Online Appendix: Bad Investments and Missed Opportunities? Postwar Capital Flows to Asia and Latin America

Lee E. Ohanian*
Paulina Restrepo-Echavarria†
Mark L. J. Wright‡

May 14, 2018

Appendix A: Model Solution and Computation

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

The Pseudo Social Planners Problem

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

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

subject to a world resource constraint for each state and date

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

*UCLA, NBER and Hoover Institution, Stanford University, 405 Hilgard Avenue Los Angeles, CA 90089, ohanian@econ.ucla.edu

†Federal Reserve Bank of St. Louis, One Federal Reserve Bank Plaza, Broadway and Locust St., St. Louis MO 63166, paulinares@me.com

‡Federal Reserve Bank of Minneapolis, and NBER, 90 Hennepin Avenue, Minneapolis MN 55401, markwright@minneapolisfed.org.

The authors thank Patrick Kehoe as well as numerous seminar participants, the editor, and three anonymous referees for helpful comments, and Maria Alejandra Arias, Salomon Garcia, and Brian Reinbold for outstanding research assistance. The views expressed in this paper are those of the authors and do not necessarily reflect the views of the Federal Reserve Banks of Minneapolis and St. Louis or the Federal Reserve System.

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

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

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

$$\begin{aligned} \chi_{jSS}^H &= 1/\left(1 - \tau_{jSS}^h\right), \\ \rho_j^H &= \rho_j^h, \\ \sigma_j^H &= \sigma_j^h. \end{aligned}$$

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

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

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

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

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

$$\begin{aligned} \rho_j^I &= \rho_j^K, \\ 1 + g_{jSS}^{\chi^I} &= 1 - \tau_{jSS}^K \\ \sigma_j^{\chi^I} &= \sigma_j^K. \end{aligned} \tag{2}$$

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

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

$$C_{jt} \quad : \quad \beta^t \chi_{jt}^C \frac{N_{jt}}{C_{jt}} = \lambda_t^{PSPP}, \tag{3}$$

$$h_{jt} \quad : \quad \beta^t \chi_{jt}^C \chi_{jt}^H \psi h_{jt}^{\gamma} = \lambda_t^{PSPP} (1-\alpha) \frac{Y_{jt}}{h_{jt} N_{jt}} \tag{4}$$

$$\begin{aligned} K_{jt+1} \quad : \quad \mu_{jt}^{PSPP} = E \Bigg[& \lambda_{t+1}^{PSPP} \chi_{jt+1}^I \alpha \frac{Y_{jt+1}}{K_{jt+1}} \\ & + \mu_{jt+1}^{PSPP} \left(1 - \delta - \phi\left(\frac{X_{jt+1}}{K_{jt+1}}\right) + \phi'\left(\frac{X_{jt+1}}{K_{jt+1}}\right) \frac{X_{jt+1}}{K_{jt+1}} \right) \Bigg] \end{aligned} \tag{5}$$

$$X_{jt} \quad : \quad \lambda_t^{PSPP} \chi_{jt}^I = \mu_{jt}^{PSPP} \left(1 - \phi'\left(\frac{X_{jt}}{K_{jt}}\right) \right) \tag{6}$$

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 (3). The corresponding FOC of the households problem from the CEP is

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

and so the two conditions are equivalent iff

$$\lambda_{jt}^{HH} = \frac{\lambda_t^{PSPP}}{\chi_{jt}^C}. \tag{7}$$

Likewise, the FOC of the PSPP with respect to hours (4) can be compared with the corresponding FOC of the households problem from the CEP

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

Hence, the two conditions are equivalent iff

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

But imposing (7), we can see that the conditions will be equivalent if

$$W_{jt} = (1-\alpha)\frac{Y_{jt}}{h_{jt}N_{jt}}, \tag{8}$$

$$1-\tau_{jt}^{h} = \frac{1}{\chi_{jt}^{H}}. \tag{9}$$

Note that (8) implies that the FOC in hours for the firm producing the consumption good in the CEP is now satisfied. Moreover, given assumption (1), the derived process for $1-\tau_{jt}^{h}$ satisfied the law of motion (**??**) from the CEP because

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

becomes

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

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

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

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

Under our normalization and parameter restrictions, this implies

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

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

The FOC with respect to capital from the PSPP (5) combined with the FOC with respect to investment (6) can be rearranged to yield

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

Comparing this with the FOC in capital from the households problem

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

we can see that the two will be equivalent if

$$r_{jt+1}^{K} = \alpha\frac{Y_{jt+1}}{K_{jt+1}},$$

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

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

$$1-\tau_{jt+1}^{K} = \frac{\chi_{jt+1}^{C}}{\chi_{jt}^{C}}\frac{\chi_{jt+1}^{I}}{\chi_{jt}^{I}}, \tag{10}$$

where in the last line we substituted from (7). The first of these conditions is simply the FOC in capital for the firm producing the consumption good in the CEP, while the second and third are the optimality conditions for the firm producing the capital good.

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

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

so that after substituting for (10) and imposing the restrictions in (2) we obtain the evolution equation for the capital wedge in the CEP

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

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

The Intensive Form Problem

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

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

so that

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

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

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

Competitive Equilibrium Problem

Recall that the problem of country j is to maximize

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

subject to a flow budget constraint for each state and date

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

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

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

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

which is an affine transformation of

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

For the household budget constraint we get

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

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

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

Noting that

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

we let

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

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

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

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

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

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

From the labor-leisure condition we get

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

From the Euler equation in physical capital we get

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

After substituting for λ^{CE} we obtain

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

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

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

Pseudo Social Planners Problem

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

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

which is equivalent to maximizing

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

The resource constraint becomes

$$\begin{aligned} & \sum_j\left\{c_{jt}+\chi^I_{jt}x_{jt}+g_{jt}\right\} \\ = & \sum_j \chi^I_{jt}y_{jt}+t^{SP}_t \\ = & \sum_j \chi^I_{jt}a_{jt}\pi_t k^{\alpha}_{jt}\left(h_{jt}n_{jt}\eta_t\right)^{1-\alpha}+t^{SP}_t, \end{aligned}$$

while the capital evolution equation is

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

The first order conditions of this problem are

$$\begin{aligned} c_{jt} &: \beta^t\left(\prod_{s=0}^{t}\eta_s\right)\chi^C_{jt}\frac{1}{c_{jt}}n_{jt}=\lambda^{SP}_t, \\ h_{jt} &: \beta^t\left(\prod_{s=0}^{t}\eta_s\right)\chi^C_{jt}\chi^I_{jt}\chi^H_{jt}\psi h^{\gamma}_{jt}n_{jt}=\lambda^{SP}_t\left(1-\alpha\right)\chi^I_{jt}a_{jt}\pi_t n_{jt}\eta_t k^{\alpha}_{jt}\left(h_{jt}n_{jt}\eta_t\right)^{-\alpha} \\ k_{jt+1} &: \mu^{SP}_{jt}z_t=E\left[\lambda^{SP}_{t+1}\chi^I_{jt+1}\alpha a_{jt+1}\pi_{t+1}k^{\alpha-1}_{jt+1}\left(h_{jt+1}n_{jt+1}\eta_{t+1}\right)^{1-\alpha}+\right. \\ & \left.\mu^{SP}_{jt+1}\left(1-\delta-\phi\left(\frac{x_{jt+1}}{k_{jt+1}}\right)+\phi'\left(\frac{x_{jt+1}}{k_{jt+1}}\right)\frac{x_{jt+1}}{k_{jt+1}}\right)\right], \\ x_{jt} &: \lambda^{SP}_t\chi^I_{jt}=\mu^{SP}_{jt}\left(1-\phi'\left(\frac{x_{jt}}{k_{jt}}\right)\right), \end{aligned}$$

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

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

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

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

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

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

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

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

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

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

Substituting gives

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

The intensive form analog is then

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

so that

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

which after recursively substituting becomes

$$\begin{aligned} b_{jt} &= -E_t\left\{nx_{jt} + \beta\eta_{t+1}\frac{c_{Rt}}{c_{Rt+1}}nx_{jt+1} + \beta^2\eta_{t+1}\eta_{t+2}\frac{c_{Rt}}{c_{Rt+2}}nx_{jt+2} + ...\right\} \\ &= -E_t\left\{\sum_{s=0}^{\infty}\beta^s\left(\prod_{r=1}^{s}\eta_{t+r}\right)nx_{jt+s}\right\}, \end{aligned} \tag{11}$$

where

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

In solving the pseudo social planners problem, we compute the solution for net foreign assets as a function of the state (which includes the pseudo social planner's international wedge) using equation (11), which allows us to numerically vary the level of the social planner's international wedge in order to keep net foreign assets constant.

The Balanced Growth Path of the Deterministic Model

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

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

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

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

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

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

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

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

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

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

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

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

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

which pins down the capital to output ratio as

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

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

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

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

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

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

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

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

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

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

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

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

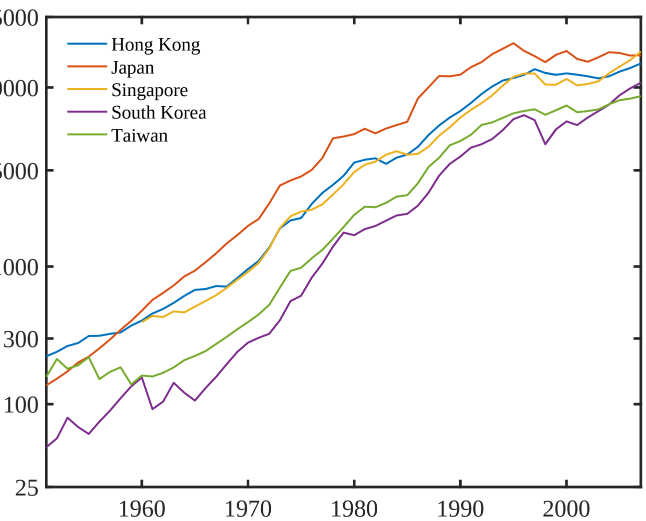
Appendix B: Data and Methods

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

Sample Definition

Our country aggregates were chosen on the basis of the similarity of their economic development paths. "Asia" is defined to be the aggregate of Japan and the four "East Asian Tigers" of Korea, Taiwan, Hong Kong, and Singapore which were the center of a great deal of attention because of their similar economic performance (see, for example, Krugman 1994 and the debate between Young 1995 and Hsieh 1999). As shown in Figure 1, which plots output per capita in constant U.S. dollars on a log scale for all five countries, their economic development paths, although by no means identical, were very similar in that they involved exceptionally strong growth.

Figure 1: Per Capita GDP in Asia



Other Asian economies were excluded on the grounds that their development proceeded differently. Most notably, as shown in Figure 2, China's rapid economic development did not begin until at least the late 1970s, while India's liberalization did not occur until the 1990s. As a consequence, they are not part of the puzzle surrounding capital flows to East Asia in the decades after the Second World War. Likewise, as shown in Figure 3, where they graphed separately to avoid clutter, the "Tiger Cub Economies" of Malaysia, Thailand, the Philippines and Indonesia also developed far less rapidly.

Figure 2: Per Capita GDP in Asia, Including China and India

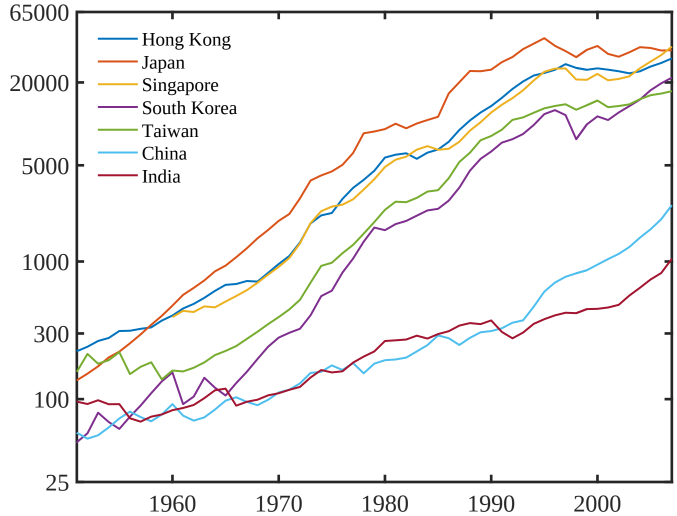
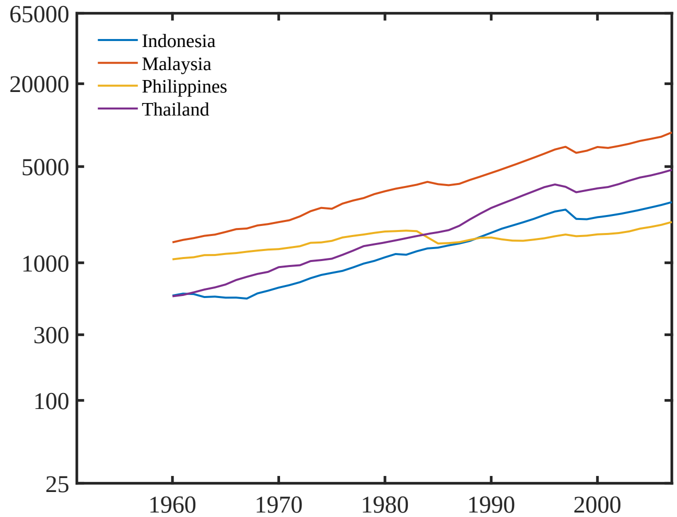
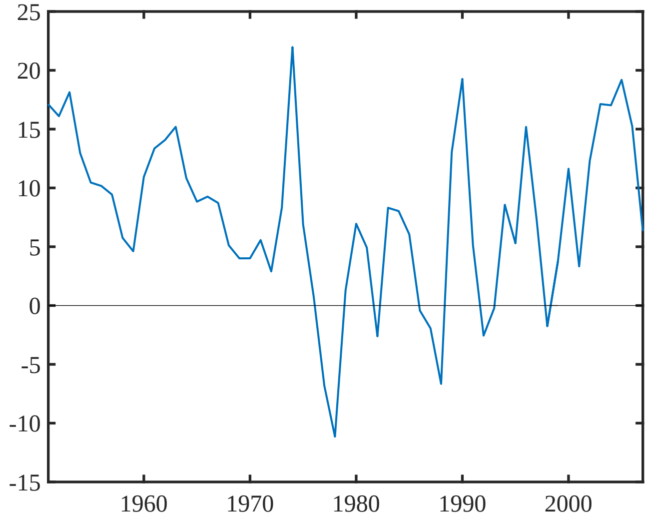


Figure 3: Per Capita GDP in the "Tiger Cub Economies"



Our Latin American aggregate was constrained by data availability to include Argentina, Brazil, Chile, Colombia, Mexico, and Peru. These six countries accounted for 82% of the GDP from the entirety of Latin American and the Caribbean in 2000 USD terms. The only Latin American country that we did not include but for which we had data was Venezuela which, as shown in Figure 4, stands apart as a major oil exporter that has run large trade surpluses during this period.

Figure 4: Net Exports in Venezuela



The rest of the world aggregates data from 22 advanced economies in North America, Europe and Oceania. The specific list of countries is: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, and the United States of America.

General Data Sources

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

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

Data Aggregation, Manipulation and Cleaning

All national accounts data were transformed to constant 2000 U.S. dollar prices. Data were aggregated by summation for each region. Net exports for the rest of the world were constructed to ensure that the world trade balance with itself was zero, and any statistical discrepancy for a region was added to government spending.

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

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

Country Specific Notes on Data

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

Asia

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

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

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

4. Singapore. Official NIPA data for Singapore first becomes available in 1960 and was taken from the WDI. Prior to 1960, NIPA estimates derived from colonial data were obtained from Sugimoto (2011). Hours worked data were taken from GGDC from 1960. Prior to 1960, we computed total hours worked from data on the employment and hours worked of laborers, shop assistants, shop clerks and industrial clerks in both public and private sector establishments as tabulated in the *Annual Report of the Labour Department* for the Colony of Singapore (1950-1956) and State of Singapore (1957-1960).

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

Latin America

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

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

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

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

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

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

Rest of the World

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

1. Australia. NIPA and population data are from the OECD. Hours worked were taken from GGDC back until 1953, and extended back to 1950 using the series in Butlin (1977).
2. Austria. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
3. Belgium. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
4. Canada. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
5. Denmark. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
6. Finland. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
7. France. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
8. Germany. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
9. Greece. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
10. Iceland. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
11. Ireland. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
12. Italy. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
13. Luxembourg. NIPA and population data are from the OECD. Hours worked were taken from GGDC back until 1958.
14. Netherlands. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
15. New Zealand. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
16. Norway. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
17. Portugal. NIPA and population data are from the OECD. Hours worked were taken from GGDC back until 1956.
18. Spain. NIPA and population data are from the OECD. Hours worked were taken from GGDC back until 1954.
19. Sweden. NIPA and population data are from the OECD. Hours worked were taken from GGDC back until 1959.
20. Switzerland. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
21. United Kingdom. NIPA and population data are from the OECD. Hours worked were taken from GGDC.
22. The United States of America. NIPA and population data are from the OECD. Hours worked were taken from GGDC.

Resulting Aggregate Data for the Three Regions

Figures 5 to 8 show plots of the data used in the estimation in natural logs for the first 3 figures (in billions of year 2000 USD) and in millions of people for population. Recall that data on the ratio of net exports to income is plotted in Figure 1 in the text, hours worked per capita are plotted in Figure 4, and that government spending was computed as a residual including any statistical discrepancy.

Figure 5: Gross Domestic Product

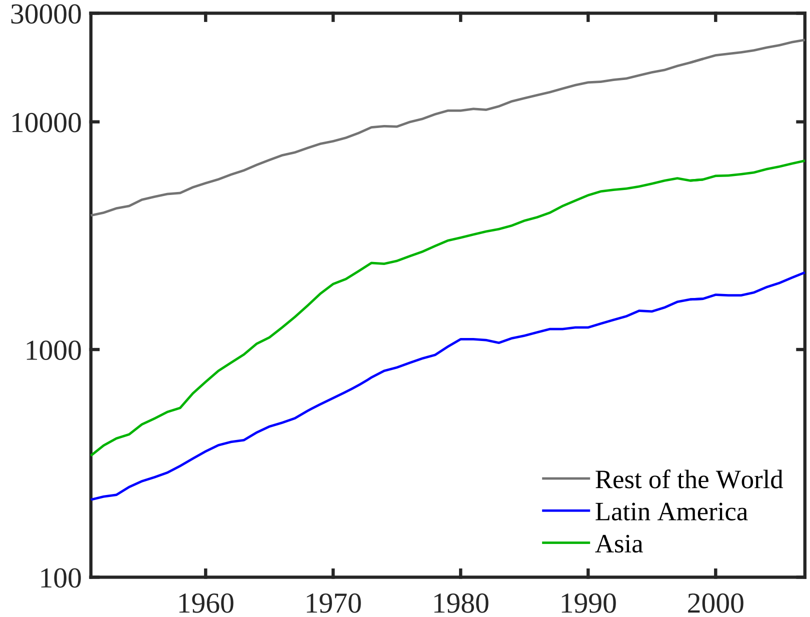


Figure 6: Consumption

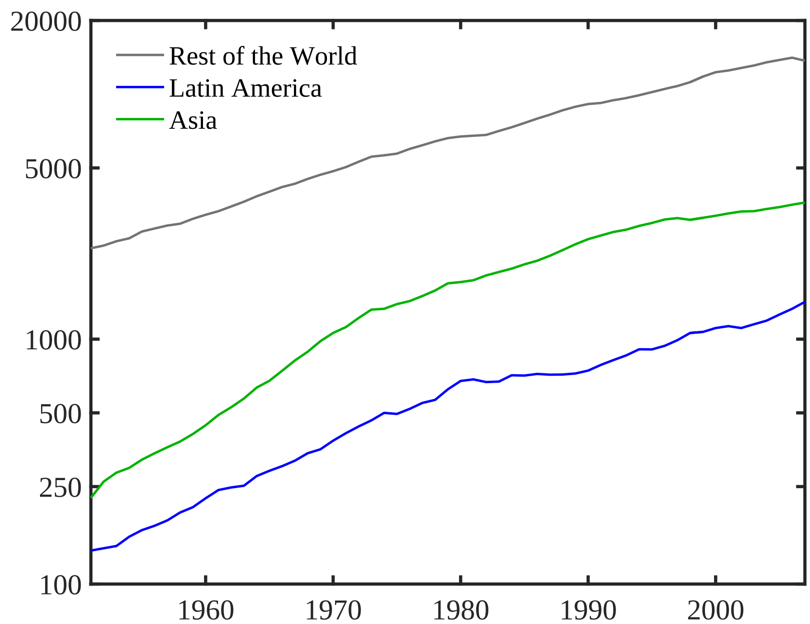


Figure 7: Investment

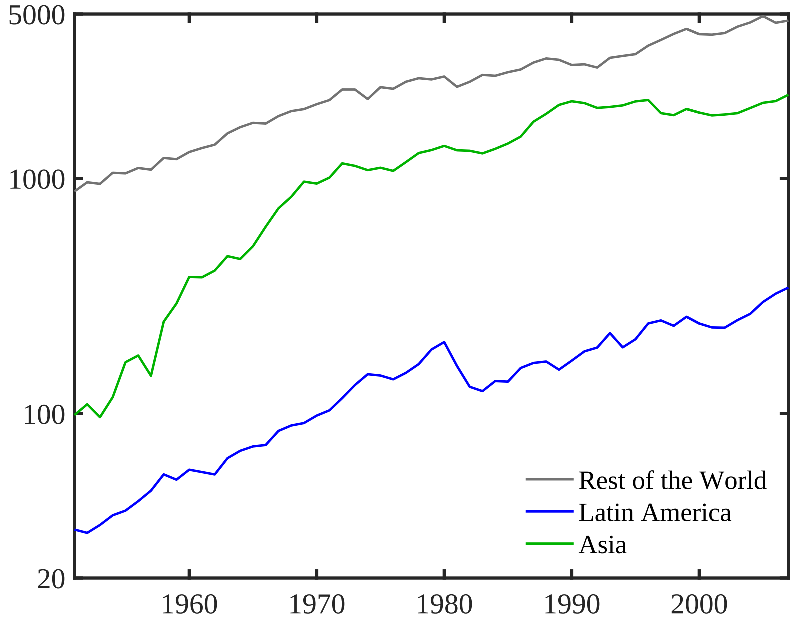
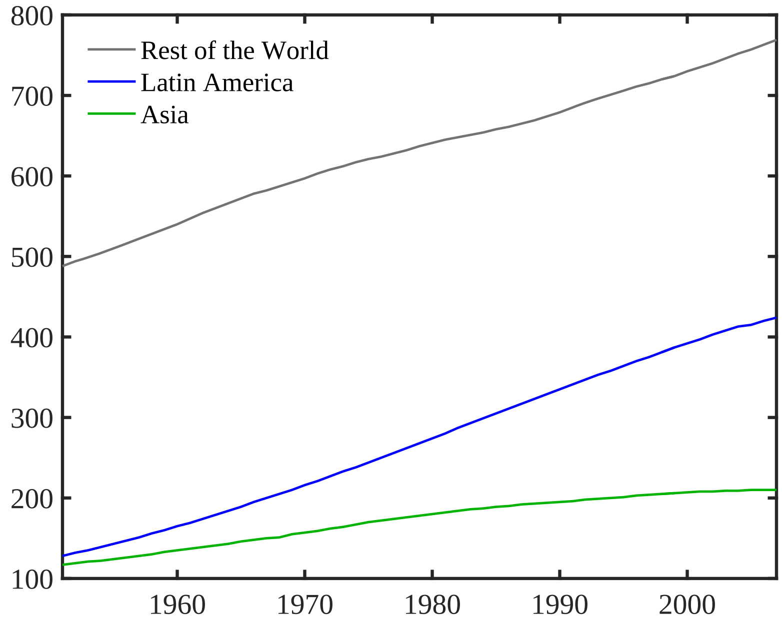


Figure 8: Population



Estimation

Figure 10 shows a plot of the prior distributions, posterior distributions and modes of the parameters estimated using Bayesian methods. From that figure it can be seen that our chosen priors are not restrictive with the estimated parameters reflecting the information contained in the data.

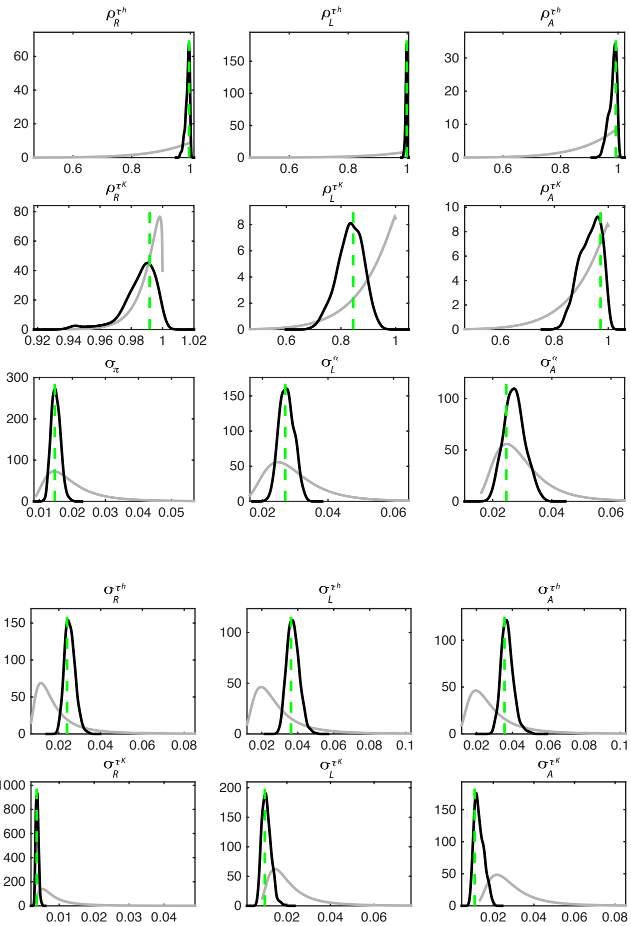
The linearized equations of the model combined with the linearized measurement equations form a state-space representation of the model. We apply the Kalman filter to compute the likelihood of the data given the model and to obtain the paths of the wedges. We combine the likelihood function $L\left(Y^{Data}|p\right)$, where p is the parameter vector, with a set of priors $\pi_0\left(p\right)$ to obtain the posterior distribution of the parameters

$\pi\left(p|Y^{Data}\right) = L\left(Y^{Data}|p\right)\pi_0\left(p\right)$. We use the Random-Walk Metropolis-Hastings implementation of the MCMC algorithm to compute the posterior distribution. Table 9 reports the prior and posterior distributions of the persistence and variance parameters of the wedges that we estimate.

Figure 9: Prior and posterior distributions of wedge parameters

Parameter	Prior			Posterior	
	Distribution	Mean	S.D.	Mean	Mode
$\rho_R^{\tau^h}$	Beta	0.90	0.09	0.99	0.99
$\rho_L^{\tau^h}$	Beta	0.90	0.09	0.99	0.99
$\rho_A^{\tau^h}$	Beta	0.90	0.09	0.98	0.99
$\rho_R^{\tau^K}$	Beta	0.99	0.01	0.98	0.99
$\rho_L^{\tau^K}$	Beta	0.90	0.09	0.83	0.84
$\rho_A^{\tau^K}$	Beta	0.90	0.09	0.93	0.97
σ_π	IGamma	0.02	0.01	0.02	0.02
σ_L^a	IGamma	0.03	0.01	0.03	0.03
σ_A^a	IGamma	0.03	0.01	0.03	0.03
$\sigma_R^{\tau^h}$	IGamma	0.02	0.02	0.02	0.02
$\sigma_L^{\tau^h}$	IGamma	0.03	0.02	0.04	0.04
$\sigma_A^{\tau^h}$	IGamma	0.03	0.02	0.04	0.04
$\sigma_R^{\tau^K}$	IGamma	0.01	0.02	0.00	0.00
$\sigma_L^{\tau^K}$	IGamma	0.02	0.02	0.01	0.01
$\sigma_A^{\tau^K}$	IGamma	0.03	0.02	0.01	0.01

Figure 10: Priors and Posteriors



Appendix C: Conceptual Issues About Measuring Capital Flows

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

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

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

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

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

The way the balance of payments is constructed, it is designed to capture transactions. It is explicitly *not* designed to capture the effect of valuation changes on a country's net foreign asset position (this has, in and of itself, led to a significant debate about how to interpret data on the balance of payments and data on net foreign assets; see the issues raised by Lane and Milesi Ferretti (2001, 2005, and 2007); Tille (2003); Higgins, Klitgaard, and Tille (2005) and Gourinchas and Rey (2007)). In addition, its ability to capture transfers such as sovereign default depends on whether the country has adopted accrual accounting standards (in which case, a debt restructuring is paired with an artificial accounting transaction) and whether it is believed that accrual accounting standards are adequate for this purpose (Sandleris and Wright (2013) and others have argued that, when a country defaults on its debts, it is better to use cash accounting concepts in evaluating their balance of payments). As a result of all these concerns, amplified by the fact that the asset structure of international finance has changed over time to emphasize more derivative securities and valuation effects have become more important in an era of floating exchange rates, confidence in the reliability and backwards comparability of balance of payments data is low, even in the absence of the measurement error noted above. The issues are well summarized by Alfaro, Kalemli-Ozcan, and Volosovych (2014) who write:

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

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

As a consequence, it is has become traditional in the literature to (1) work with models that either have a very limited asset structure (such as with bonds only or a bond and one equity), which misses much of the richness of the international asset trade but can give precise predictions for the balance of payments, or (2) to work with complete market models to focus on allocations—such as net exports—which are invariant across different decentralizations. A particularly strong statement of this position is provided by Backus, Kehoe, and Kydland (1994). This is the approach we have adopted in this paper.

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

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

The start-of-period definition is

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

so that, recalling also that

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

we can write the current account as

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

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

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

The end-of-period definition is

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

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

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

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

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

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

so that

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

we get

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

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

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

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

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

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.

Appendix D: Additional Results

Labor Market Rigidity Index and Taxes

Figure 11 shows an aggregate index for Asia and Latin America, constructed from the Labor Market Rigidity Index of Campos and Nugent (2012). The index captures the rigidity of employment protection legislation for an unbalanced panel of more than 140 countries between 1960 and 2004 based on comparisons of labor laws across countries and over time. When constructing the index, the authors focus on legislation related to: work conditions (hours worked, paid leave), employment security, termination of employment, conditions of employment (wages, contracts, personnel management), and other general provisions (labor codes and general employment acts). The index values range from 0 to 3.5, with higher values indicating more rigid employment protection laws.

For the paper, the indexes used are a weighted average of Latin American and Asian countries. The countries included in the index for Latin America are Argentina, Brazil, Chile, Colombia, Mexico, and Peru, and those included in the index for Asia are Hong Kong, Japan, Singapore, South Korea, and Taiwan. The weights used to construct the regional indexes are the relative share of GDP per capita in 1960 (the beginning of the sample period).

The figure shows that Latin America faced greater labor rigidity relative to Asia and that it increased prior to 1970, decreased between 1970 and 1985, increased again between 1985 and 1995 to fall down again. This is the same behavior of our labor wedge for Latin America.

Figure 11: Campos and Nugent Labor Market Rigidity Index for Asia and Latin America

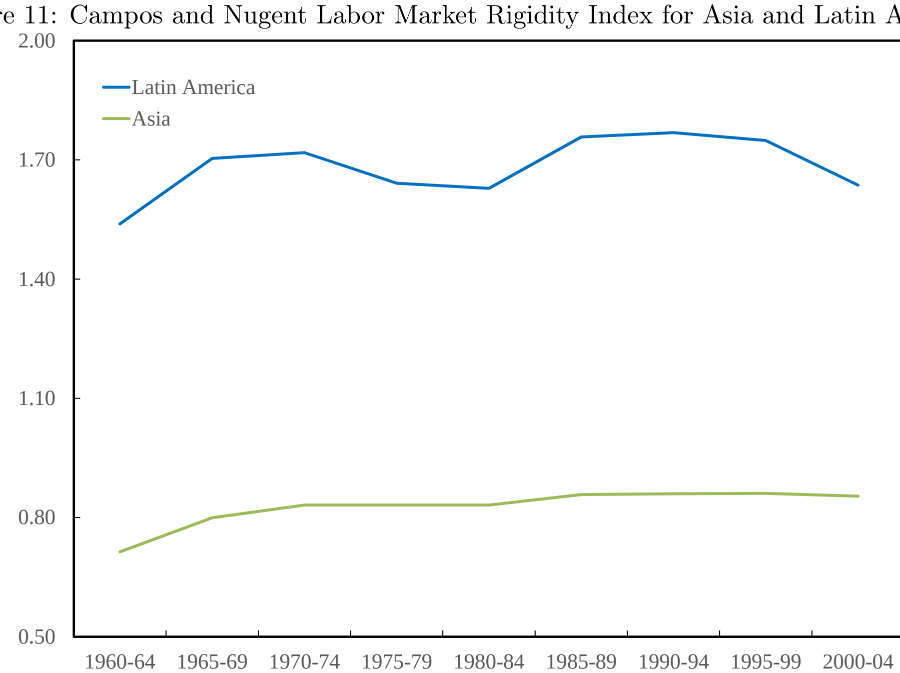
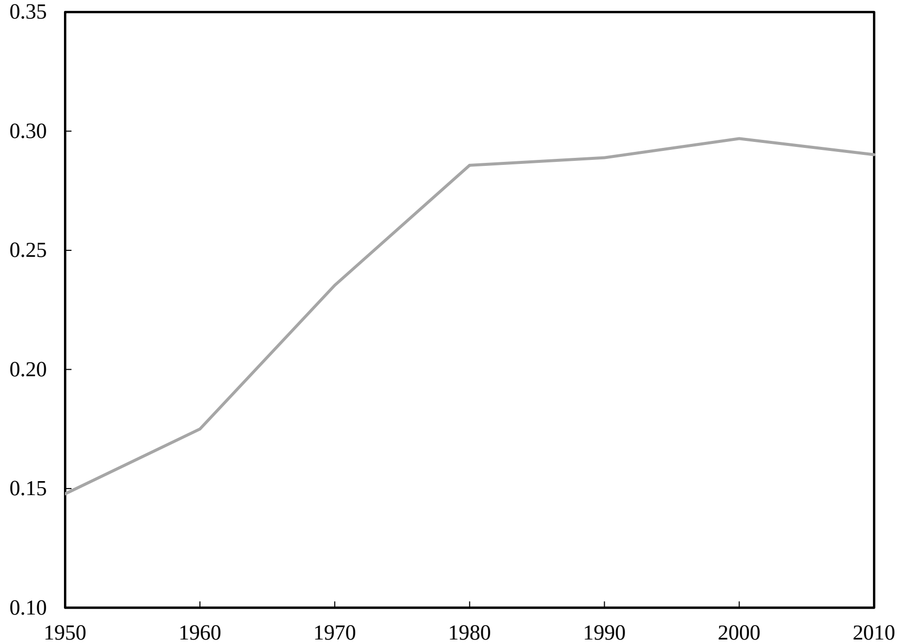


Figure 12 plots the tax wedge for European countries. The tax wedge is defined as

$$tax\,wedge = 1 - \frac{1-\tau_l}{1+\tau_c},$$

where τ_l is the labor income tax and τ_c is the consumption tax. The figure shows a weighted average using annual GDP. The countries included are Austria, Belgium, Finland, France, Germany, Italy, Netherlands, Spain, Sweden, Switzerland and the United Kingdom. As can be seen, it reflects the fact that taxes were increasing in Europe throughout the period.

Figure 12: Tax Wedge for Europe



Domestic Financial Reforms Index

Figures 13 to 15 plot the Financial Reforms Index from Abiad et al (2008) for our three regions. The index measures financial liberalization across 91 economies between 1973 and 2005 based on graded measures of seven aspects of financial sector policy: credit controls and reserve requirements, interest rate controls, entry barriers, state ownership, policies on securities markets, banking regulations, and restrictions on the capital account. The index is constructed by first assigning a raw score to each category and normalizing it to a scale of 0 to 3 (fully repressed to fully liberalized). Then, the normalized scores are combined and normalized again so each country's score is a graded index between 0 and 1.

For the paper, the financial reform index is recalculated to include only the national financial policy components, excluding the international capital flows component.

Figure 13: Domestic Financial Reforms Index for Latin America

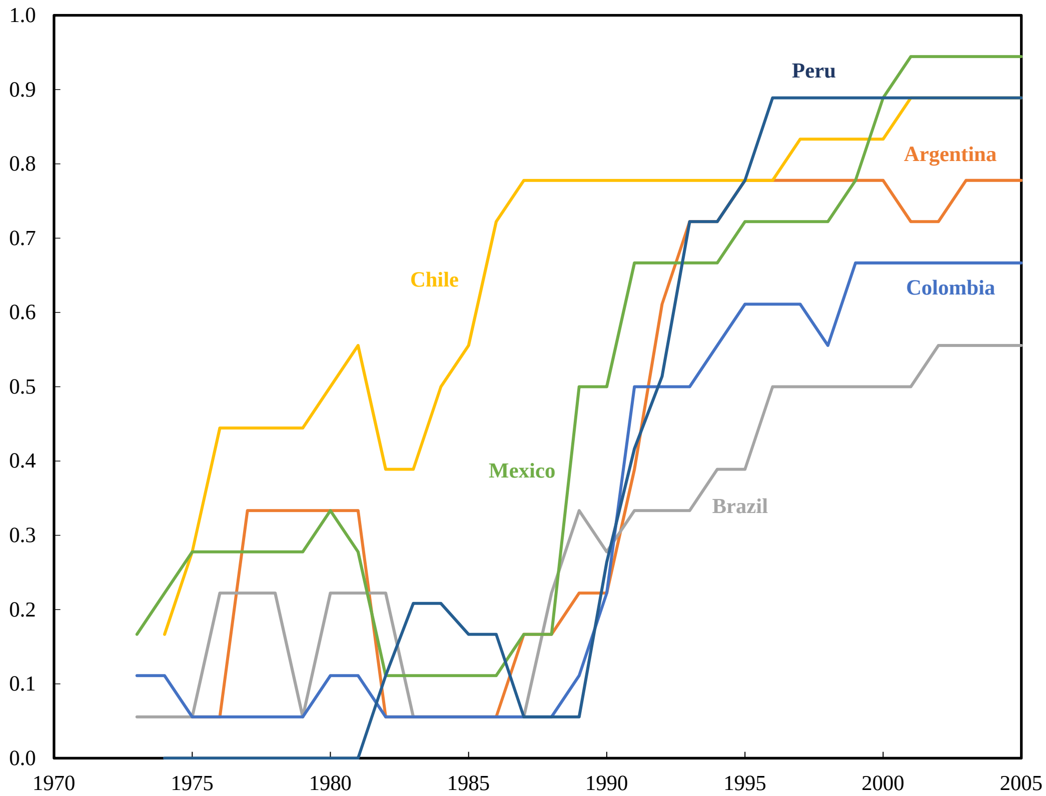


Figure 14: Domestic Financial Reforms Index for Asia

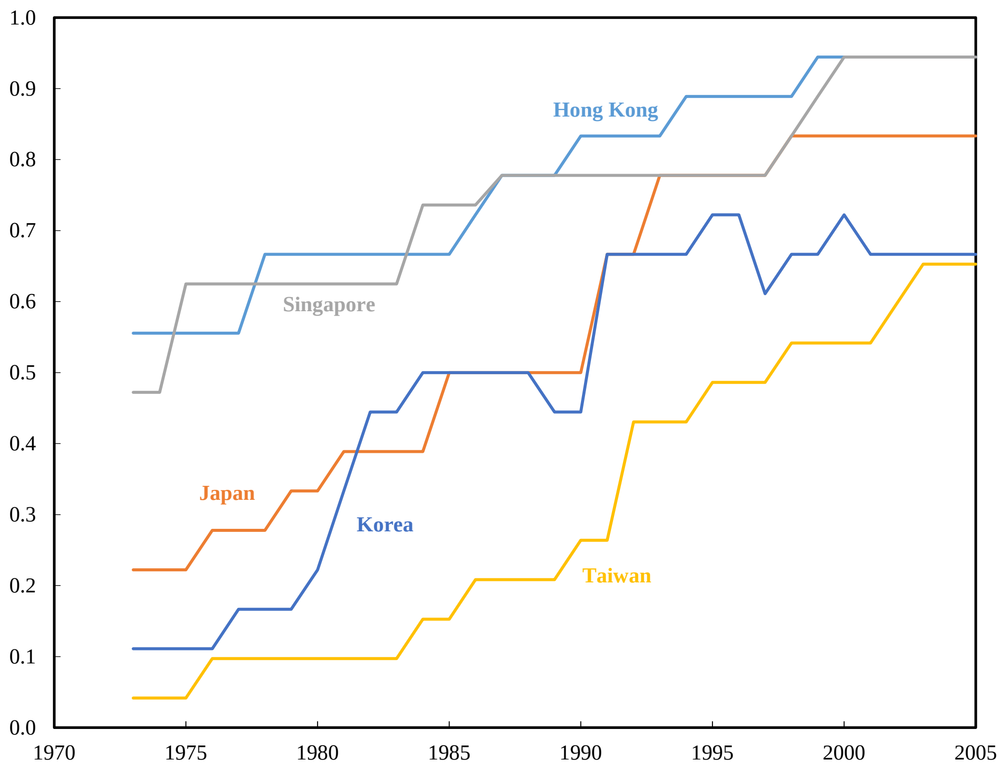
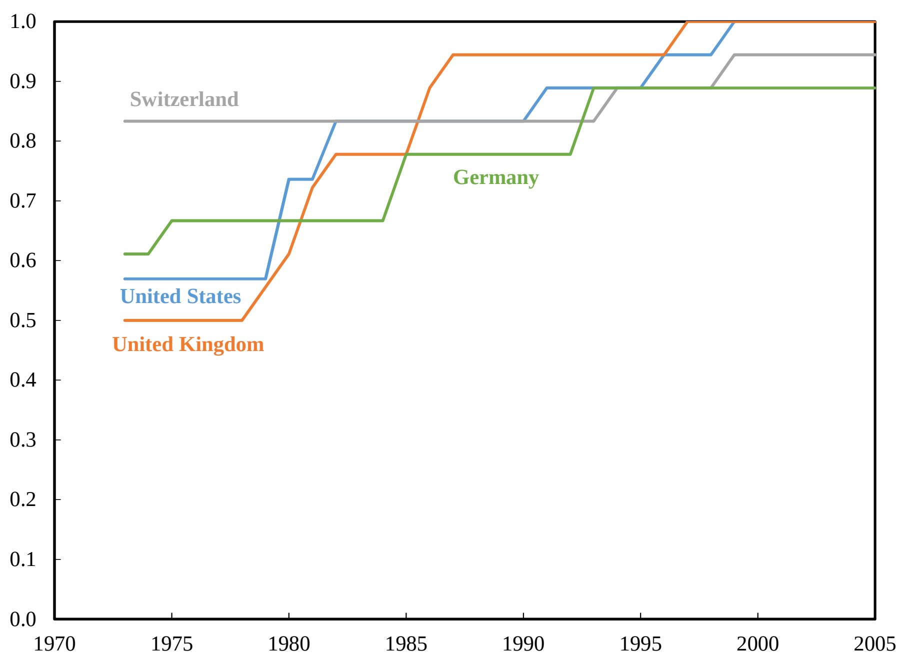


Figure 15: Domestic Financial Reforms Index for the Rest of the World



International Financial Reforms Index

Financial Openness Index from Chinn and Ito (2006). The index measures a country's degree of capital account openness for 181 countries between 1970 and 2005 based on the binary variables that identify restrictions on cross-border financial transactions from the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER). The variables included are those that indicate multiple exchange rates, restrictions on current account transactions, restrictions on capital account transactions (measured as the average of the previous 5 years), and the requirement of the surrender of export proceeds. The dummy variables are recoded so that 1 represents no capital account restrictions. The index is then constructed as the first principal component of the binary variables, so the higher index values represent a higher degree of openness.

Figure 16: International Financial Reforms Index for Latin America

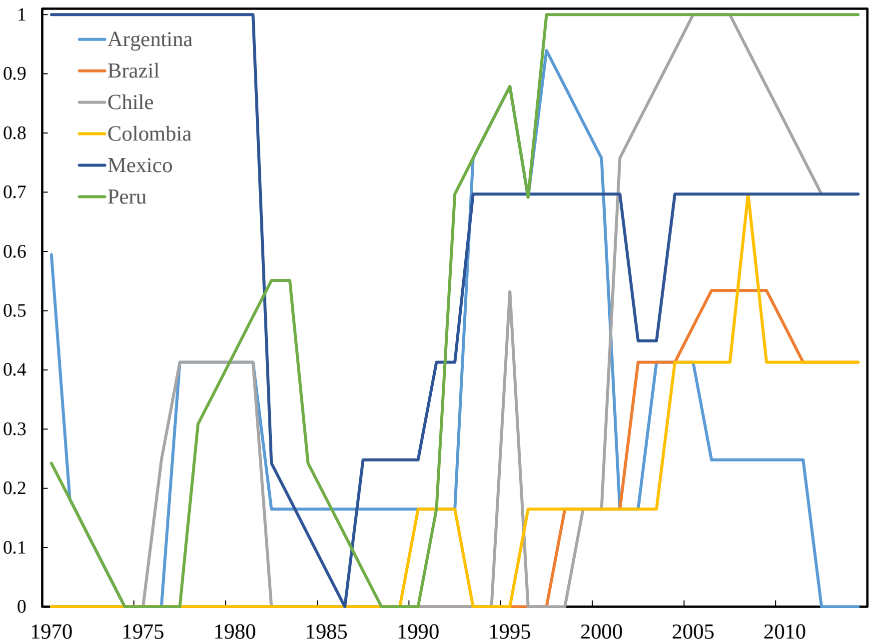


Figure 17: International Financial Reforms Index for Asia

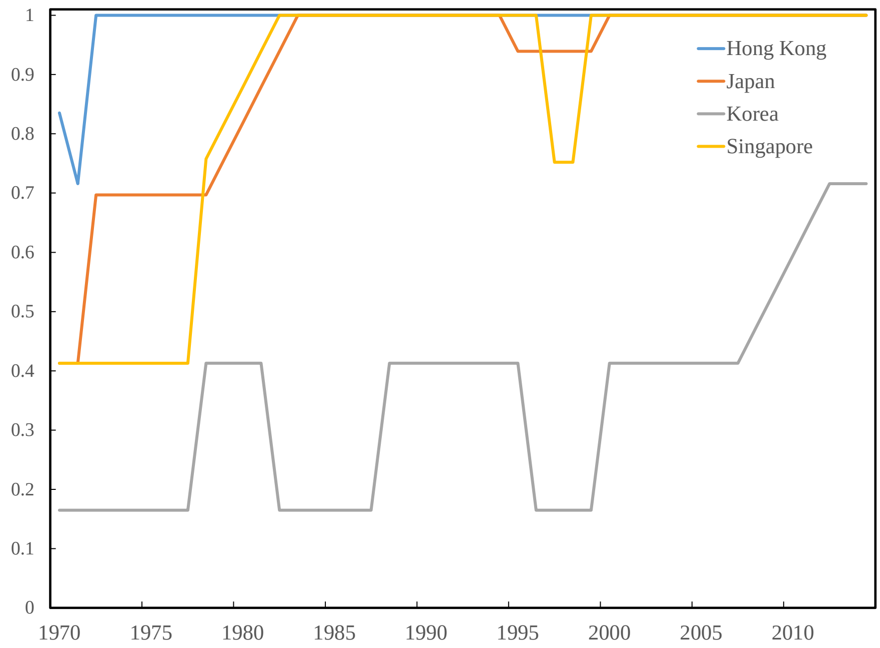
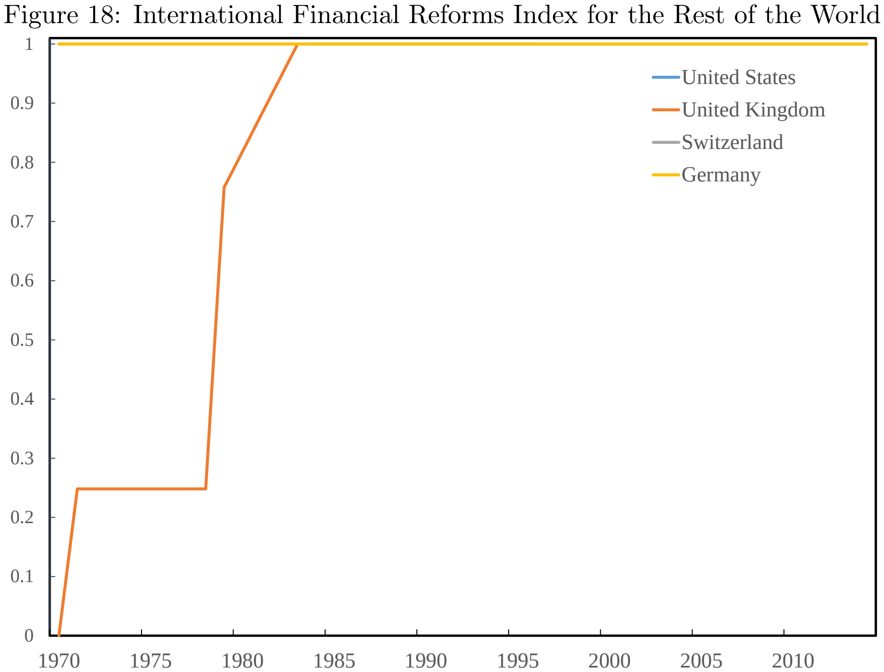


Figure 18: International Financial Reforms Index for the Rest of the World



Appendix E: More on Robustness and Extensions

Functional Forms and Parameter Values

Above we wrote down a benchmark model against which the data could be compared with a view to identifying wedges between what the model predicts and what the data show. As is conventional, and for concreteness, we interpreted these wedges as taxes and subsidies that affect the marginal optimality conditions of firms and households. In discussing our results, we compared our estimated wedges with both qualitative and quantitative indicators of taxes and factor market distortions and argued that the results were similar. That is, the interpretation of these wedges as a combinations of taxes and subsidies and no-tax distortions was reasonable.

Nonetheless, any differences between our benchmark model and the "true model" of the data generating process will also show up as wedges. One possible cause of misspecification arises from specific parameter choices that were calibrated *ex ante*, as opposed to being estimated from the data. This includes the levels of some parameters which might be viewed as controversial, as well as the assumption that the key parameters describing production and preferences across countries are the same across countries and over time. In this subsection, we illustrate how alternative assumptions about parameter values affect the identified wedges and the resulting analysis.

To preview our results, we show that, for two such parameters—the discount factor β and the preference for leisure parameter ψ—changing their values or allowing variation across countries has no effect on our results, as they serve only to scale up or down the average level of the labor and capital wedges. That is, they affect the level of the estimated wedges, but not their relative movements over time. Although the remaining calibrated parameters could conceivably play a more significant role, we show that our results vary little when two of these parameters—the output elasticity of capital α and the size of adjustment costs parameter ν—are varied within the range of estimates available in the literature.

The Discount Factor β and Preference for Leisure ψ

Rearranging the optimality conditions of the household and firms yields

$$1-\tau_{jt}^{h}=\frac{\psi}{1-\alpha}h_{jt}^{\gamma+1}\frac{C_{jt}}{Y_{jt}},$$

which shows that, given data for country j at time t on hours h_{jt}, consumption C_{jt} and output Y_{jt}, and given the Frisch elasticity of labor supply parameter γ, we can pin down the product of the labor wedge with the output elasticity of labor parameter α divided by the parameter governing the value of leisure ψ. This means that we cannot separately identify the level of the labor wedge from α and ψ, and that varying the level of α or ψ (for all countries or for any one country) will only scale up and down the level of the labor wedge. Similarly, from the Euler equation

$$1=E\left[\frac{C_{jt}}{C_{jt+1}}\frac{N_{jt+1}}{N_{jt}}\beta\left(1-\tau_{jt+1}^{K}\right)\frac{\alpha Y_{jt}/K_{jt}+P_{jt+1}^{*K}}{P_{jt}^{K}}\right],$$

it should be immediately obvious that β cannot be separately identified from the level of the capital wedge.

Thus, although changes in β and ψ will change the level of the recovered labor and capital wedges, they will not change the movement sin these wedges. Given that in our experiments we shut down movements in these wedges by equating them to their sample averages in the data, our results are unaffected by the precise levels we choose for β and ψ.

The Inter-temporal Elasticity of Substitution

In our benchmark model, we assume logarithmic preferences over consumption. This implies an inter-temporal elasticity of substitution of one. This is not only relatively standard, but turns out to have very little effect on the results of our analysis. This is intuitive: although increasing/decreasing the inter-temporal elasticity of substitution (IES) will scale down/scale up the values of our international and capital wedges, as smaller/greater wedges are necessary to explain observed consumption patterns when consumption is more/less sensitive to rates of return, this also amplifies/dampens the response of the economy when we shut these wedges down.

To see this more clearly, suppose that the IES is given by $1/\xi$ (note that, in order to preserve *both* additive separability in leisure *and* preferences that support a balanced growth path, we would need to add the appropriate trend to the marginal disutility of work). Consider first the international wedge. The "true" international wedge (ignoring the portfolio adjustment cost) is given by

$$1-\tau_{jt+1}^{B,TRUE}=\left(\frac{C_{jt+1}/N_{jt+1}}{C_{Rt+1}/N_{Rt}}/\frac{C_{jt}/N_{jt}}{C_{Rt}/N_{Rt}}\right)^{\xi}.$$

Therefore, our recovered international wedge will depart from the "true" wedge by

$$1-\tau_{jt+1}^{B}=\left(\frac{C_{jt+1}/N_{jt+1}}{C_{jt}/N_{jt}}/\frac{C_{Rt+1}/N_{Rt}}{C_{Rt}/N_{Rt}}\right)^{1-\xi}\left(1-\tau_{jt+1}^{B,TRUE}\right).$$

This tells us two things. First, our recovered wedge will differ from the true wedge only to the extent that consumption per capital growth rates in country j differ from those in the rest of the world, with the recovered wedge being larger than the true wedge if consumption in country j is growing relative fast *and* the IES is greater than one (or $\xi<1$), or if consumption growth in country j is relative slow *and* the ISE is greater than one. This is intuitive; if consumption in country j is growing relatively fast, it must be because the country perceives a relatively higher return to foreign investments. The smaller is the IES, the greater is the wedge required to induce faster consumption growth. Second, when we do experiments in which we shut this wedge down, we are also shutting the true wedge down. That is, when we assess the importance of the wedge, we are generating the same behavior for relative consumption growth in country j, regardless of whether we have identified the true wedge of nor. Of course, the behavior of other countries may still differ.

Now consider the capital wedge under the same assumption. The "true" capital wedge satisfies

$$1=E\left[\left(\frac{C_{jt}/N_{jt}}{C_{jt+1}/N_{jt+1}}\right)^{\xi}\beta\left(1-\tau_{jt+1}^{K,TRUE}\right)\frac{\alpha Y_{jt}/K_{jt}+P_{jt+1}^{*K}}{P_{jt}^{K}}\right],$$

and hence, everything else equal, our recovered wedge departs from the "true wedge" by

$$1-\tau_{jt+1}^{K}=\left(\frac{C_{jt+1}/N_{jt+1}}{C_{jt}/N_{jt}}\right)^{1-\xi}\left(1-\tau_{jt+1}^{K,TRUE}\right).$$

The findings are similar to those for the international wedge, except now we refer to the absolute growth rate of consumption rather than the relative growth rate. That is, the wedges are scalings that depend on the growth rate of consumption and the size of the IES, and that shutting down the recovered wedge is equivalent to shutting down the true wedge.

However, unlike with the international wedge where consumption per capita growth was data, the calculation of the capital wedge requires estimating a capital stock. Hence, it is possible that our procedure will return different capital stocks and hence wedges that are not simply scaled in this fashion. However, in practice, this does not appear to be the case. Moreover, experiments with different assumptions on the IES reveal almost identical results.

The Output Elasticity of Capital α

One parameter that has been the subject of a great deal of attention in the literature is the output elasticity of capital parameter α which, in a frictionless world, also parameterizes the capital share. Not only do measured capital shares vary across countries, but there has been a substantial debate as to whether they accurately capture the division of factor payments between labor and capital (for example, Gollin 2002), and whether they are miss-measured due to the inclusion of returns to non-reproducible factors such as land in returns to capital (for example, Caselli and Feyrer (2007)). There is also a significant literature looking at trends in the capital share over time that questions whether a Cobb-Douglas production function is a good representation of production possibilities in the economy (for example, Karabarbounis and Neiman (2014)).

In what follows, we address each of these issues looking at both whether or not they would affect our results, as well as assessing whether or not there is a need to address these concerns in our model.

First, consider the possibility of cross country differences in a (constant over time) level of the output elasticity of capital parameter, so that α_j varies with j. Cross country differences in capital shares can, in principle, have a number of impacts on our results. However, the primary impact is on estimates of the capital and labor wedges. Consider first the labor wedge. Rearranging the first order conditions for the firm and household yields the following expression for the labor wedge

$$1 - \tau_{jt}^{h} = \frac{\psi}{1-\alpha} h_{jt}^{\gamma+1} \frac{C_{jt}}{Y_{jt}}.$$

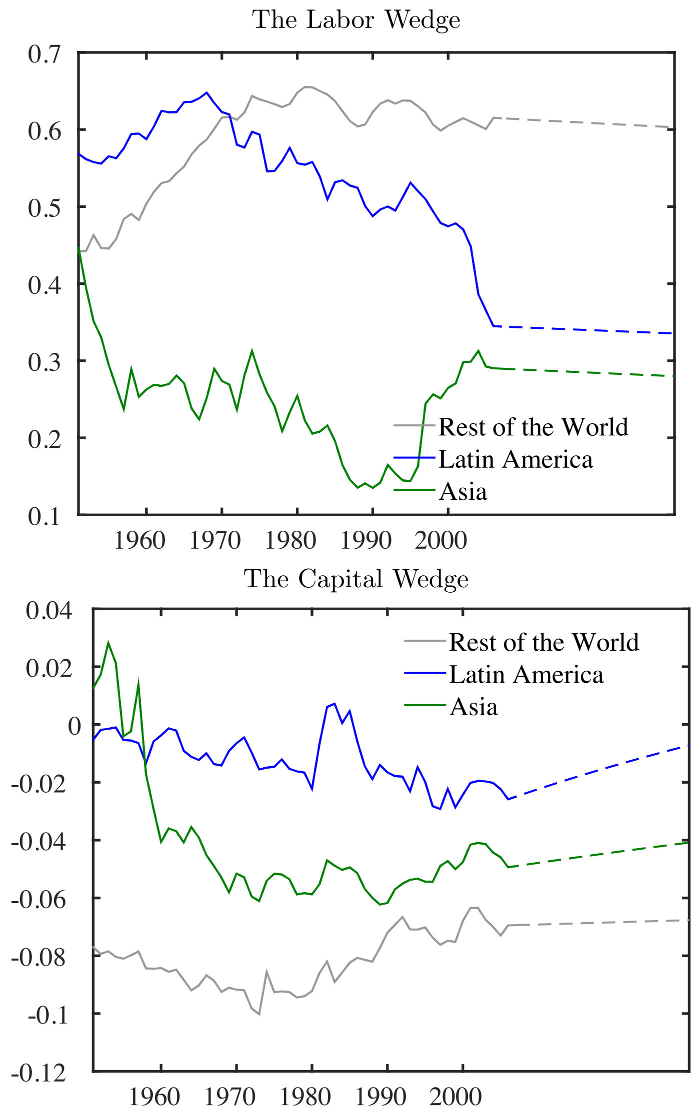
As shown in the expression, given data for country j at time t on hours h_{jt}, consumption C_{jt} and output Y_{jt}, and given the parameter γ, we can pin down the product of the labor wedge with the labor share divided by the parameter governing the value of leisure ψ. This means that we cannot separately identify the level of the labor wedge from α and ψ using these data alone. In other words, one of the main impacts of allowing α (or ψ) to vary across countries is that it will scale up and down the level of the labor wedge. Given that in all of our experiments we equate the labor wedge to its average level in the data, allowing α to vary across countries will have no direct effect on our results; indirect effects may result from changes in the equilibrium quantities in our model.

Next, turn to the capital wedge. From the Euler equation we find that the capital wedge is given by

$$1 = E\left[\beta \frac{C_{jt}}{C_{jt+1}} \frac{N_{jt+1}}{N_{jt}} \left(1 - \tau_{jt+1}^{K}\right) \frac{\alpha Y_{jt}/K_{jt} + P_{jt+1}^{*K}}{P_{jt}^{K}}\right].$$

Although our method takes consumption, population and output as given, we estimate an initial capital stock that evolves in a way constrained by data on investment. In principle, then, allowing α to vary across countries could impact the estimated capital wedge through changes in K_0 and hence K_t, and hence through the relative importance of the return to capital term. However, for a given initial K estimate, α tends to have only a modest effect on the estimated return to capital and thus increasing/decreasing α serves mostly to decrease/increase the estimated capital wedge each period. Once again, given that our experiments set the capital wedge equal to its sample mean, we might expect the resulting outcomes to turn out to be both qualitatively and quantitatively similar to those reported in the paper with common capital shares.

Figure 19: Labor and Capital Wedges for Alternate Capital Shares



To verify that our logic is correct, we re-estimated a version of the model while calibrating the capital shares to be different across countries. To do this, we took the estimates from Caselli and Feyrer (2007) that adjust for possible inclusion of factor income to non-reproducible capital for each country in our sample and combined them to form an estimate of the capital share in each region by taking an income weighted average for the region. Whereas in the baseline we imposed $\alpha = 0.36$ for all countries, this results in capital shares of $\alpha_{ASIA} = 0.23$, $\alpha_{LATAM} = 0.26$, and $\alpha_{ROW} = 0.18$. The capital shares are lower due to Caselli and Feyrer's natural resource adjustment. Note that in previous work, we have been quite critical of this natural resource adjustment to capital shares (See Ohanian and Wright (2008) for details). We nonetheless use these estimates since they differ most from our benchmark and hence better serve to show the robustness of our results.

The resulting estimates of the capital and labor wedges using heterogeneous capital shares are presented in Figure 19. Comparing these with the ones appearing in the paper (Figures **??** and **??**), it should be clear that the results are very similar, with the new estimates roughly scaled values of the estimates in the paper; the largest relative change corresponds to the rest of the world which had the largest absolute change in the output elasticity of capital parameter. Absolute levels are now mostly negative, which would be interpreted as a subsidy to accumulating capital, although the level of this wedge cannot be separately identified from the discount rate of households and so we do not stress this interpretation. The only other significant difference comes from the movement in the capital wedge for Asia in the first few years in the sample, which is now somewhat smaller. As a result, the quantitative implications of shutting down movements in this wedge are also quantitatively smaller. This further strengthens our finding that the capital wedge plays a small role in explaining capital flows to Asia.

Now consider the issue of capital shares varying over time. As noted, a recent literature has pointed to movements in the labor share for the USA and many other (but not all) countries and has argued that this is evidence that the aggregate production function is not well approximated by a Cobb-Douglas production function. While this is one possible interpretation of varying factor shares, another possibility that is closely related to our paper is that changes in factor market frictions are responsible for the changing levels of the factor share. Under this interpretation, measured factor shares do not identify the relevant parameter of the Cobb-Douglas production function nor are they indicative of any departure from the Cobb-Douglas functional form.

Specifically, consider the following minor variant of our model. Suppose that, in addition to their being a tax on labor income levied on the consumer τ^h_{jt}, firms face a distortion that increases the cost of hiring labor above the wage rate. We will call this τ^{hFIRM}_{jt} and note that it could take the form of a tax, as long as it is not recorded as payments to labor in the national income and product accounts (NIPA), or could be a non-tax distortion (which by construction would not appear in the NIPA). Then the first order condition for the firm can be rearranged to find

$$\frac{W_{jt}h_{jt}N_{jt}}{Y_{jt}} = \frac{1-\alpha}{1+\tau^{hFIRM}_{jt}},$$

where the distortion faced by the firm enters positively (that is, as $1+\tau^{hFIRM}_{jt}$) because it increases the cost of labor to the firm. That is, the measured labor share will differ from the parameter governing the output elasticity of labor in the production function $1-\alpha$ by the size of this distortion to firms hiring decisions. Under this interpretation, movements in the labor share can be interpreted as movements in this distortion. Note, however, that our method will continue to identify the total wedge on labor, calculated in this modified version as

$$\frac{1-\tau^h_{jt}}{1+\tau^{hFIRM}_{jt}} = \frac{\psi}{1-\alpha}h^{\gamma+1}_{jt}\frac{C_{jt}}{Y_{jt}}.$$

In other words, the usual tax incidence result holds. Note also that it is worth pointing out that, returning to our first point, differences in the level of factor market frictions across countries could also explain recorded differences in the level of capital shares across countries, and not just time series variation in factor shares.

In light of these issues, and given that the Cobb-Douglas assumption remains relatively standard in many models, we retain the Cobb-Douglas assumption and note that our recovered wedges could form the basis of a promising research agenda in which data on our labor wedge, along with data on the changing labor share, can be used to separately identify changes in labor market distortions that are priced into wages, and those that are not.

The Adjustment Cost Parameter ν

It has long been recognized that adjustment costs play an important role in helping international real business cycle models more closely match the data on investment fluctuations in open economies (Baxter and Crucini (1993)). However, in calibrated versions of these models, there has been little agreement as to how best to calibrate the parameters of the adjustment cost function. In this subsection, we review the issues, especially as applied to data on emerging market countries, describe our calibration strategy, and report sensitivity results for a different calibration.

As is traditional, we parameterize the adjustment cost of capital reference level κ so that adjustment costs are zero in the deterministic steady state. This also implies that average Tobin's q is one in the deterministic steady state. To parameterize adjustment costs outside of steady state, we follow Bernanke, Gertler, and Gilchrist (1999), Chari, Kehoe and McGrattan (2007) and others by setting the scale parameter ν to deliver a specific elasticity of the price of capital with respect to the investment-capital ratio. Noting that

$$\frac{d\log P_{jt}^{K}}{d\log\left(X_{jty}/K_{jt}\right)}=\frac{\phi''\left(\frac{X_{jt}}{K_{jt}}\right)\frac{X_{jt}}{K_{jt}}}{1-\phi'\left(\frac{X_{jt}}{K_{jt}}\right)},$$

and imposing the fact that under our assumptions on ϕ, in steady state

$$\phi\left(\frac{X_{jt}}{K_{jt}}\right)=\phi'\left(\frac{X_{jt}}{K_{jt}}\right)=0,$$

while

$$\phi''\left(\frac{X_{jt}}{K_{jt}}\right)=\nu,$$

we obtain

$$\frac{d\log P_{jt}^{K}}{d\log\left(X_{jty}/K_{jt}\right)}=\nu\kappa.$$

Bernanke, Gertler and Gilchrist (1999) calibrate their model of the US economy to match an elasticity of $1/4$, which yields a value of $\nu=1/\left(4\kappa\right)$. Chari, Kehoe and McGrattan (2007) also use a value of $1/4$ in their baseline analysis of the United States. There is some evidence, however, that adjustment costs differ across countries and might be larger for less developed and emerging market economies. Some evidence comes from estimates of Tobin's average q. The amount of cross country heterogeneity in the empirical literature, and the tremendous amount of heterogeneity observed within a country, means that a consensus on this question has not been reached. However, it seems a reasonable summary of the literature to say that studies on developed economy financial markets such as the United States typically find a median value across firms for average Tobin's q between one and two, with estimates towards the low end of this range. However, studies on emerging market countries often find values for average q closer to two (for example, Magud and Sosa (2015)). This suggests that an appropriate calibration for an emerging market might require larger adjustment costs than for a developed economy. Following Bernanke, Gertler and Gilchrist's argument that plausible values for the elasticity of the price of capital with respect to the investment to capital rate must lie between 0 and $1/2$, we use a value for the elasticity of $1/2$ which yields $\nu=1/\left(2\kappa\right)$ in our benchmark calibration, or in other words, adjustment costs that are roughly twice as large in emerging markets as they are in the United States.

To examine the extent to which our results are sensitive to this assumption, we also estimated a version of our model under the assumption that the elasticity was equal to $1/4$ as used for the U.S. and other advanced economies. Figures 20 and 21 plot the recovered values of the labor and capital wedges under this alternative parameterization of ν. The international wedge is not plotted as it is, by construction, unaffected. A comparison with the benchmark wedges in Figures **??**, and **??** shows that they are very similar, with slightly smaller fluctuations in the Asian capital wedge at the start of the sample, and slightly larger fluctuations thereafter, accompanied by slightly smaller fluctuations in the Latin American capital wedge during the 1980s. As a consequence, this has only a small quantitative effect on our findings.

Figure 20: The Labor Wedge (Elasticity of 0.25)

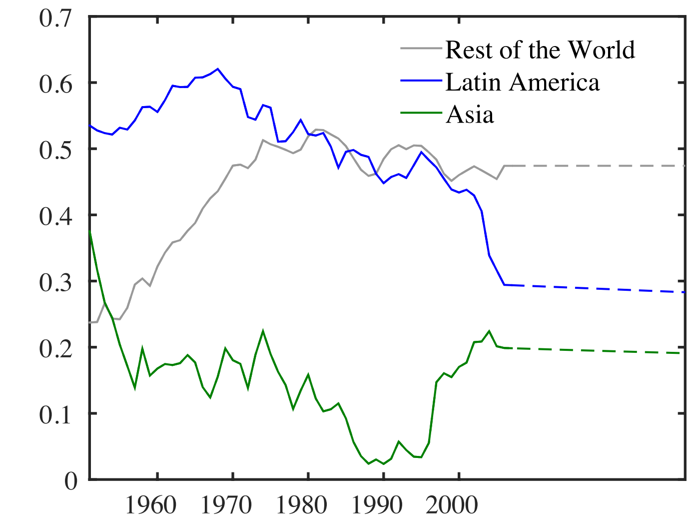
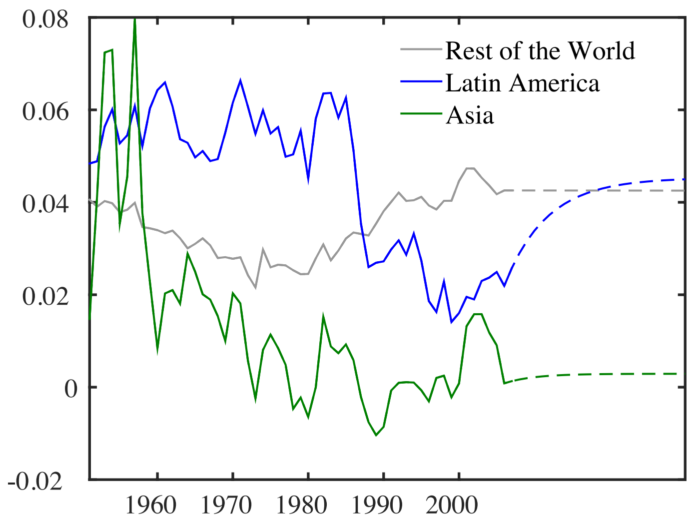


Figure 21: The Capital Wedge (Elasticity of 0.25)



Mapping Alternative Models into Wedges

Multiple Consumption Goods

Our benchmark model made the relatively standard assumption that each country produces the same consumption good, so that the relative prices of these goods across countries were fixed at one. This means that the model makes no allowance for fluctuations in the terms of trade or real exchange rate, so that when our method is applied to the data any observed fluctuations in a country's terms of trade will be attributed to movements in the wedges. To see how this affects our analysis, we consider a simple multi-good international real business cycle model along the lines of Backus, Kehoe, and Kydland (1994) adapted to our framework.

Specifically, consider a version of the world economy in our benchmark in which there are only 2 countries (which allows for a simpler representation of relative prices), the population is fixed at one in each country in all periods, there is no government, and there are no adjustment costs. Preferences are given by

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

where consumption is of a non-traded aggregate good that is described below. The budget constraint for households in each region is given by

$$P_{jt}\left(C_{jt}+K_{jt+1}-(1-\delta)K_{jt}\right)+E_t\left[q_{t+1}B_{jt+1}\right]\leq W_{jt}H_{jt}++r_{jt}^K K_{jt}+B_{jt},$$

where the bond is the numeraire, and P_{jt} is the price of the non-traded aggregate good specific to country j that can be used for both consumption and investment. The wages and rental rates of capital paid by the firms that produce the domestic tradable good are also expressed in terms of the numeraire. The FONCs of the households problem include

$$\begin{aligned}\beta^t\frac{1}{C_{jt}} &= \lambda_{jt}P_{jt},\\ \beta^t\psi H_{jt}^{\gamma} &= \lambda_{jt}W_{jt},\\ \lambda_{jt}P_{jt} &= E_t\left[\lambda_{jt+1}\left(r_{jt+1}^K-P_{jt+1}(1-\delta)\right)\right]\\ q_{t+1}\lambda_{jt} &= \lambda_{jt+1}.\end{aligned}$$

There are two types of firms in the economy. The first produces the domestic tradable good and maximizes profits

$$p_{jt}A_{jt}K_{jt}^{\alpha}\left(h_{jt}N_{jt}\right)^{1-\alpha}-W_{jt}H_{jt}-r_{jt}^K K_{jt},$$

where p_{jt} is the price of the $j'th$ country's tradable good. This problem yields optimality conditions

$$\begin{aligned}p_{jt}\alpha\frac{Y_{jt}}{K_{jt}} &= r_{jt}^K,\\ p_{jt}(1-\alpha)\frac{Y_{jt}}{H_{jt}} &= W_{jt}.\end{aligned}$$

The second type of firm produces the domestic non-tradable good using both the domestic and foreign tradable goods. They maximize profits

$$P_{jt}G^j\left(Y_{1t}^j,Y_{2t}^j\right)-p_{1t}Y_{1t}^j-p_{2t}Y_{2t}^j,$$

where the production function G^j is country specific and takes the constant elasticity of substitution form

$$G^j\left(Y_{1t}^j,Y_{2t}^j\right)=\left(\chi\left(Y_{jt}^j\right)^{(\sigma-1)/\sigma}+(1-\chi)\left(Y_{-jt}^j\right)^{(\sigma-1)/\sigma}\right)^{\sigma/(\sigma-1)},$$

where $-j$ denotes the country that is "not j." We will assume that the elasticity of substitution is no greater than one so that both goods are necessary for production and hence we do not have to worry about a corner in which one country's exports are zero. Competition ensures that the price of the non-tradable is given by

$$P_{jt}=\left(\chi p_{jt}^{1-\sigma}+(1-\chi)p_{-jt}^{1-\sigma}\right)^{1/(1-\sigma)}.$$

The optimality conditions of the household can then be combined with these results on equilibrium prices to deduce the implications of the model for our recovered wedges. Specifically, assume that our procedure was applied to data generated by this model with multiple consumption goods. Then the optimal choice of leisure satisfies

$$\psi H_{jt}^{\gamma}=\frac{1}{P_{jt}C_{jt}}p_{jt}(1-\alpha)\frac{Y_{jt}}{H_{jt}},$$

so that the recovered labor wedge satisfies

$$\begin{aligned}
1-\tau_{jt}^{h} &= \frac{\psi}{1-\alpha}H_{jt}^{\gamma}\frac{H_{jt}}{Y_{jt}}C_{jt} \\
&= \frac{p_{jt}}{P_{jt}} = \left(\chi+(1-\chi)\left(\frac{p_{-jt}}{p_{jt}}\right)^{1-\sigma}\right)^{-1/(1-\sigma)} \\
&= \left(\chi+(1-\chi)\left(TOT_{jt}\right)^{-(1-\sigma)}\right)^{-1/(1-\sigma)},
\end{aligned}$$

a positive function of country $j's$ terms of trade $TOT_{jt}=p_{jt}/p_{-jt}$. That is, if the terms of trade deteriorates, the labor wedge τ^h rises. Why? If the price of the foreign good rises, while the price of the domestic good is unchanged, the price index for consumers goes up and labor supply falls for the given price of the country's output. To put it differently, the real wage received by the supplier of labor differs from the real cost of labor to the firm, because they face different prices. Thus, a deterioration in a country's terms of trade acts like an increase in the labor wedge.

The optimal choice of capital satisfies

$$\begin{aligned}
1 &= \beta E_t\left[\frac{C_{jt}}{C_{jt+1}}\frac{1}{P_{jt}}\left(p_{jt}\alpha\frac{Y_{jt}}{K_{jt}}-P_{jt+1}(1-\delta)\right)\right] \\
&= \beta E_t\left[\frac{C_{jt}}{C_{jt+1}}\frac{\left(\frac{p_{jt}}{P_{jt+1}}\right)\alpha\frac{Y_{jt}}{K_{jt}}-(1-\delta)}{\alpha\frac{Y_{jt}}{K_{jt}}-(1-\delta)}\left(\alpha\frac{Y_{jt}}{K_{jt}}-(1-\delta)\right)\right],
\end{aligned}$$

so that the capital wedge is given by

$$1-\tau_{jt}^{K}=\frac{\frac{p_{jt}}{P_{jt}}\alpha\frac{Y_{jt}}{K_{jt}}-(1-\delta)}{\alpha\frac{Y_{jt}}{K_{jt}}-(1-\delta)},$$

and, once again, a deterioration in the terms of trade increases the capital wedge and causes the capital and labor wedges to comove positively.

Lastly, the optimality condition for bonds yields

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

or

$$\frac{C_{jt+1}}{C_{jt}}=\beta\frac{1+r_{t+1}}{P_{jt+1}/P_{jt}},$$

where

$$1+r_{t+1}=1/q_{t+1},$$

for all j. That is, the real interest rate in country j departs from the world interest rate r_{t+1} by the country specific rate of inflation.

Hence, the international wedge is given by differences in country specific rates of inflation which, in this two good two country world, are determined by fluctuations in the terms of trade. To see this, note that our method recovers

$$\begin{aligned}
\tau_{jt+1}^{B} &= 1-\frac{C_{jt+1}/C_{jt}}{C_{-jt+1}/C_{-jt}} \\
&= 1-\frac{P_{jt}/P_{jt+1}}{P_{-jt}/P_{-jt+1}} \\
&= 1-\left(\frac{\left(\chi p_{jt}^{1-\sigma}+(1-\chi)p_{-jt}^{1-\sigma}\right)/\left(\chi p_{jt+1}^{1-\sigma}+(1-\chi)p_{-jt+1}^{1-\sigma}\right)}{\left((1-\chi)p_{jt}^{1-\sigma}+\chi p_{-jt}^{1-\sigma}\right)/\left((1-\chi)p_{jt+1}^{1-\sigma}+\chi p_{-jt+1}^{1-\sigma}\right)}\right)^{1/(1-\sigma)} \\
&= 1-\left(\frac{\left(\chi\left(TOT_{jt}\right)^{1-\sigma}+(1-\chi)\right)/\left(\chi\left(TOT_{jt+1}\right)^{1-\sigma}+(1-\chi)^{1-\sigma}\right)}{\left((1-\chi)\left(TOT_{jt}\right)^{1-\sigma}+\chi\right)/\left((1-\chi)\left(TOT_{jt+1}\right)^{1-\sigma}+\chi^{1-\sigma}\right)}\right)^{1/(1-\sigma)}.
\end{aligned}$$

Regarding production and productivity, movements in the terms of trade plays no role in measured outcomes. This is easiest to see if we consider the incomes method for computing nominal gross domestic product which yields, in terms of the numeraire

$$GDP_{jt} = W_{jt}H_{jt} + +r_{jt}^{K}K_{jt} = p_{jt}A_{jt}K_{jt}^{\alpha}\left(h_{jt}N_{jt}\right)^{1-\alpha}.$$

Holding prices constant in some base year T, real GDP in period t is then given by

$$GDP_{jt}^{T} = p_{jT}A_{jt}K_{jt}^{\alpha}\left(h_{jt}N_{jt}\right)^{1-\alpha},$$

so that measured productivity growth is unaffected by movements in the terms of trade. Thus, in the context of this model, terms of trade fluctuations imply no specific pattern of correlation between our recovered wedges and productivity.

In summary, this model implies that the labor and capital wedges should comove with the terms of trade of a country, while the international wedge will in general move (positively or negatively) with the change in the terms of trade. Note that, if $\chi = 1/2$, the international wedge is always zero. As our recovered wedges show only modest comovement with each other, we conclude that this model is not especially promising as an explanation for the patterns we observe.

However, an alternative specification with multiple consumption goods, and possibly the addition of transport costs along the lines of Obstfeld and Rogoff (2001), may contribute towards an explanation of our findings. We consider this next.

Transport Costs

Obstfeld and Rogoff (2001) and others have argued that the addition of transport costs in international goods trade may help explain patterns in international capital flows. To understand this argument, note that trade costs—modeled as iceberg costs—serve primarily to influence the terms of trade by driving a wedge between the domestic and foreign price of a given good. Specifically, in the model of the previous subsection—where each country produces and exports its own good in all periods—trade costs of size τ on all goods imply the following relationship between relative prices of the same good across countries

$$\begin{aligned} p_{-jt}^{j} &= \frac{p_{-jt}^{-j}}{1-\tau}, \\ p_{jt}^{j} &= (1-\tau)\, p_{jt}^{-j}, \end{aligned}$$

where p_{jt}^{i} denotes the price in country i of the good produced by country j at time t. Note that our expressions for the capital and labor wedges are unchanged, although in the background the transport costs affects both the level of the terms of trade, and its relationship across countries

$$TOT_{jt} = \frac{p_{jt}^{j}}{p_{-jt}^{j}} = (1-\tau)^{2}\,\frac{p_{jt}^{-j}}{p_{-jt}^{-j}} = \frac{(1-\tau)^{2}}{TOT_{-jt}}.$$

Transport costs play a more obvious role in the international wedge as

$$\begin{aligned} \frac{P_{jt}}{P_{jt+1}} &= \left(\frac{\chi\left(p_{jt}^{j}\right)^{1-\sigma} + (1-\chi)\left(p_{-jt}^{j}\right)^{1-\sigma}}{\chi\left(p_{jt+1}^{j}\right)^{1-\sigma} + (1-\chi)\left(p_{-jt+1}^{j}\right)^{1-\sigma}}\right)^{1/(1-\sigma)} \\ &= \frac{p_{-jt}^{j}}{p_{-jt+1}^{j}}\left(\frac{\chi\left(TOT_{jt}\right)^{1-\sigma} + (1-\chi)}{\chi\left(TOT_{jt+1}\right)^{1-\sigma} + (1-\chi)}\right)^{1/(1-\sigma)}, \\ \frac{P_{-jt}}{P_{-jt+1}} &= \left(\frac{(1-\chi)\left(p_{jt}^{-j}\right)^{1-\sigma} + \chi\left(p_{-jt}^{-j}\right)^{1-\sigma}}{(1-\chi)\left(p_{jt+1}^{-j}\right)^{1-\sigma} + \chi\left(p_{-jt+1}^{-j}\right)^{1-\sigma}}\right)^{1/(1-\sigma)} \\ &= \frac{p_{-jt}^{-j}}{p_{-jt+1}^{-j}}\left(\frac{(1-\chi)\left(\frac{TOT_{jt}}{(1-\tau)^{2}}\right)^{1-\sigma} + \chi}{(1-\chi)\left(\frac{TOT_{jt+1}}{(1-\tau)^{2}}\right)^{1-\sigma} + \chi}\right)^{1/(1-\sigma)}, \end{aligned}$$

so that

$$\begin{aligned}
\tau^B_{jt+1} &= 1-\frac{P_{jt}/P_{jt+1}}{P_{-jt}/P_{-jt+1}} \\
&= 1-\frac{\frac{p^j_{-jt}}{p^j_{-jt+1}}\left(\frac{\chi(TOT_{jt})^{1-\sigma}+(1-\chi)}{\chi(TOT_{jt+1})^{1-\sigma}+(1-\chi)}\right)^{1/(1-\sigma)}}{\frac{p^{-j}_{-jt}}{p^{-j}_{-jt+1}}\left(\frac{(1-\chi)(TOT_{jt})^{1-\sigma}+\chi(1-\tau)^{2(1-\sigma)}}{(1-\chi)(TOT_{jt+1})^{1-\sigma}+\chi(1-\tau)^{2(1-\sigma)}}\right)^{1/(1-\sigma)}} \\
&= 1-\frac{\left(\frac{\chi(TOT_{jt})^{1-\sigma}+(1-\chi)}{\chi(TOT_{jt+1})^{1-\sigma}+(1-\chi)}\right)^{1/(1-\sigma)}}{\left(\frac{(1-\chi)(TOT_{jt})^{1-\sigma}+\chi(1-\tau)^{2(1-\sigma)}}{(1-\chi)(TOT_{jt+1})^{1-\sigma}+\chi(1-\tau)^{2(1-\sigma)}}\right)^{1/(1-\sigma)}}.
\end{aligned}$$

That is, with constant τ over time, transport costs further the difference in χ.

Many authors have argued that transport costs have declined over time and have played a causal role in the expansion of global trade. To see the effect of this, consider a version of the above world in which one country is small and so takes world prices as given. We denote world prices by an asterisk, and index τ by time, while still maintaining the assumption that both goods attract the same transport costs. Then substituting into the above formulae the fact that the terms of trade of this small country, given a (assumed constant) world relative price of goods

$$TOT_{jt} = (1-\tau_t)^2\,\frac{p^*_{jt}}{p^*_{-jt}}.$$

With world relative prices fixed, this small country should then have experienced an increase in its terms of trade over time. Given the results above, this implies that our recovered labor and capital wedges should both display downward trends over time. Although we find some evidence for downward trends in our results above, it is possible that these trends were driven by other factors such as the tendency to liberalize factor markets over time. More work will be required to distinguish the effect of trade costs from the effect of other changes in these economies. Over shorter horizons, the absence of a significant correlation between our measures suggests that this mechanism is less important.

Lastly, in the above we have assumed that each country produces its own distinct good and exports it in all periods. Suppose that this is not true, and further, suppose that our small open economy is a net importer and borrower in one period. In a finite horizon economy, it is necessarily the case that, in some future period, the country must become a net exporter to pay off this borrowing. If this does not affect the identity of who exports which good, this has no additional effect to what we have identified above. If however, in order to pay off its borrowing a country must switch from importing a good to exporting that same good, Obstfeld and Rogoff (2001) have shown that this can lead to movements in relative prices that deter capital flows.

To see this, note that if a small country imports the foreign good $-j$ at time t then the price it pays is given by

$$p^j_{-jt} = \frac{p^*_{-jt}}{1-\tau},$$

as above. However, if at some later date $s > t$ it switches to exporting that good, the price it receives is given by

$$p^j_{-js} = (1-\tau)\,p^*_{-jt}.$$

If we, for simplicity, assume that world prices are constant over time, then this implies that

$$\begin{aligned}
\frac{P_{jt}}{P_{js}} &= \left(\frac{\chi\left((1-\tau)\,p^*_j\right)^{1-\sigma}+(1-\chi)\left(\frac{p^*_{-j}}{1-\tau}\right)^{1-\sigma}}{\chi\left((1-\tau)\,p^*_j\right)^{1-\sigma}+(1-\chi)\left((1-\tau)\,p^*_{-j}\right)^{1-\sigma}}\right)^{1/(1-\sigma)} \\
&= \left(\frac{\chi\left(p^*_j\right)^{1-\sigma}+(1-\chi)\left(\frac{p^*_{-j}}{(1-\tau)^2}\right)^{1-\sigma}}{\chi\left(p^*_j\right)^{1-\sigma}+(1-\chi)\left(p^*_{-j}\right)^{1-\sigma}}\right)^{1/(1-\sigma)} > 1,
\end{aligned}$$

so that there is deflation between periods t and s. But this implies that the real interest rate faced by borrowers in the country over this time horizon is larger than the real interest rate available in world markets. Likewise, a country that saves will eventually be repaid and the same mechanism will operate in reverse.

In terms of the international wedge (against the rest of the world where, for simplicity, prices were assumed constant), if the switch between importing and exporting the good occurred between periods t and $t+1$, we would recover

$$\begin{aligned}\tau_{jt+1}^{B} &= 1-\frac{P_{jt}/P_{jt+1}}{P_{Rt}/P_{Rt+1}}\\ &= 1-P_{jt}/P_{jt+1},\end{aligned}$$

which, for a country that imported in period t and exported in period $t+1$, is greater than one implying a tax on foreign borrowing.

As this mechanism requires that a country switch from importing to exporting a set of goods, it is not clear that this mechanism should generate quantitatively significant effects on the level of capital flows in practice. Nonetheless, we note that Reyes-Heroles (2016), Alessandria and Choi (2015), and Eaton, Kortum, and Neiman (2016) all find that trade costs play significant (but quantitatively varying) roles in explaining the *level* of capital flows in the context of their own models. For this mechanism to explain the *relative pattern* of capital flows to Asia and Latin America in the 1950s and 1960s, Asia must have expected a large number of goods to switch from being imported to being exported in order to significantly deter capital flows, while the switches in Latin America would have been expected to be smaller. To fully investigate this possibility would require a detailed examination of international trade at a commodity level which would be a worthwhile subject for a future paper.

Capacity Utilization

In the text, we completely abstracted from the possibility of fluctuations in capacity utilization. This was deliberate as fluctuations in capacity utilization tend to occur at business cycle frequencies, and hence did not seem to be especially important in driving the medium term movements in fundamentals that primarily determine capital flows. Nonetheless, we quickly review the issues in this section.

One possible way to incorporate variable capacity utilization into a business cycle accounting framework was explored in Chari, Kehoe, and McGrattan (2007) who consider a variable workweek along the lines of that studied in Hornstein and Prescott (1993). They show that, when introduced in this way, variable capacity utilization generates measured labor wedges and productivity (they refer to productivity as the efficiency wedge) that are negatively correlated, without generating a capital wedge. Adapted to an open economy, this will not affect our international wedge.

In this section, we consider an alternate variant, designed for our open economy framework, in which capital utilization requires the use of an important input which we refer to as energy and which we think of as representing imported oil. As above, we assume that the population is fixed at one in every country and that there is no government or adjustment costs in capital. Suppose that capital services are produced using physical capital and energy

$$KS_{jt}=K_{jt}^{\phi}E_{jt}^{1-\phi},$$

and that

$$\begin{aligned}Y_{jt} &= A_{jt}\left(KS_{jt}\right)^{\alpha}H_{jt}^{1-\alpha}\\ &= A_{jt}K_{jt}^{\alpha\phi}E_{jt}^{\alpha(1-\phi)}H_{jt}^{1-\alpha}.\end{aligned}$$

This framework bears a resemblance to the set-up in Backus and Crucini (2000). Unlike that paper, we will interpret increases in energy expenditures per unit capital as representing increases in capacity utilization which come at the cost of increasing the rate of depreciation of capital, so that

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

With a little bit of work, it can be shown that the Euler equation for the household in capital is given by

$$1 = E_t \left[\beta \frac{C_{jt}}{C_{jt+1}} \left(\phi\alpha \frac{Y_{jt}}{K_{jt}} + 1 - \delta \left(\frac{E_{jt}}{K_{jt}} \right) + \delta' \left(\frac{E_{jt}}{K_{jt}} \right) \frac{E_{jt}}{K_{jt}} \right) \right],$$

so that, if we apply our methodology using a fixed depreciation rate of $\delta \left(E_j / K_j \right)$ calculated at the balanced growth path level of energy use per unit of capital E_j/K_j we obtain a capital wedge

$$1 - \tau_{jt}^K = \frac{\phi\alpha \frac{Y_{jt}}{K_{jt}} + 1 - \delta \left(\frac{E_{jt}}{K_{jt}} \right) + \delta' \left(\frac{E_{jt}}{K_{jt}} \right) \frac{E_{jt}}{K_{jt}}}{\phi\alpha \frac{Y_{jt}}{K_{jt}} + 1 - \delta \left(\frac{E_{jss}}{K_{jss}} \right)}.$$

Now, suppose we are in the vicinity of the average level of energy usage per unit capital, and further suppose that an increase in the price of oil causes energy per unit capital to fall. Then depreciation falls and the capital wedge falls. That is, there is a negative relationship between the price of energy and the capital wedge.

Financial Frictions due to Limited Commitment

One model of international financial frictions that has attracted a great deal of attention posits that international capital flows are constrained by the possibility that a country might choose to exit the international financial system and stay in autarky. These limited commitment models have been studied by many authors including Wright (2001), Kehoe and Perri (2002) and Restrepo-Echavarria (2018).

In this subsection, we outline a variant of these models in an environment similar to the one considered in our paper. For simplicity we assume that there are no adjustment costs of capital, no government, and that the population of each country is fixed at one throughout time. Specifically, consider a social planner whose problem is to choose state, date and country contingent sequences of consumption, capital, and hours worked to maximize

$$E_0 \left[\sum_j \chi_{jt}^C \sum_{t=0}^{\infty} \beta^t \left\{ \ln C_{jt} - \frac{\psi}{1+\gamma} H_{jt}^{1+\gamma} \right\} \right],$$

subject to a world resource constraint for each state and date,

$$\sum_j \left\{ C_{jt} + K_{jt+1} + G_{jt} \right\} = \sum_j Y_{jt} = \sum_j \left\{ A_{jt} K_{jt}^{\alpha} H_{jt}^{1-\alpha} + (1-\delta) K_{jt} \right\},$$

and a series of state and date contingent participation constraint for each country j of the form,

$$E_t \left[\sum_{t=0}^{\infty} \beta^t \left\{ \ln C_{jt} - \frac{\psi}{1+\gamma} H_{jt}^{1+\gamma} \right\} \right] \geq V_j^A \left(K_{jt}, s_t \right),$$

where V_j^A is the value to country j of exiting the international economy and staying in autarky forever after, which depends on the amount of capital they would take with them and the current state of the world indexed by s_t (the expectation operator E_t is an expectation conditioned on this s_t).

If we let λ_t denote the multipliers on the world budget constraint at time t, and μ_{jt}/β^s the multipliers on the participation constraints of country j, the first order conditions for an optimum yield

$$\begin{aligned} \beta^t \left(\chi_{jt}^C + \sum_{s=0}^{t} \mu_{js} \right) \frac{1}{C_{jt}} &= \lambda_t, \\ \beta^t \left(\chi_{jt}^C + \sum_{s=0}^{t} \mu_{js} \right) \psi H_{jt}^{\gamma} &= \lambda_t (1-\alpha) \frac{Y_{jt}}{H_{jt}}, \\ \lambda_t &= E_t \left[\lambda_{t+1} \left(\alpha \frac{Y_{jt+1}}{K_{jt+1}} + 1 - \delta \right) - \mu_{jt+1} \frac{dV_j^A \left(K_{jt+1}, s_{t+1} \right)}{dK_{jt+1}} \right]. \end{aligned}$$

If we let $M_{-1} = \chi_{jt}^{C}$ and recursively define

$$M_{jt} = M_{jt-1} + \mu_{jt},$$

then the first order conditions with respect to consumption for countries i and j will yield

$$\frac{C_{jt}}{C_{it}} = \frac{M_{jt}}{M_{it}}. \tag{12}$$

Note that M_{jt} can be thought of as a cumulative planner weight, which depends on the initial planner weight assigned to each country and past Lagrange multipliers on the country's participation constraint which are positive only when the participation constraint binds.

Rearranging these equations and comparing them to the equations derived for our model it is straightforward to show that the limited commitment model implies that there is no labor wedge

$$\tau_{jt}^{h} = 1 - \frac{\psi}{1-\alpha} H_{jt}^{\gamma} \frac{H_{jt}}{Y_{jt}} C_{jt} = 0, \tag{13}$$

and that the international wedge (relative to the rest of the world) is given by

$$\tau_{jt+1}^{B} = 1 - \frac{C_{jt+1}/C_{jt}}{C_{Rt+1}/C_{Rt}} = 1 - \frac{M_{jt+1}/M_{jt}}{M_{Rt+1}/M_{Rt}}. \tag{14}$$

As for the capital wedge, the Euler equation can be rearranged to yield

$$\begin{aligned}
1 &= \beta E_t \left[\left(\frac{M_{jt+1}}{M_{jt}} \right) \frac{C_{jt}}{C_{jt+1}} \left(\alpha \frac{Y_{jt+1}}{K_{jt+1}} + 1 - \delta \right) - \mu_{jt+1} \frac{dV_j^A \left(K_{jt+1}, s_{t+1} \right)}{dK_{jt+1}} \right] \\
&= \beta E_t \left[\frac{C_{jt}}{C_{jt+1}} \left(\frac{M_{jt+1}}{M_{jt}} - \mu_{jt+1} \frac{C_{jt+1}}{C_{jt}} \frac{1}{A_{jt+1} \alpha k_{jt+1}^{\alpha-1} + 1 - \delta} \frac{dV_j^A \left(K_{jt+1}, s_{t+1} \right)}{dK_{jt+1}} \right) \right. \\
&\quad \left. \times \left(\alpha \frac{Y_{jt+1}}{K_{jt+1}} + 1 - \delta \right) \right]. \qquad (15)
\end{aligned}$$

Recall that the Euler equation derived in the paper, under the simplifying assumptions used here, is given by

$$1 = \beta E_t \left[\frac{C_{jt}}{C_{jt+1}} \left(1 - \tau_{jt+1}^{K} \right) \left(\alpha \frac{Y_{jt+1}}{K_{jt+1}} + 1 - \delta \right) \right]. \tag{16}$$

This means that the limited commitment model produces a capital wedge for the competitive equilibrium formulation of the problem of

$$\tau_{jt+1}^{K} = 1 - \left(\frac{M_{jt+1}}{M_{jt}} - \mu_{jt+1} \frac{C_{jt+1}}{C_{jt}} \frac{1}{A_{jt+1} \alpha k_{jt+1}^{\alpha-1} + 1 - \delta} \frac{dV_j^A \left(K_{jt+1}, s_{t+1} \right)}{dK_{jt+1}} \right),$$

which will, in general, be highly correlated with the international wedge.

Overall, the predictions of the limited commitment model are not borne out by the data on capital flows. We find that there is a significant labor wedge, and that the correlation between the international and capital wedges is low.

Government Borrowing and Ricardian Equivalence

In our benchmark model, we assumed that the government in each region levied lump sum taxes (or made lump sum transfers) in order to ensure that the budget was balanced in each period. As a result, all capital flows were private in the sense of being owned or owed by households. This was without loss of generality in the theory because the model exhibited a form of Ricardian Equivalence.

In practice, however, the distinction between private and public capital flows could be relevant in explaining the pattern of capital flows into Latin America, instead of into Asia, that we observe in the first few decades of the post war period. Other authors have argued that this distinction matters for the later period when data on capital flows becomes more widely available. For example, both Aguiar and Amador (2016) and Alfaro, Kalemli-Ozcan and Volosovych (2014), have argued that public capital flows—borrowing and saving by emerging market country governments—are the key component in explaining capital flows beginning in the 1970s. It is also possible that similar forces were also relevant in the early decades that are our focus, although data limitations prevent an extension of their analysis back to 1950. Implicitly, of course, this requires that there must be a significant departure from Ricardian Equivalence that prevents private capital flows (that is, flows to the private sector of these economies) from offsetting these public flows. In the model of Amador and Aguiar (2016), for example, domestic voters are assumed to have no access to international capital markets and so Ricardian Equivalence does not hold. We are quite open to this possibility and note that plausible reasons for the departure from Ricardian Equivalence have testable implications that our wedges approach is well-designed to examine.

Specifically, one plausible hypothesis is that the capital controls that were introduced under the Bretton-Woods system prevented the private sector from accessing international capital markets to offset the effect of public capital flows. As noted, Aguiar and Amador (2016) impose this as an assumption in their model. But this implies that private consumption should depart from the levels implied by the Euler equation for bonds which would show up as an international wedge in our framework. The fact that we find that the international wedge has a relatively small impact on capital flows is evidence against this departure from Ricardian Equivalence being important in explaining capital flows.

To see this, suppose to begin that households in Asia were limited in their ability to borrow as much as they would like. If borrowing constraints on Asian households were binding, the Euler equation governing the household's choice of foreign assets becomes (for $j = A$)

$$\lambda_{At} q_{t+1} = \beta^{t+1} \zeta^B_{At+1} + \lambda_{At+1},$$

where ζ^B_{At+1} is the current value Lagrange multiplier on the constraint limiting borrowing (the superscript B denotes a limit on borrowing) against income in the relevant state of the world in period $t+1$. Our method would then use relative consumption per capita growth rates to recover the following wedge (under the assumption that the rest of the world is not borrowing constrained)

$$1 - \tau^B_{At+1} = \frac{C_{At+1}/N_{At+1}}{C_{At}/N_{At}} / \frac{C_{Rt+1}/N_{Rt+1}}{C_{Rt}/N_{Rt}} = 1 + \zeta^B_{At+1}.$$

That is, to explain the lack of capital flows into Asia, this departure from Ricardian Equivalence would show up as a negative international wedge τ^B_{jt+1}. This is intuitive: If Asian households do not borrow, the method interprets this as a subsidy on savings or a tax on borrowing. Note also that binding borrowing constraints have no effect on the labor or capital wedges as we define them.

Now suppose that Latin American governments were borrowing in the 1950s and 1960s and that Latin American households were limited in their ability to save so as to offset this borrowing as Ricardian equivalence would require. In this case, it is straightforward to show that the wedge recovered for Latin America ($j = L$) would be

$$1 - \tau^B_{Lt+1} = \frac{C_{Lt+1}/N_{Lt+1}}{C_{Lt}/N_{Lt}} / \frac{C_{Rt+1}/N_{Rt+1}}{C_{Rt}/N_{Rt}} = 1 - \zeta^S_{Lt+1},$$

where ζ^S_{Lt+1} is now the current value multiplier on the binding constraint on international savings. That is, we recover a tax on international savings in order to rationalize the relative lack of international savings by Latin American households.

In summary, if this departure from Ricardian equivalence is invoked to explain why private savings and borrowing behavior did not offset public borrowing in the first few decades of our sample, we should expect to see a large tax on international savings for Latin America, and a significant subsidy on savings for Asia. Our recovered wedges provide only partial support for this hypothesis. On the one hand, we do find a significant subsidy—averaging around 5% during the 1950s and 1960s—on international savings (or a tax on borrowing) in Asia during the start of this period. In Latin America, however, we also see a subsidy on savings, although it is quite a bit smaller—no more than 2% during this period. Moreover, while the size of the subsidy for Asia looks large, when it is removed we find that capital flows increase only during the 1950s, and that capital flows out in even larger quantities during the 1960s despite continuing strong growth. In both cases, the effects of the international wedge are dwarfed by the effect of the labor and domestic capital wedges.

This should not necessarily be taken as evidence against (or at best weak evidence for) the claim that public capital flows drove national capital flows during this period. Instead, it might simply imply a different departure from Ricardian Equivalence. But it is not obvious that the evidence favors other departures. For example, another commonly used departure from Ricardian equivalence is myopia from some or all consumers. But this would lead to correlated international and domestic capital wedges, for which we find little evidence in the data. Nonetheless, we view our approach as complementary to this argument in that it provides evidence of what these departures from Ricardian Equivalence might be, and believe it will be a fruitful avenue for future research.

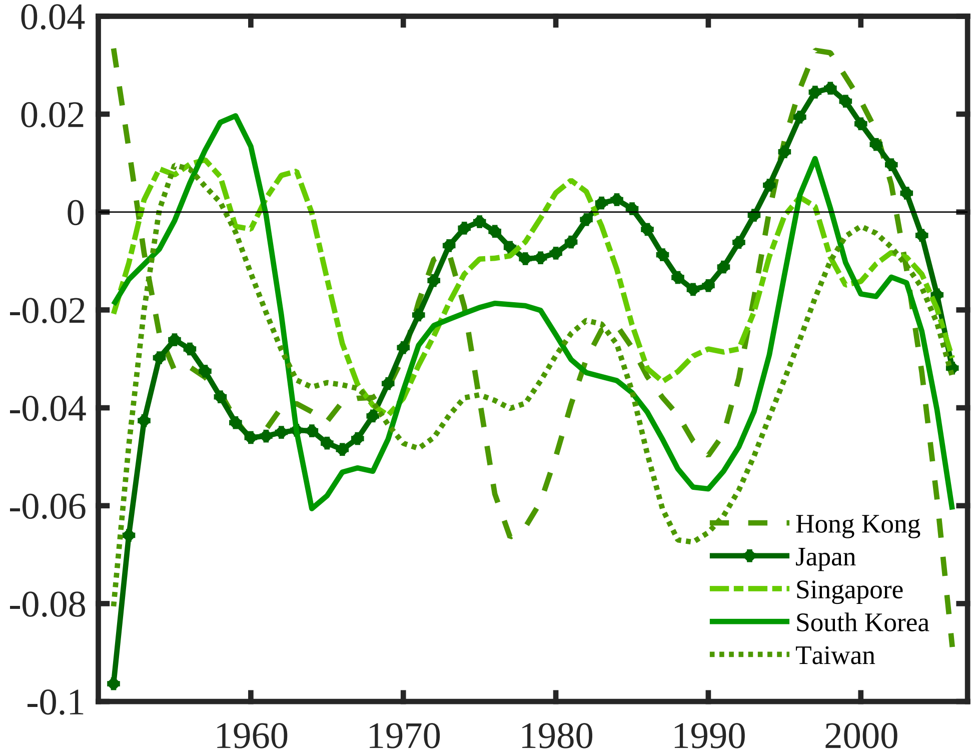
Appendix F: Country Level Wedges

In this section, we present the labor and international wedges for each country in our Asia and Latin America samples and show that there are significant common components to these wedges across countries. We focus on these wedges because they can be measured without solving for the equilibrium of the model as they are defined by static first order conditions. We take the optimality condition with resect to consumption from the pseudo-planners problem, and the labor-leisure condition, and keep the parameters fixed at the value that was estimated originally for the corresponding region. We then use individual country data to pin down these wedges for all Latin American and Asian countries in our sample.

Figure 22 plots the Hodrick-Prescott trend of these international wedges. In this graph, note that a value of -0.05 is equivalent to a five percent tax on borrowing and a positive number represents a subsidy on borrowing. As can be seen in the plot, the wedges for individual countries share a significant common component. Most important for our purposes, all countries except Hong Kong experience a significant decline in the tax on borrowing at the start of the sample, which reverses around the beginning of the 1960s, and returns around the start of the 1970s. In the mid-1980s, all countries in the sample see an increase in the tax on international borrowing (a more negative international wedge) which declines in the mid 1990s, before rising again around 1998 in the aftermath of the Asian financial crisis.

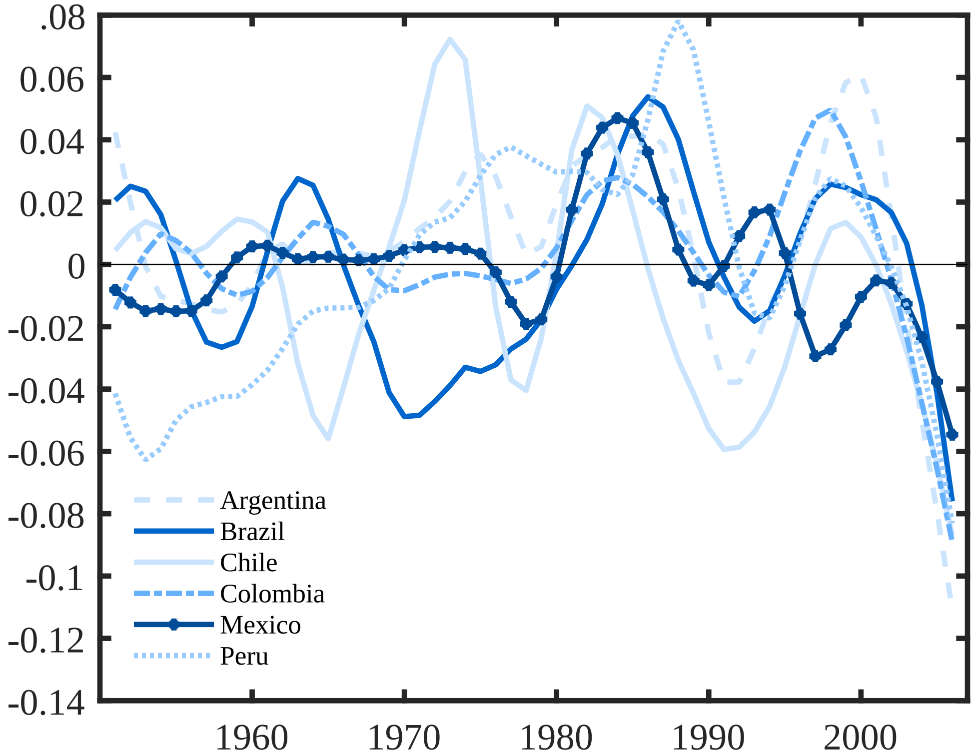
These overall common patterns are quite close to those for the Asian region aggregate found in Figure 3 of the paper. Note that, as a result of the fact that Japan and South Korea are the largest countries in the region, the aggregate international wedge in the paper most closely follows the individual international wedges for these two countries. This is particularly true in the early years of the sample; in 1950, these two countries alone accounted for more than 95% of aggregate consumption in the region.

Figure 22: International Wedge for Asian Countries



Next, Figure 23 plots the Hodrick-Prescott trend (smoothed component) of the international wedge for the countries of our Latin America region. Once more, the plot reveals a significant common component in the international wedge for all of our countries. This pattern is especially striking in the latter half of our sample: all countries see an increase in the tax on borrowing beginning somewhere around the middle of the 1980s as the Latin American debt crisis reached its peak, and all see a recovery in the 1990s as these countries participated in Brady plans. The tax on borrowing rises again for all countries around the turn of the millennium.

Figure 23: International Wedge for Latin American Countries

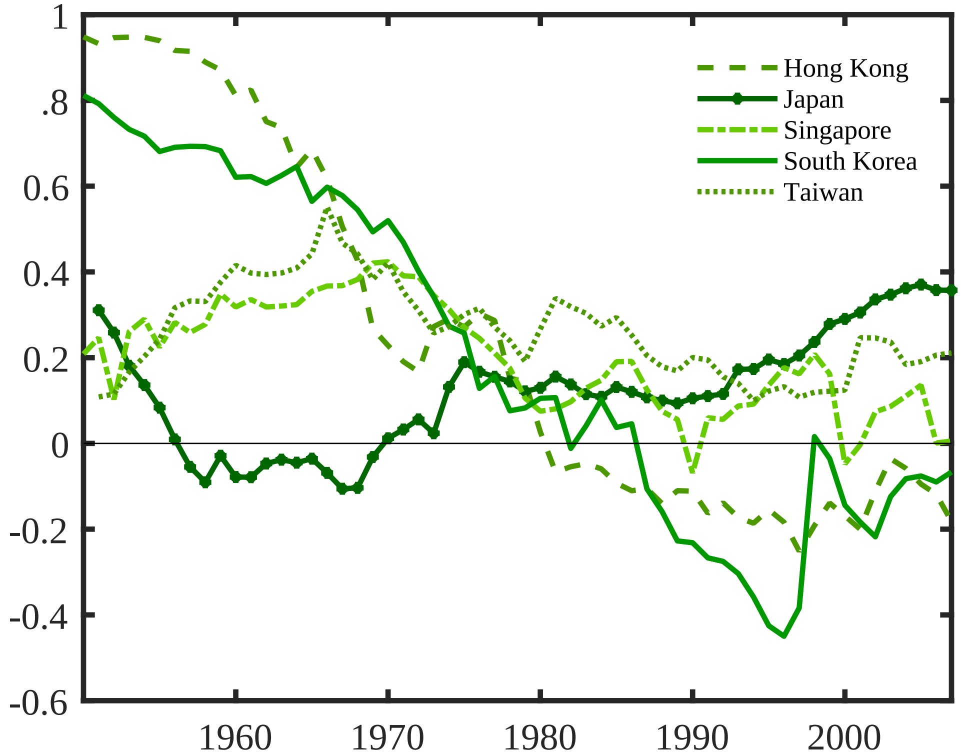


The case of Mexico is particularly interesting. Like the other countries, the tax on borrowing for Mexico starts falling when it signs its Brady plan (Mexico signed its first agreement in March 1989 and its second in February 1990, and the international wedge for Mexico reaches its local minimum in 1989 and 1990). Unlike the other countries, this fall in the tax on borrowing is reversed temporarily in 1994 at the time of the Tequila crisis, before continuing to improve again after 1998.

In fact, the turning points in the HP-smoothed international wedge around the end of the 1980s and early 1990s line up remarkably closely with the dates of Brady agreements in a number of countries. In addition to Mexico in 1989, the Argentine wedge starts turning upwards in 1992 (Argentina signed its first Brady agreement in April of 1992 and its second in April 1993), the Brazilian wedge turns upwards in 1993 (Brazil signed its first agreement in August of 1992 and its second in April 1994), and the Peruvian wedge turns upwards in 1995 (Peru signed its Brady agreement in October 1995). We intend to develop these findings in future work.

In the earlier years of the sample, the aggregate international wedge for Latin America shown in Figure 3 of the paper most closely resembles the wedges of Mexico, Brazil and Argentina, who combined make up roughly two-thirds of our sample in the early years. For these countries, as well as Colombia, the international wedge becomes less positive or more negative in the 1950s (the tax on borrowing grows), before rising at the start of the 1960s, and falling again in the late 1960s.

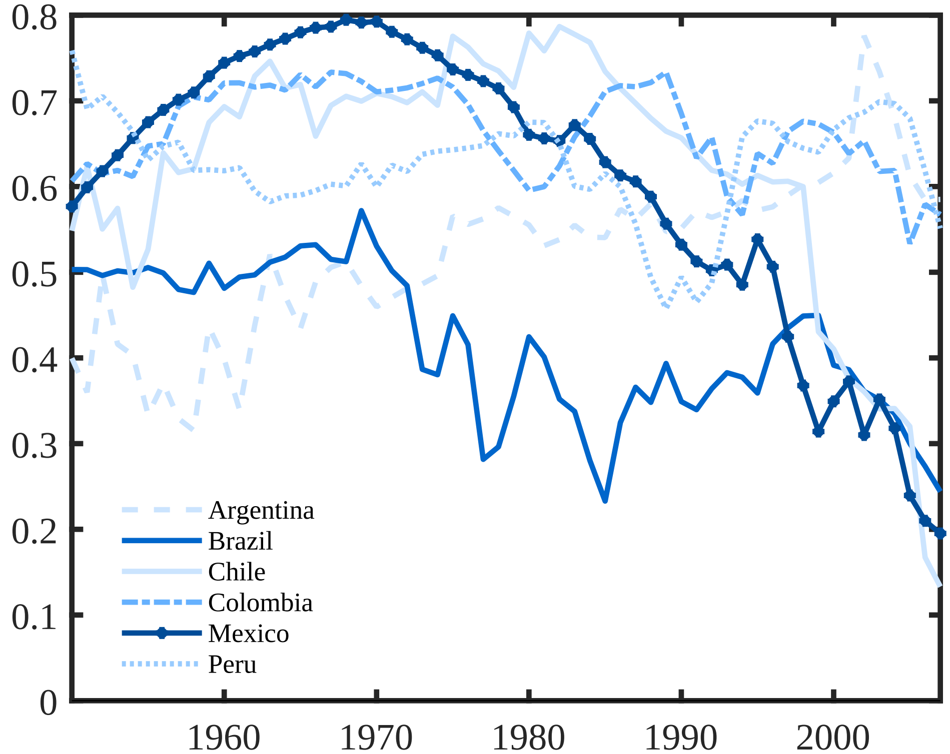
Figure 24: Labor Wedge for Asian Countries



Turning to the labor wedge, Figure 24 plots the labor wedge for all the countries in our Asia region. When compared with the aggregate Asian labor wedge in Figure 4 of the paper we can see that the results, especially in earlier years, are driven mainly by Japan and South Korea who in 1950 account for roughly 90% of total hours worked. There is also a significant common component for all countries: all country's labor wedges in 1990 were at or below their levels at the start of the sample and in most cases were dramatically lower; all countries see a rise in the labor wedge after around 1990. The differences are mostly ones of timing: Japan, Korea and Hong Kong all see large declines in their labor wedges in the 1950s; after 1960, Japan's wedge is flat for a time before rising in the 1970s, while South Korea's and Hong Kong's keep falling; the labor wedges of Taiwan and Singapore do not begin to decline until the late 1960s.

Lastly, Figure 25 plots the labor wedge for all the countries in our Latin America region. If one compares the wedges for the different countries with the aggregate Latin American labor wedge (see Figure 4 in the paper) the common component is again striking. The labor wedge for all countries except Peru rises between 1950 and 1970, in line with the aggregate wedge plotted in the paper. For Mexico, Brazil and Colombia, the labor wedge peaks around 1970, and then falls until the 1980s where it is reversed (in the case of Brazil, only very briefly). For these three countries, the labor wedge is flat or falling until the mid 1990s, where it rises for a time, before falling again after the turn of the millennium. As Brazil and Mexico alone make up roughly half the sample, the aggregate wedge in the paper follows this pattern.

Figure 25: Labor Wedge for Latin American Countries



The other Latin American countries display similar patterns over this period, but with somewhat different timing. Peru's labor wedge is falling in the 1950s before rising slightly to 1980. After that, Peru's labor wedge falls with Brazil's in the 1980s, rises with the aggregate in the 1990s, and then falls after the turn of the millennium. Chile's labor wedge also rises at the beginning of the sample but does not reach a peak until roughly 1980, after which it falls with a pause in the mid 1990s that coincides with the increases in the labor wedge in the other countries. Argentina's wedge falls in the 1950s before rising until the late 1970s. After that, Argentina's labor wedge is flat before rising with other countries around 1990s, spiking at the turn of the millennium with its sovereign default, and then recovering sharply thereafter.

In sum, we find a significant common component in the international and labor wedges for each group of countries. The differences that do exist tend to be confined to smaller countries, and are mostly matters of timing rather than differences in qualitative behavior. As a result, we take this is evidence in favor of our aggregation assumptions.

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