} = \frac{\lambda_t^{PSPP}}{\chi_{jt}^C}. \quad (24)$$

Likewise, the FOC of the PSPP with respect to hours (21) can be compared with the corresponding FOC of the households problem from the CEP

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

Hence, the two conditions are equivalent iff

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

But imposing (24), we can see that the conditions will be equivalent if

$$W_{jt} = (1 - \alpha) \frac{Y_{jt}}{h_{jt} N_{jt}}, \quad (25)$$

$$1 - \tau_{jt}^h = \frac{1}{\chi_{jt}^H}. \quad (26)$$

Note that (25) implies that the FOC in hours for the firm producing the consumption good in the CEP is now satisfied. Moreover, given assumption (18), the derived process for $1 - \tau_{jt}^h$ satisfied the law of motion (6) from the CEP because

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

becomes

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

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 (15) from the CEP problem with $\varepsilon_{jt+1}^C = \ln (1 - \tau_{jt+1}^{*B})$.

The FOC with respect to capital from the PSPP (22) combined with the FOC with respect to investment (23) 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

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

we can see that the two will be equivalent if

$$\begin{aligned} r_{jt+1}^K &= \alpha \frac{Y_{jt+1}}{K_{jt+1}}, \\ P_{jt}^K &= \frac{1}{1 - \phi' \left(\frac{X_{jt}}{K_{jt}} \right)}, \\ P_{jt+1}^{*K} &= \frac{1 - \delta - \phi \left(\frac{X_{jt+1}}{K_{jt+1}} \right) + \phi' \left(\frac{X_{jt+1}}{K_{jt+1}} \right) \frac{X_{jt+1}}{K_{jt+1}}}{1 - \phi' \left(\frac{X_{jt+1}}{K_{jt+1}} \right)}, \\ 1 - \tau_{jt+1}^K &= \frac{\chi_{jt+1}^C}{\chi_{jt}^C} \frac{\chi_{jt+1}^I}{\chi_{jt}^I}, \end{aligned} \tag{27}$$

where in the last line we substituted from (24). 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

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

so that after substituting for (27) and imposing the restrictions in (19) we obtain the evolution equation for the capital wedge in the CEP

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

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 2.1 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

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

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

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

For the household budget constraint we get

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

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

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

Noting that

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

we let

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

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 $z_t k_{jt+1}$ using x_{jt} units of deferred consumption and k_{jt} units of the old capital good. Their objective function is

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

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

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

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

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

From the labor-leisure condition we get

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

From the Euler equation in physical capital we get

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

After substituting for λ^{CE} we obtain

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

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

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

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

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

which is equivalent to maximizing

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

The resource constraint becomes

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

while the capital evolution equation is

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

The first order conditions of this problem are

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

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

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

Imposing the “equilibrium” restriction on the wedges and additive shock yields

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

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

$$1 + r_{ss}^W = (1 - \tau_{jss}^K) \left(\alpha \left(\frac{Y_j}{K_j} \right)_{ss} + 1 - \delta \right)$$

which pins down the capital to output ratio as

$$\frac{K_{jss}}{Y_{jss}} = \alpha \frac{1}{\frac{1+r_{ss}^W}{1-\tau_{jss}^K} - (1-\delta)}.$$

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

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

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 balanced 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 United 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. Data on exchange rates per dollar spans the years 1950 to 2008. The country-level data was not available from a single source, thus, it was obtained from different sources. Namely, the OECD, the World Development Indicators, and the Penn World Tables.

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.

We proceed in several steps to create the regional exchange rates. First, we use data on each country's consumption across time, along with total yearly consumption by region. We then calculate the following weight for each country j : $w_{jt} = c_{jt} / \sum_{j \in R} c_{jt}$, where the denominator represents regional consumption, such that $R \in \{EUR, RoW\}$. Finally, we calculate the exchange rate for each region, as follows: $\sum_{j \in R} w_{jt} e_j$, where e_j is the real exchange rate between country j and the U.S.

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.

Rest of the World

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 popu-

lation 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.
6. 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.
7. 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.
8. 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.
9. 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.
10. 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.
11. 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.
12. 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).

13. Canada. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
14. New Zealand. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
15. Iceland. NIPA and population data are from the OECD. Hours worked were taken from GGDC.

Europe

1. Austria. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
2. Belgium. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
3. Denmark. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
4. France. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
5. Germany. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
6. Greece. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
7. Italy. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
8. Luxembourg. NIPA and population data are from the OECD. Hours worked were taken from GGDC back until 1958.
9. Netherlands. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
10. Norway. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
11. Portugal. NIPA and population data are from the OECD. Hours worked were taken from GGDC back until 1956.
12. Spain. NIPA and population data are from the OECD. Hours worked were taken from GGDC back until 1954.
13. Sweden. NIPA and population data are from the OECD. Hours worked were taken from GGDC back until 1959.
14. Switzerland. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
15. United Kingdom. NIPA and population data are from the OECD. Hours worked were taken from GGDC.

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 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

$$CA_{jt}^1 = B_{jt+1} - B_{jt},$$

so that, recalling also that

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

we can write the current account as

$$CA_{jt}^1 = NX_{jt} + B_{jt+1} - E_t[q_{t+1}B_{jt+1}],$$

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

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

The end-of-period definition is

$$\begin{aligned} CA_{jt}^2 &= E_t[q_{t+1}B_{jt+1}] - E_{t-1}[q_t B_{jt}] \\ &= NX_{jt} + B_{jt} - E_{t-1}[q_t B_{jt}]. \end{aligned}$$

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:

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

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

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

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

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

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

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

as

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

Then we have a fourth measure of the current account:

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

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.