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

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Abstract

After World War II, international capital flowed into slow-growing Latin America rather than fast-growing Asia. This is surprising as, everything else equal, fast growth should imply high capital returns. This paper develops a capital flow accounting framework to quantify the role of different factor market distortions in producing these patterns. Surprisingly, we find that distortions in labor markets — rather than domestic or international capital markets — account for the bulk of these flows. Labor market distortions that indirectly depress investment incentives by lowering equilibrium labor supply explain two-thirds of observed flows, while improvement in these distortions over time accounts for much of Asia's rapid growth.

Keywords: Capital Flows, Labor Markets, Domestic Capital Markets, International Capital Markets.

JEL Codes: E21, F21, F41, J20.

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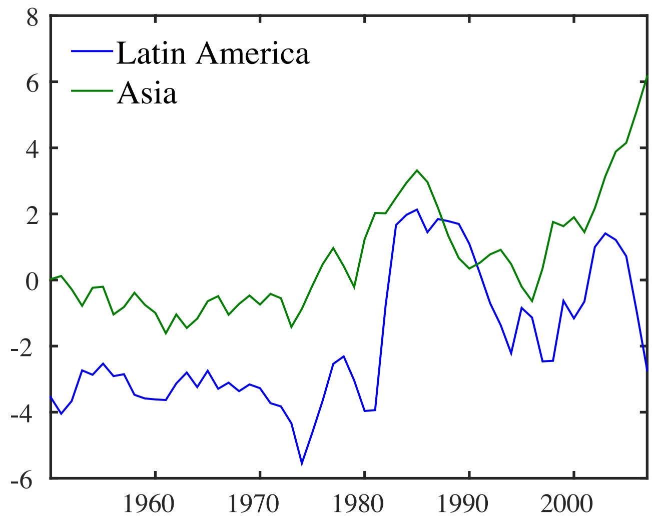
1 Introduction

After World War II, the economies of East Asia boomed while the economies of Latin America stagnated. At the same time, international capital flowed into Latin America in much greater quantities than it did into East Asia. Figure 1 shows that net exports for East Asia (Japan, South Korea, Singapore, Hong Kong, and Taiwan) were close to zero after World War II, while the net exports of Latin America (Argentina, Brazil, Chile, Colombia, Mexico, and Peru) were consistently negative. This is surprising because, all else equal, rapidly growing countries should generate higher returns and thus should receive more capital than slow-growing countries.

Figure 1: Capital Flows to Asia and Latin America (Net Exports % GDP)



Why didn't capital flow into rapidly-growing East Asia after World War II? And why didn't it flow out of slow-growing Latin America? An enormous literature has attempted to explain international capital flows as the result of capital market imperfections—both domestic and international—that limit the opportunities and distort the incentives to move capital out of slow-growing regions and into fast-growing regions. This is natural both because such distortions are the most direct channel for affecting capital flows and because there is significant documentation of capital market imperfections within the literature. In contrast, in this paper we argue that labor market distortions and their evolution simultaneously explain why capital flowed into Latin America and not into Asia, and also why the growth experiences of the two regions were so different.

Our argument is quite simple and is based on the fact that distortions in domestic labor markets caused by labor taxes, labor market regulations, and trade unions, among other factors, reduce the incentive to invest by reducing the equilibrium supply of labor. Lower labor supply depresses the marginal product of capital, which in turn reduces the return to capital and limits the incentive for investment. This is particularly stark in the case of Asia, where hours worked per capita were relatively low in 1950, grew rapidly in the succeeding decade, and then continued to rise more slowly until the beginning of the 1990s. This suggests that labor market distortions were very high in 1950 and declined rapidly initially, with less-rapid declines thereafter. High and declining labor market distortions thus help to explain both why Asia initially grew so fast as well as why growth leveled off after 1995, while the initially high level of these distortions explains why so little capital flowed into the region immediately after World War II.

To the best of our knowledge, labor market distortions have not previously been studied as determinants of the pattern of capital flows. Consequently, the relative importance of labor versus capital market distortions in understanding capital flows is an open question. Toward an answer to this question, this paper presents a capital flow accounting framework to quantitatively assess the relative impact of capital and labor market distortions on the pattern of capital flows between East Asia, Latin America, and the rest of the world (primarily Europe and North America) from 1950 to 2007. Specifically, we construct a multi-country dynamic stochastic general equilibrium model of the world economy augmented with "wedges" that affect the incentives to invest, work, and trade capital internationally. This framework builds on the (closed economy) business cycle accounting framework of Cole and Ohanian (2002) and Chari, Kehoe, and McGrattan (2007) and extends it to an open economy setting through the introduction of an international wedge in which a country-specific tax is applied to the purchase of international contingent claims. In contrast to the business cycle accounting approach, we focus our analysis on lower frequency movements in the data that influence the incentives to consume and save, and hence play a major role in determining international capital flows.

With the wedges added, the model can exactly replicate the data on economic outcomes in the world economy, including world capital flows. We estimate the parameters of the model on a novel dataset of factor accumulation, employment, economic outcomes, and capital flows in Latin America, East Asia, and the rest of the world and use the estimated model to recover the wedges that account for world capital flows. We compare movements in the resulting wedges to a narrative history of significant policy changes in these regions and argue that a significant component of the movements in the wedges is associated with fluctuations in government policies, thus leading us to interpret the wedges structurally as policy distortions.

Our first finding is that the labor market distortions exhibit by far the most variation over time, changing by as much as 50 percent in all three regions. To assess the relative quantitative importance of labor market distortions in explaining capital flows over time, we then conduct counterfactual experiments that shut down movements in all of these distortions. We interpret these experiments as policy reforms. Our most striking finding from these experiments is that labor market distortions—rather than either international or domestic capital market distortions—have been the single most important factor driving the pattern of capital flows for much of the postwar period. Specifically, domestic labor market distortions explain roughly 30 percent of the variation in capital flows to Asia and Latin America during the 1950s and 1960s, while the general equilibrium effects of labor market distortions in other regions account for another 30 to 40 percent in total. All told, the direct and indirect impact of labor market distortions account for about 60-70 percent of capital flows to Asia and Latin America.

International capital market distortions also matter. The most surprising finding is that these fluctuations have had their most significant impact in more recent decades, after many countries liberalized international capital transactions, rather than in the 1950s and 1960s when these distortions were believed to be large. This finding primarily reflects the legacy of past distortions and their propagation through a country's stock of net foreign assets, rather than the contemporaneous effect of new distortions, with the exception of the Latin American debt crisis of the 1980s. We find that the international capital market distortions operated to discourage capital inflows into Asia in the 1950s. However, from the 1960s onward, and contrary to what is commonly believed, Asian capital outflows would have been far greater if not for international capital market distortions. Domestic capital market distortions are found to have a quantitatively far less important impact on capital flows throughout the postwar period.

The remainder of the paper is organized as follows. The next subsection discusses previous literature. Section 2 presents the benchmark model economy and describes how the closed economy wedge methodology used at business cycle frequencies is adapted to the open economy setting using lower frequency data. Section 3 discusses the measurement of the wedges, our data sources, and our procedures for calibrating and estimating parameters. Section 4 presents our results. Section 5 discusses robustness and extensions, and Section 6 concludes. An online appendix collects more details on the material presented in the text.

1.1 Previous Literature

Our paper connects to four distinct but related literatures. First, the paper contributes to the very large literature that studies patterns in capital flows. This literature has largely been focused on how various *capital* market distortions affect flows. Indeed, much of the literature, following Feldstein and Horioka's (1980) examination of the correlation between domestic savings and investment rates, has interpreted their analyses as "tests" of international capital market efficiency (see also Bayoumi and Rose (1993), Taylor (1996), Tesar (1991), and many others). Responding to the failures of these tests, the literature has responded by developing models of international financial frictions ranging from limited commitment (Wright (2001), Kehoe and Perri (2002), and Restrepo-Echavarria (2018)) and default risk (Eaton and Gersovitz (1981), Arellano (2008), Aguiar and

Gopinath (2006), Tomz and Wright (2013), and many others) to exogenous market incompleteness (Bai and Zhang (2010)) and asymmetric information (Atkeson (1991)). A problem with these "tests" of capital mobility is that they typically rely on strong assumptions about the existence and source of gains from trade, and hence these have low power against plausible alternatives as to the nature of the gains from trade. Our approach complements this literature on international financial market inefficiency by evaluating these frictions using a different framework that uses data on a wider set of macroeconomic variables to simultaneously identify the sources of gains from international trade in capital *and* to back out the potential role of distortions in limiting that trade.

Our emphasis on measuring the gains from trade and in exploring the role of frictions outside of capital markets is shared by a number of other recent studies of international capital flows. Caselli and Feyrer (2007) directly estimate the marginal product of capital for many countries and find that these estimates have converged over time, once the marginal products are adjusted for the share of non-reproducible capital, such as land and natural resources. They conclude on the basis of this convergence that the gains from international trade in capital have declined, implying that any international capital market distortions have become less important over time.[1]

We explore the connection of their results to our own below in Subsection 4.3.1. Obstfeld and Rogoff (2001), Fitzgerald (2012), Reyes-Heroles (2016), Eaton, Kortum, and Neiman (2016), and others explore the role of trade costs in explaining a number of facts about international flows. We argue that our approach is complementary in that it provides evidence that can be used to test for the role of trade costs, although we argue in Section 5 that our findings suggest a relatively minor role for these costs in explaining the relative allocation of capital flows between Asia and Latin America.

We follow in the footsteps of Alfaro, Kalemli-Ozcan, and Volosovych (2008), who study the role of institutions in driving the incentive to reallocate capital around the world. Unlike them, we focus on labor market institutions that depress labor supply and lower the return to capital as the key factor. Alfaro, Kalemli-Ozcan, and Volosovych (2014) study the difference between official and private capital flows since 1970 and find that private flows are more closely in accordance with standard models than are official flows. This relies on significant departures from Ricardian equivalence to explain why private flows do not offset official flows in order to produce aggregate capital flows in line with the theory. Below in Section 5, we argue that our approach yields evidence as to the kind of departure that might be relevant in the data. Aguiar and Amador (2016) provide a model of one such mechanism.

Second, our paper makes contact with the literature on East Asian growth and the debate as to

[1]Ohanian and Wright (2008) and Monge-Naranjo, Sanchez, and Santaeulalia-Llopis (2015) extend the Caselli and Feyrer (2007) approach and propose alternative methods for estimating the marginal product of physical capital.

the relative contribution of factor accumulation (see Young (1995)) and productivity growth (see Hsieh (1999)) in explaining East Asia's rapid growth. We argue that incorporating data on international capital flows, and understanding the causes of the observed rapid factor accumulation, help to shed light on this debate. Specifically, we find evidence for substantial distortions in East Asian labor markets in the 1950s that both depressed returns to investment, limiting the incentive for international capital inflows, and, as the distortions were unwound, drove rapid factor accumulation and economic growth thereafter.

Third, our paper builds on the literature on business cycle accounting in closed economies following Cole and Ohanian (2002) and Chari, Kehoe, and McGrattan (2007). Unlike these papers, we examine open economies and focus on medium- and longer-term movements in economic variables, which play a larger role in determining the level of consumption, and hence also savings and international capital flows, than do fluctuations at business cycle frequencies. Our paper is also related to the literature on business cycle accounting in small open economies (see Lama (2011) and Rahmati and Rothert (2014)). In contrast to their partial equilibrium (small open economy) approach with incomplete markets, we show how to apply a general equilibrium complete markets model to data on the world economy constituted from multiple countries.

A related approach, and the paper perhaps most closely related to ours, is Gourinchas and Jeanne (2013), which studies capital flow data from 1980 to 2000 for individual countries using wedges in a deterministic open economy growth model without transitional dynamics. They also abstract from labor supply decisions and so are unable to address the importance of the labor wedge. We discuss the differences between our analysis and that of Gourinchas and Jeanne (2013) in greater detail in Subsection 4.3.2 below. For now, we simply note that in comparison we emphasize capital flows during the decades from 1950 to 1970, and that our dynamic out-of-steady-state analysis allows us to study the impact of movements in the labor wedge, which chiefly matter out of steady-state.

Fourth and finally, our paper complements the large literature seeking to identify the presence of distortions to factor markets both at home and abroad. Much of this literature computes indices of distortions by examining legal restrictions on the operation of markets and then counting up the number of different types of restrictions. As such they provide a *qualitative* measure of the presence of restrictions that are "on the books" (*de jure*). Examples of this approach in international capital markets include the large number of studies based on the International Monetary Fund's *Annual Report on Exchange Arrangements and Exchange Restrictions,* including Chinn and Ito (2001), Quinn (1997), and many others, while examples covering domestic labor markets and capital markets are cited below. As is openly acknowledged, these measures have two problems. First, some restrictions that are on the books may not be enforced in practice, while some restrictions that are in practice may not appear on the books (a *de jure* restriction may not be a *de facto* restriction and vice versa). Second, ultimately we are more interested in the quantitative significance of such controls than we are in a qualitative measure of their presence. By contrast, our paper uses data on equilibrium quantities to construct quantitative measures of the impact of *de facto* restrictions on international and domestic capital markets as well as domestic labor markets that we believe serve as a useful complement to these qualitative *de jure* measures.

2 Capital Flow Accounting

As noted in the introduction, the existing literature has focused on distortions in capital markets, both domestic and international, in explaining anomalous international capital flows. In contrast, we hypothesize that labor market distortions played an important role in determining capital flows. In situations like this with a clear substantive question, many possible theories, and no canonical answer, it is productive to adopt an approach capable of identifying possible explanatory channels and quantifying their significance. Hence, we develop a capital flow accounting framework. Our method is a direct descendant of the closed economy business cycle accounting approaches of Cole and Ohanian (2002) and Chari, Kehoe, and McGrattan (2007) extended to the general equilibrium of a world economy. Unlike this earlier literature, which focuses on business cycle fluctuations in macroeconomic variables, we are also interested in medium- and long-term frequencies that play a large role in determining capital flows and hence pay particular attention to long-run trends in variables.

Also unlike this literature, we start with a variant on the class of models typically used to analyze international capital flows (for example, Mendoza (1991) and Baxter and Crucini (1993, 1995)). We refer to this as our benchmark model and augment it with wedges so that it is able to exactly replicate the data on macroeconomic outcomes including capital flows. These wedges are described as taxes that distort the marginal conditions determining optimal labor supply, domestic investment, and foreign investment but stand in for a wider range of departures from our benchmark accounting framework. We explore alternative interpretations of these wedges in Section 5 below.

2.1 Households

Consider a world economy composed of three "countries" indexed by j, where $j = L$ stands for "Latin America," $j = A$ stands for "(East) Asia," and $j = R$ stands for the "rest of the world." Time evolves discretely and is indexed by $t = 0, 1, \ldots$, so that N_{jt} denotes the population of country j at time t. The decisions of each country are made by a representative agent with preferences over consumption C_{jt} and per capita hours worked h_{jt} ordered by

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

The parameters governing preferences—the discount factor β, the preference for leisure φ, and the Frisch elasticity of labor supply $1/\gamma$—are assumed common across countries; therefore, any cross-country differences in core preferences will hence be attributed to the wedges that we introduce next. We discuss how this assumption affects our results in Subsection 5.1 below.

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

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

with initial capital K_{j0} and bonds B_{j0} given. Here W_{jt} is the wage per hour worked, r_{jt}^{K} the rental rate of capital, P_{jt}^{K} the price of new capital goods, and P_{jt}^{*K} the price of old capital goods, which will differ from the price of new capital goods due to the presence of adjustment costs in capital. In this complete markets environment, the prices of state-contingent international bonds at time t that pay off in one state at $t+1$ are composed of a risk-adjusted world price q_{t+1} multiplied by the probability of the state occurring, which allows us to write the expected value of the risk-adjusted expenditures on bonds on the left-hand side of the flow budget constraint. Households also receive profits Π_{jt} from their ownership of domestic firms.

The τ represent taxes or "wedges" on factor payments and investment income. Specifically, τ^h is a tax on wage income (the labor wedge), τ^B is a tax on income derived from international assets or, equivalently, a subsidy on the cost of paying for international liabilities (the international wedge), while τ^K is a tax on income from domestic capital (the capital wedge). Any revenue from these taxes net of the level of government spending G_{jt} are assumed to be transferred in lump-sum fashion to or from households each period as T_{jt},

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

This implies that there is no government borrowing. As Ricardian equivalence holds in our model, this is without loss of generality. However, some authors (for example, Alfaro, Kalemli-Ozcan, and Volosovych (2014)) have argued that an understanding of government borrowing is necessary to rationalize observed capital flows. We discuss these issues in more detail in Subsection 5.3 below.

The first-order conditions for the household can be rearranged to find the optimal condition governing the labor supply,

$$\left(1-\tau_{jt}^{h}\right) W_{jt} \frac{N_{jt}}{C_{jt}} = \varphi h_{jt}^{\gamma}, \tag{2}$$

the Euler equation for domestic capital,

$$1 = E_t \left[\beta \frac{C_{jt}/N_{jt}}{C_{jt+1}/N_{jt+1}} \left(1-\tau_{jt+1}^{K}\right) \frac{r_{jt+1}^{K} + P_{jt+1}^{*K}}{P_{jt}^{K}} \right], \tag{3}$$

and the Euler equation for state-contingent international assets,

$$\frac{C_{jt+1}/N_{jt+1}}{C_{jt}/N_{jt}} = \frac{\beta}{q} \left(1-\tau_{jt+1}^{B}\right). \tag{4}$$

Although our focus is on capital flows, which are influenced by economic fluctuations at short-, medium-, and long-run frequencies, our framework shares a number of elements with the closed economy business cycle accounting literature (see Cole and Ohanian (2002) and Chari, Kehoe, and McGrattan (2007)). However, while the labor and capital wedges are familiar, the international wedge is new and has been added to create an open economy accounting framework. This term drives a wedge between the growth rate of the domestic marginal utility of consumption and the return on international assets. It differs from the way international factors are subsumed into the closed economy framework of Chari, Kehoe, and McGrattan (2007), where net exports are treated as an additive output shock equivalent to government expenditure.

2.2 Firms

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

$$W_{jt} = (1-\alpha)\frac{Y_{jt}}{h_{jt}N_{jt}}, \text{ and } r_{jt}^{K} = \alpha \frac{Y_{jt}}{K_{jt}}. \tag{5}$$

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

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

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

$$P^K_{jt} = \frac{1}{1-\phi'\left(\frac{X_{jt}}{K_{jt}}\right)}, \tag{6}$$

$$P^{*K}_{jt} = P^K_{jt}\left(1-\delta-\phi\left(\frac{X_{jt}}{K_{jt}}\right)+\phi'\left(\frac{X_{jt}}{K_{jt}}\right)\frac{X_{jt}}{K_{jt}}\right). \tag{7}$$

We assume that adjustment costs are of the quadratic form:

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

All production parameters—the output elasticity of capital α, the depreciation rate δ, and those governing adjustment costs ν and κ—are assumed constant across countries; we return to this assumption in Section 5.1 below.

2.3 Growth and Uncertainty

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

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

$$\begin{aligned}
\ln A_{Rt+1} &= \ln A_{Rt} + \ln\pi_{ss} + \sigma^A_R\varepsilon^A_{Rt},\\
\ln N_{Rt+1} &= \ln N_{Rt} + \ln\eta_{ss} + \sigma^N_R\varepsilon^N_{Rt},
\end{aligned}$$

where π_{ss} and η_{ss} are the growth rates in world productivity and population that would occur in the deterministic steady-state of our model. The parameters σ_R^A and σ_R^N govern the volatility of these stochastic trends. In order to make our model of the world economy stationary, we scale by the level of effective labor in the rest of the world $Z_t = A_{Rt}^{1/(1-\alpha)} N_{Rt}$. Note that our specification nests a constant growth rate as a special case.

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

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

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

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

$$\ln\left(1-\tau_{jt+1}^m\right) = \left(1-\rho_j^m\right) \ln\left(1-\tau_{jss}^m\right) + \rho_j^m \ln\left(1-\tau_{jt}^m\right) + \sigma_j^m \varepsilon_{jt+1}^m, \tag{8}$$

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

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

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

2.4 Model Solution

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

The large number of state variables (23) leads us to use perturbation methods. To do so, we make additional assumptions to ensure that the model has a unique non-degenerate deterministic steady-state (which serves as the point about which the approximation is taken). To see the need for these assumptions, note that for our reference country R and any other country j, we can take equation (4) and rearrange to obtain the first equality in

$$\frac{C_{jt+1}/N_{jt+1}}{C_{Rt+1}/N_{Rt+1}} = \frac{C_{jt}/N_{jt}}{C_{Rt}/N_{Rt}} \frac{1-\tau^B_{jt+1}}{1-\tau^B_{Rt+1}} = \frac{C_{jt}/N_{jt}}{C_{Rt}/N_{Rt}} \left(1-\tau^B_{jt+1}\right). \tag{9}$$

This means we cannot separately identify each country's international wedge τ^B_j, and so we normalize the rest of the world international wedge to zero, $\tau^B_{Rt+1} = 0$, yielding the second equality. It also means that, if the steady-state international wedge, τ^B_{jss}, is not equal to zero, there is a long-run trend in relative consumption levels so that the deterministic steady-state distribution of consumption is degenerate (one country's share of consumption must converge to zero). Moreover, simply assuming that $\tau^B_{jss} = 0$ for all j does not pin down a *unique* steady-state relative consumption level. Intuitively, the level of the international wedge out of steady-state affects the accumulation of international assets, which in turn affects long-run consumption levels. In terms of equation (9), the *growth rate* of relative consumption is a first-order autoregressive process that converges to zero in the deterministic steady-state; the long-run *level* of relative consumption depends upon the entire sequence of realizations of the international wedge.

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

$$1-\tau^B_{jt} = 1-\tau^{*B}_{jt} + \Psi_{jt}.$$

We refer to τ^{*B} as the international wedge from now on (typically suppressing the asterisk) and assume that it follows a first-order autoregressive process with the steady-state assumed to be zero:

$$\ln\left(1-\tau_{jt+1}^{*B}\right)=\rho_j^B \ln\left(1-\tau_{jt}^{*B}\right)+\sigma_j^B \varepsilon_{jt+1}^B. \tag{10}$$

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

$$\Psi_{jt}=\left(1-\tau_{jt}^{*B}\right)\left[\left(\frac{C_{jt}/N_{jt}}{C_{Rt}/N_{Rt}}\frac{1}{\psi_{j0}}\right)^{-\psi_{j1}}-1\right]. \tag{11}$$

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

$$\ln\frac{C_{jt+1}/N_{jt+1}}{C_{Rt+1}/N_{Rt+1}}=\frac{\psi_{j1}}{1+\psi_{j1}}\ln\psi_{j0}+\frac{1}{1+\psi_{j1}}\ln\frac{C_{jt}/N_{jt}}{C_{Rt}/N_{Rt}}+\frac{1}{1+\psi_{j1}}\ln\left(1-\tau_{jt+1}^{*B}\right). \tag{12}$$

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

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

3 Implementation

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

3.1 Using the Data to Measure the Wedges

Realizations of the labor, capital, and international wedges can all be measured by feeding data on the national income and accounting expenditure aggregates through the optimality conditions of households and firms combined with the equilibrium conditions of the model. Realizations of the labor and international wedges can be computed directly from first-order conditions without knowing the solution of the model. The capital wedge, on the other hand, requires the computation of expectations about future capital returns and hence requires both estimating and solving the model.

To see this, note that under our assumption of complete markets, the composite international wedge and portfolio tax τ^{B}_{jt+1} can be recovered from data on the growth in relative consumption levels, as shown in equation (9). Estimation of equation (12) serves to both decompose the composite into the international wedge τ^{*B}_{jt+1} and the portfolio tax Ψ_{jt+1} and estimate the parameters governing the evolution of the international wedge and the portfolio tax. Note that under the assumptions of our model, the residual in this equation—the international wedge—follows an autoregressive process; relative consumption does not follow a simple first-order autoregressive process. Nonetheless, all that is needed to estimate the process governing the international wedge and the parameters of the portfolio tax is data on the growth in relative consumption levels. This can be done without solving the entire model.

The labor wedge can also be recovered, and its evolution process estimated, outside of the model. Specifically, using the optimal labor supply condition for the household (2) and the optimal employment decision of the firm (5), we obtain

$$1-\tau^{h}_{jt} = \frac{\varphi}{1-\alpha} h^{\gamma}_{jt} \frac{h_{jt}N_{jt}}{Y_{jt}} \frac{C_{jt}}{N_{jt}}. \tag{13}$$

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

Lastly, the capital wedge is determined from the Euler equation for the household (3), the optimal capital decision of the consumer good firm (5), and the optimality conditions of the capital good firm (6) and (7). Denoting by $x_{jt+1} = X_{jt+1}/K_{jt+1}$ the ratio of investment to the capital stock, we obtain the capital wedge from

$$1 = E_t \left[\beta \frac{C_{jt+1}/N_{jt+1}}{C_{jt}/N_{jt}} \left(1 - \tau^K_{jt+1}\right) \frac{\alpha \frac{Y_{jt+1}}{K_{jt+1}} + \frac{1-\delta-\phi\left(x_{jt+1}\right)+\phi'\left(x_{jt+1}\right)x_{jt+1}}{1-\phi'\left(x_{jt+1}\right)}}{\frac{1}{1-\phi'\left(x_{jt}\right)}} \right]. \tag{14}$$

Note that it is impossible to separately identify the level of the capital wedge from the level of the discount factor, and hence we focus on changes in the levels of these wedges, and not the levels themselves, below. Unlike the labor and international wedges, this requires computing an expectation, which in turn requires the solution of the model and estimation of the processes governing the evolution of all exogenous variables. Moreover, it also requires a value for the initial capital stock from which data on investment can be used to derive the entire sequence of capital stocks, which we estimate along with all other parameters in the model. We describe the solution and estimation of the model after we describe our data sources.

3.2 Data Sources and Methods

As discussed in the previous subsection, to recover our wedges we need data on the main national accounts expenditure aggregates—output Y_{jt}, consumption C_{jt}, investment X_{jt}, and net exports NX_{jt}—along with data on population N_{jt} and hours worked h_{jt}, for each of our three "countries." In this subsection, we first describe our rationale for grouping countries into regions and then briefly describe data sources and methods. More detail is available in Appendix B.

Our country aggregates for Asia and Latin America were chosen on the basis of the similarity of their economic development paths, as well as on the availability of data. Asia is defined to be the aggregate of Japan and the four "East Asian Tigers" of South 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) and Figure 11 in Appendix B). Other Asian economies were excluded on the grounds that their development proceeded differently: the "Tiger Cub Economies" of Malaysia, Thailand, Philippines, and Indonesia developed less rapidly and followed different development strategies (see Figure 13 in Appendix B); China's rapid economic development did not begin until at least the late 1970s; and India's liberalization did not occur until the 1990s (see Figure 12 in Appendix B).

Our Latin American aggregate was constrained by data availability to include only Argentina, Brazil, Chile, Colombia, Mexico, and Peru. These six countries accounted for 82 percent of the GDP from the entirety of Latin America 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 stands apart as a major oil exporter that ran trade surpluses averaging 10 percent of GDP between 1950 and 1975 (see Figure 14 in Appendix B). The rest of the world aggregates data from 22 advanced economies in North America, Europe, and Oceania, which are described in more detail in Appendix B. Appendix B also plots the resulting data series that are used in the estimation.

Data were obtained from a number of sources. Briefly, where available, data from the Organisation for Economic Co-operation and Development were used for its member countries. For other countries, data from the World Bank's *World Development Indicators* were our primary source. Data prior to 1960 were typically taken from the World Bank's *World Tables of Economic and Social Indicators*. The Groningen Growth and Development Center was a valuable source of hours worked data. Gaps in the resulting database were filled using a number of other sources as detailed in the online appendix. A small number of missing observations are replaced using data extrapolated or interpolated from other countries in the relevant country aggregate. 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. Appendix B provides a detailed country-by-country description of data sources.

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

3.3 Calibration and Estimation

As noted above, we solve the model numerically by taking a first-order log-linear approximation of the model around its deterministic steady-state, which is well defined under our assumptions on the portfolio tax. After imposing symmetry in the preference and production parameters across countries, we must assign values to 68 parameters. In this subsection, we describe how some parameters are calibrated to standard values and others are estimated outside the model, while the remainder are estimated by Bayesian methods using the Kalman filter.

The parameters governing preferences and production are assumed constant across countries, so that any differences across countries are attributed to the wedges. Of these common parameters (collected in Table 1), six are calibrated to standard values, while a seventh is a normalization. Specifically, we set the output elasticity of capital in the Cobb-Douglas production function α to 0.36, the discount factor β to 0.96, and the depreciation rate δ to 7 percent per year. These are all standard values. The curvature for the disutility of labor γ is set to 1.5, which implies a Frisch elasticity of labor supply of two-thirds. This is within the range typically estimated using micro

Table 1: Common Parameter Values

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

data on the labor supply intensive margin, a little higher than estimates using micro data on the extensive margin, but smaller than estimates typically found using macro data (see the surveys by Pencavel (1987), Keane (2011), and Reichling and Whalen (2012)). As is evident from equation (13), we cannot separately identify the household's preference for leisure φ from the long-run labor wedge τ^h_{jss}, so we normalize φ to 1; this means that we are cautious in interpreting the estimated level of the labor wedge and only conduct experiments in which this wedge is set to its sample mean.

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

The remaining parameters govern the evolution of population, productivity, government spending; the labor, capital, and international wedges; the portfolio tax; and the initial levels of capital in each country. As noted above, some can be estimated without knowing the solution of the model, which helps reduce the number of parameters that are estimated within the model. The processes for the evolution of population, government spending, and the international wedges, as well as the parameters for the portfolio tax, are estimated outside of the model. We impose the assumption that the world economy grows at 2 percent per year in the long run, or $z_{ss} = \pi_{ss}^{1/(1-\alpha)} \eta_{ss} = 1.02$.

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

All other parameters are then estimated using Bayesian methods (see An and Schorfheide (2007)). Our decision to use Bayesian methods is a pragmatic one; our use of standard prior distributions serves to focus the estimation on the "right" region of the parameter space. Our choices are collected in Appendix C along with the plots of the prior and posterior distributions, which show 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.

The point values for each of our parameters are collected in Table 2. The estimates imply that long-run population growth of the world is roughly 0.67 percent per year. In the long run, it is estimated that the population of Latin America will exceed that in the rest of the world aggregate by 13 percent, while in East Asia the population will settle down to 29 percent of the rest of the world level. Productivity, on the other hand, will converge to 37 percent of the rest of the world level in Latin America and to 77 percent of that level in Asia. Under our assumption of 2 percent long-run growth, the long-run growth of productivity settles down to 0.85 percent per year, or $\pi_{ss} = 1.0085$. Productivity and population are very persistent in all regions. Government expenditure stabilizes at between 12 percent (Asia) and 19 percent (rest of the world) of GDP and is estimated to be quite persistent.

The long-run level of the labor wedge cannot be separately identified from a country's preference for leisure parameter φ. After normalizing $\varphi = 1$ for all countries, the long-run labor wedge is found to be positive for Asia and the rest of the world and negative for Latin America, indicating that average hours worked in Latin America are larger than predicted from implied wages and consumption levels and hence must require a subsidy. Of course, this could simply reflect differences in preferences: perhaps people in Latin American have a lower preference for leisure? In order to avoid being drawn into debates on this question, we focus our attention on changes in these measured wedges over time rather than cross-country differences in their levels. Likewise, the steady-state levels of the capital wedge cannot be separately identified from the discount factor. Given our normalization for β, all long-run capital wedges are small and are approximately zero in Asia.

Table 2: Country-Specific Parameter Values

Process	Region	Steady State	Persistence	Standard Deviation
Population	Asia	$n_{Ass} = 0.29$	$\rho^n_A = 0.97$	$\sigma^n_A = 0.004$
	Latin America	$n_{Lss} = 1.13$	$\rho^n_L = 0.90$	$\sigma^n_L = 0.003$
	Rest of World	$\eta_{ss} = 1.0067$	$\rho^n_R = 1^{**}$	$\sigma^N_R = 0.001$
Productivity	Asia	$a_{Ass} = 0.77$	$\rho^a_A = 0.89$	$\sigma^a_A = 0.03^*$
	Latin America	$a_{Lss} = 0.37$	$\rho^a_L = 0.99$	$\sigma^a_L = 0.03^*$
	Rest of World	$\pi_{ss} = 1.0085^{**}$	$\rho^a_R = 1^{**}$	$\sigma_\pi = 0.01^*$
Government Wedge	Asia	$g_{Ass} = 0.12$	$\rho^g_A = 0.86$	$\sigma^g_A = 0.17$
	Latin America	$g_{Lss} = 0.18$	$\rho^g_L = 0.80$	$\sigma^g_L = 0.05$
	Rest of World	$g_{Rss} = 0.19$	$\rho^g_R = 0.73$	$\sigma^g_R = 0.03$
Labor Wedge	Asia	$\tau^h_{Ass} = 0.14$	$\rho^h_A = 0.99^*$	$\sigma^h_A = 0.04^*$
	Latin America	$\tau^h_{Lss} = -0.25$	$\rho^h_L = 0.99^*$	$\sigma^h_L = 0.04^*$
	Rest of World	$\tau^h_{Rss} = 0.47$	$\rho^h_R = 0.99^*$	$\sigma^h_R = 0.02^*$
Capital Wedge	Asia	$\tau^k_{Ass} = 0.002$	$\rho^K_A = 0.76^*$	$\sigma^K_A = 0.01^*$
	Latin America	$\tau^k_{Lss} = 0.05$	$\rho^h_A = 0.83^*$	$\sigma^K_A = 0.01^*$
	Rest of World	$\tau^k_{Rss} = 0.04$	$\rho^h_A = 0.98^*$	$\sigma^K_A = 0.00^*$
International Wedge	Asia	$\tau^B_{Ass} = 0^{**}$	$\rho^B_A = 0.36$	$\sigma^B_A = 0.02$
	Latin America	$\tau^B_{Lss} = 0^{**}$	$\rho^B_L = 0.24$	$\sigma^B_L = 0.03$
Portfolio Tax	Asia	$\psi_{A0} = 0.95$	$1-\psi_{A1} = 0.94$	—
	Latin America	$\psi_{L0} = 0.13$	$1-\psi_{L1} = 0.94$	—

Notes: * denotes parameter is estimated inside the model; ** denotes the parameter is set by assumption; all other parameters are estimated or calibrated to match some feature of the data, outside the model; "—" denotes "not applicable." Appendix C contains more details on the estimation procedures.

We have also normalized the international wedge in the rest of the world to 1, and by assumption the international wedge is zero in steady-state in both regions in order to ensure a non-degenerate steady-state level of relative consumption. The international wedge in either region is not estimated to be particularly persistent. Long-run relative consumption per capita levels are pinned down by the portfolio tax parameters and imply that consumption per capita in Asia will tend to 95 percent, and in Latin America will tend to only 13 percent, of the rest of the world levels. The curvature parameters of the portfolio tax are quite small—roughly 0.06—ensuring that the tax is also quite small and that convergence to this long-run portfolio is slow, implying in turn that the addition of this portfolio tax has little impact on the short- and medium-run dynamics of the model.

4 Results

In this section, we report the recovered values of productivity and of the labor, capital, and international wedges. We first examine productivity in order to ascertain where capital should have flowed in the absence of wedges. We then examine each wedge in turn with a view to accounting for actual capital flows.

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

Nonetheless, toward a structural interpretation of these wedges, we present our findings on the behavior of the recovered wedges in parallel with a narrative history of factor market distortions in Latin America and Asia. We show that movements in our recovered wedges are often associated with changes in both quantitative and qualitative changes in measures of both tax and non-tax regulatory distortions. This leads us to a structural interpretation of the wedges as reflecting policy distortions affecting factor markets. With this structural interpretation in hand, we carry out counterfactual exercises to assess the relative importance of labor market, domestic capital market, and international capital market distortions. Our interest is in the answer to the following question: Given the evolution of productivity growth across countries, why didn't more capital flow into Asia and out of Latin America? As a result, we take the evolution of productivity as given in our counterfactual experiments.

4.1 The Evolution of Productivity and the Wedges

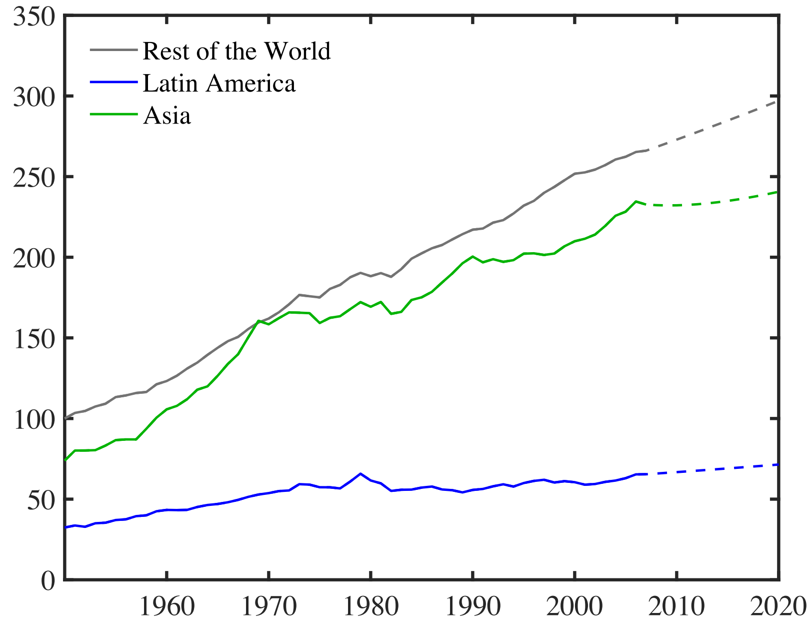
4.1.1 Productivity

Our estimates of total factor productivity across the three regions (A_{jt}) are depicted in Figure 2. The solid lines represent the realizations of the wedges, while the dashed segments represent the forecast implied by the stochastic process of each of the wedges, which is important in evaluating incentives to save and consume, and hence also for capital flows. All levels are scaled relative to the rest of the world in 1950, which is normalized to 100.

The figure shows that Asia's productivity starts at about three-quarters of the rest of the world level in 1950 and catches up by 1970 before beginning to fall behind again thereafter. This is made more explicit in Table 3, which collects by decade the growth rates of output and hours worked from the data, and capital and productivity growth implied by the estimated model.[2] Latin American productivity growth is lower than that in Asia for the first two decades of our sample and especially so in the 1960s. This further emphasizes the puzzle: everything else equal, capital should have flowed into Asia in greater quantities than into Latin America in the first few decades

[2]Note that we do not use capital data for the estimation. We use the capital accumulation equation together with investment data and allow the Kalman filter to estimate the initial level of capital.

Figure 2: Productivity



after World War II.

Our productivity estimates for the rest of the world and for Latin America are within the ranges found by other authors. The productivity growth slowdown of the 1970s appears clearly for the rest of the world, while the Latin American lost decade of the 1980s shows up as negative productivity growth.

Our findings for East Asia contribute to the debate on the East Asian miracle associated with Young (1995), Hsieh (2002), and Krugman (1994). As our method takes data on the quantity of hours worked and investment as inputs into computing productivity, our approach to calculating productivity growth is most similar to the commonly used primal approach, used in the context of this debate by Young (1995). Although similar in spirit, the implementation differs in the details: whereas Young reports estimates using a rich dataset of labor input controlling for educational differences starting in 1966, our cross-country comparison begins in 1950, which forces us to use data on raw hours worked, and whereas Young identifies the output elasticities of factors off their observed labor shares, we calibrate these elasticities to a standard value as a result of the fact that the taxes and other distortions that are central to our framework can drive a wedge between factor shares and these elasticities. Despite these differences, our conclusions are largely in accord. Whereas Young finds average productivity growth from 1966 to 1990 ranged from 0.2 (Singapore) to 2.3 percent (Hong Kong), our aggregate productivity growth rate (which includes Japan) averages 1.8 percent from 1966 to 1990. This is also in the neighborhood of the primal estimates reported by Hsieh (2002).

Our results differ from the dual estimates computed by Hsieh—which rely on data on factor

Table 3: Model-Estimated Growth Rates of Output, Factor Inputs, and TFP

	1950s	1960s	1970s	1980s	1990s	2000s
	Rest of the World					
Y	3.8	4.4	3.4	2.6	2.7	2.4
K	3.2	4.1	3.9	2.7	2.2	2.7
H	0.9	0.3	0.3	0.7	0.6	0.9
A	2.1	2.7	1.8	1.2	1.5	0.9
	Latin America					
Y	5.4	5.5	5.8	1.9	2.9	3.3
K	2.7	5.4	4.0	6.2	2.1	2.7
H	2.2	2.2	3.4	2.5	1.5	2.3
A	3.0	2.2	2.2	-1.9	1.2	0.8
	Asia					
Y	8.3	10.1	5.4	4.0	2.1	2.4
K	7.3	10.9	10.2	5.2	4.7	2.1
H	3.5	2.3	1.6	1.4	-0.1	0.2
A	3.4	4.7	0.7	1.3	0.5	1.5

prices instead of quantities—who finds significantly higher growth rates of productivity for Singapore and Taiwan. One possible explanation is that data on asset returns used by Hsieh deviate from the true return to capital as a result of distortions like the ones we emphasize in this paper. Young (1992, 1998) and Hsieh (2002) debate this possibility in the context of Singapore, where changes in corporate taxes, forced savings, banking regulations, and a monopolistic banking system may have all produced a capital wedge. Our findings can therefore be construed as supportive of the arguments of Young. Having said that, our results also indicate that by excluding the period 1950 to 1965, Young's analysis omitted some of the most impressive periods of East Asian productivity growth.

In summary, our findings for productivity growth, particularly between 1950 and 1970, suggest that, all else equal, capital should have flowed into Asia rather than into Latin America. In order to account for this discrepancy, there must exist offsetting incentives in either domestic or international capital markets, or in domestic labor markets. We turn to our estimates of these incentives—the wedges—and their interpretation as policy distortions, next.

4.1.2 The International Wedge

The evolution of the international wedge τ^B is depicted in Figure 3. Since all wedges are relative to the rest of the world, the figure depicts only Latin America and Asia. A key contribution to the accounting literature is that the international wedge is identified off of *relative* consumption *growth* rates from the Euler equation for international asset purchases (4). As a consequence, the wedge is quite volatile, and so, in addition to the recovered wedge (the dotted lines), we also plot the Hodrick-Prescott trend of the wedge (solid line) in order to highlight the medium-term movements of the wedge.[3]

To interpret Figure 3, note that a positive wedge reduces payments on net foreign assets and hence acts as a tax on foreign savings and a subsidy on foreign borrowing; a negative wedge is a subsidy on foreign savings and a tax on foreign borrowing. That is, a value of -0.05 is equivalent to a 5 percent tax on borrowing. Viewed in this light, the figure shows that from 1950 until the end of the 1970s (roughly corresponding to the Bretton Woods era), both Latin America and Asia faced taxes on international borrowing. This is consistent with the idea that capital controls under Bretton Woods discouraged foreign borrowing. However, the implied tax in Asia was roughly four times larger than the one faced by Latin America during this period. By the 1990s, these wedges had largely converged, consistent with the pattern identified in Figure 1, which shows that capital flows to the two regions become more synchronized toward the end of the sample. The boom in borrowing by Latin America at the end of the 1970s shows up as a significant increase in the subsidy on borrowing that is sharply reversed in the mid-1980s when the Latin American debt crisis reached its peak. The subsidy on borrowing in both Latin America and Asia quickly became a tax on borrowing at the end of the 1990s, which coincides with a series of financial crises that directly or indirectly affected countries in both regions.

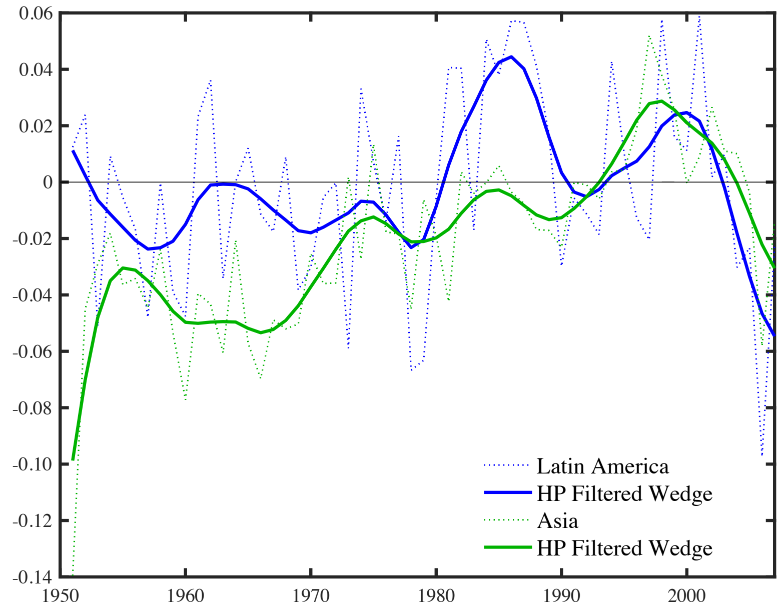
In summary, the levels and medium-term movements in the international wedge are qualitatively consistent with well-known events in the history of the international financial system: capital controls under Bretton Woods discouraged borrowing, while financial crises in the 1980s and late 1990s are associated with declines in borrowing subsidies or increases in taxes on borrowing. This leads us to conclude that movements in our international wedge are associated with structural shocks to international financial markets; below we will conduct experiments to assess the importance of the international wedge in which these structural shocks are assumed not to occur.

Perhaps more surprisingly, our method reveals that capital controls in Asia were much more significant than those in Latin America in the first three decades of our sample. This highlights one of the advantages of our approach over studies that construct qualitative indicators of capital controls based on descriptions of capital controls in the IMF's *Exchange Arrangements and Exchange Restrictions* publication (for example, Chinn and Ito (2001), Quinn (1997), and many others). Whereas the *de jure* system of capital controls in a country can be very complicated and may not always be enforced in practice,[4] our approach collapses a potentially complicated system

[3] We set the smoothing parameter $\lambda = 6.25$ given our annual data.

[4] As one example of the difficulties involved, consider the case of Japan. In the 1950s and 1960s, Japan put in place a range of regulations and restrictions on capital flows, with the stated goal of limiting debt accumulation (Pyle (1996)). These controls were particularly strict on foreign direct investment, although Japan also encouraged international licensing arrangements to access new technologies. By the late 1960s, Japan's entrance into the OECD required some capital market liberalization. By 1980, broad controls were apparently eliminated, though many international financial

Figure 3: The International Wedge



into a straightforward measure of the quantitative significance of *de facto* capital controls. In Appendix D we compare our international wedge to the qualitative measures constructed by Chinn and Ito.

4.1.3 The Labor Wedge

Figure 4 reports our estimate of the labor wedge τ^h (left panel) and per capita hours worked (right panel). Recall that this wedge is identified off of the relationship among consumption, wages, and hours worked in equation (2). Bearing in mind the caveat that the level of the recovered labor wedge cannot separately be identified from preference parameters that could vary across countries, under our normalization a wedge that is greater than zero is interpreted as a tax on labor income and reflects employment levels lower than predicted by the model with a labor wedge that is equal to zero; a number less than zero identifies relatively high employment, which is interpreted as a subsidy to labor. A value of 0.4 denotes a 40 percent tax on wage income. The figure shows that Latin America faced a larger labor wedge than all other regions in the early decades of this period, although it declined after 1970. Asia started with a significant labor wedge that fell quickly, while the labor wedge for the rest of the world rose during the first 30 years and then remained constant. As can be seen from the figure, movements in the labor wedge closely mimic inverse movements

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transactions were still subject to a variety of specific controls and regulations. In the mid-1980s, the dollar-yen accord created additional liberalization by establishing markets that previously had not existed for some financial instruments.

In contrast to qualitative measures, which typically construct categorical variables for the presence of certain types of restrictions and average them to create an aggregate measure, our method looks directly at allocations to divide the quantitative importance of these restrictions.

in hours worked per capita.

To interpret the labor wedge, note that it reflects various factors that affect the relationship between the household's marginal rate of substitution between consumption and leisure and the marginal product of labor. These may include forces that can be affected by policy, such as labor and consumption taxes (Chari, Kehoe, and McGrattan (2007) and Ohanian, Raffo, and Rogerson (2008)), employment protection laws and other restrictions on hiring or firing workers (Cole and Ohanian (2015)), unemployment benefits (Cole and Ohanian (2002)), and limitations on product market competition that increase firm monopoly power (Chari, Kehoe, and McGrattan (2007)), as well as search and matching frictions (Cheremukhin and Restrepo-Echavarria (2014)) that form part of the "technology" of the economy. As with the international wedge, we show that the labor wedges estimated here often move with changes in taxes and changes in labor market rigidities, leading us to conclude that our estimated labor wedge is capturing structural policy changes that affect the labor market.

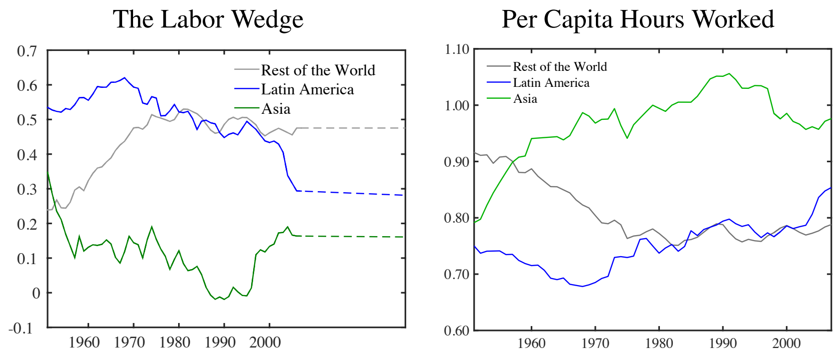
Studies of taxes on labor income and consumption in OECD countries coincide closely with the rest of the world labor wedge. Prescott (2002) and Ohanian, Raffo, and Rogerson (2008) report that in most European countries consumption and labor taxes rose substantially between 1950 and the mid-1980s and then were roughly stable on average after that (see Figure 22 in Appendix D). This closely mimics the pattern of our labor wedge for the rest of the world that shows an increase until the mid-1970s and little movement thereafter.

In terms of labor market distortions, a number of studies construct measures of these distortions across countries. In the most comprehensive study that we know of, Campos and Nugent (2012) construct an index of *de jure* employment law rigidities for 145 countries between 1950 and 2004. Their approach is similar to that of Botero et al. (2004), who identify labor market rigidities based on employment, collective bargaining, and social security laws. However, unlike the Botero et al. analysis, the Campos and Nugent data span the full period we analyze.

Our measure of the labor wedge has some patterns that are qualitatively similar to those reported by Campos and Nugent (2012). Specifically, Campos and Nugent's measure of aggregated Latin American labor market rigidity shows an increase in rigidity between 1960 and the beginning of the 1970s, then a decline until 1985, followed by an increase until 1994, and a larger improvement from then on (see plot of the labor market rigidity index in Figure 21 of Appendix D). Our labor wedge follows this pattern. The Campos and Nugent measure of aggregated European labor market rigidity shows increased rigidity from the 1950s up until the mid-1980s, the same time the rest of the world labor wedge is increasing.

For Asia, Campos and Nugent report a relatively modest increase in rigidity throughout the period (see Figure 21 in Appendix D). Our Asian labor wedge increases after the mid-1990s, which is qualitatively similar to Campos and Nugent. However, our Asian labor wedge declines con-

Figure 4: The Labor Wedge



siderably before then. This likely reflects factors that are not considered by Campos and Nugent, such as the migration of labor from rural areas, in which labor markets may not be as efficient, to more urban areas. It may also reflect the changes in education emphasized by Kim (1990), Kim et al. (1980), McGinn (1980), and Ohkawa and Rosovsky (1973) among others. Likewise, the labor market reforms in Latin America emphasized by Heckman and Pagés (2004), Murillo (2001), and Duryea and Székely (2000) coincide with a decline in the Latin American labor wedge.

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

4.1.4 The Capital Wedge

Figure 5 presents our estimates of the capital wedge τ^K. This wedge is identified off of the Euler equation (3) and thus reflects the difference between returns to investment estimated from the marginal product of capital and the return to savings estimated from the growth rate of consumption. Bearing in mind our caveat about the recovered levels of this wedge, under our normalization a value of 0.05 is equivalent to a 5 percent tax on capital income. As shown in the figure, the rest of the world and Latin America have a capital tax (a wedge that is greater than zero), while Asia's capital wedge deteriorates in the 1950s before falling dramatically between 1960 and 1980. Latin America is estimated as having larger domestic capital market distortions through the mid-1980s during the debt crisis, with the wedge falling thereafter to levels in between those of Asia and the rest of the world.

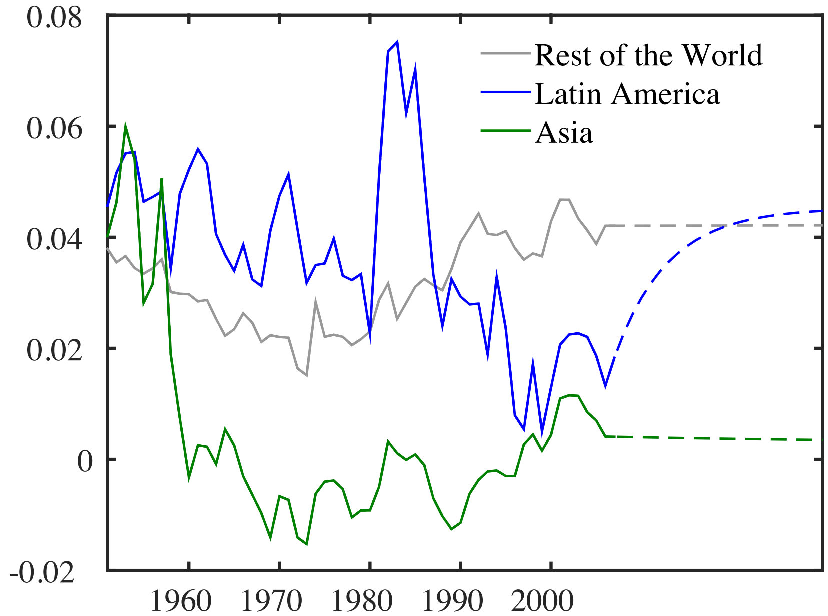
To assess whether or not these patterns in the capital wedge are consistent with an interpretation of domestic capital market policy distortions, it is useful to compare these results with the IMF's index of capital market liberalization (Abiad, Detragiache, and Tressel (2008)). This index was constructed from surveyed changes in capital market regulations and restrictions for a number of countries between 1973 and 2005, including credit controls, interest controls, privatization of banks, entry barriers to banking, the details of banking supervision regimes, and bank reserve requirements. We remove the subindex of changes in international capital market regulations. The resulting indicator ranges from a value of zero, meaning "fully repressed," to four, meaning "fully liberalized." We find that movements in our estimated capital wedges line up with movements in the IMF's index.

According to the IMF index, the four largest Latin American countries—Argentina, Brazil, Chile, and Mexico—liberalized their domestic financial markets between 1973 and 2005, with some re-regulation occurring in the early to mid-1980s coinciding with the Latin American debt crisis. Specifically, whereas in 1973 the financial markets of Argentina, Brazil, and Chile were ranked as "fully repressed" and Mexico was ranked as "partially repressed," these countries implemented reforms in the 1970s that included less reliance on interest rate controls, more market-based securities market policies, increased privatization of banks, and increased banking supervision. The debt crises of the 1980s saw a temporary reversal of these policy shifts, particularly on interest rate controls and credit controls. Following the 1980s, however, Latin America made further progress in the operation of its capital markets, including the reduction of entry barriers, further privatization of commercial banks, less reliance on interest rate and credit controls, and more market-based securities market policies. By 2005, these countries all had composite rankings of financial markets between fully liberalized and partially liberalized. This general pattern of trend improvement in capital market regulations and restrictions, with a temporary reversal in the 1980s, is consistent with the estimated capital wedge of Latin America, which trends downward in the 1970s, increases significantly during the 1980s, and reverts to its declining trend thereafter.

For Asia, whereas in 1973 the IMF ranked the financial markets of Taiwan as fully repressed, those of Japan as partially repressed, and those of Hong Kong and Singapore as partially liberalized, the 1970s and 1980s saw all of these countries liberalize securities markets and impose fewer controls on interest rates and credit levels, so that by 2005 all of these countries were ranked as fully liberalized or close to fully liberalized. These patterns dovetail with our estimated capital wedge for Asia, which shows a trend narrowing over this same period. Appendix D, Figures 23, 24, and 25, show the plots of the indices for the different regions.

In summary, as with the labor and international wedges, we conclude that movements in our estimated wedges are often closely associated with reforms in economic policy. Obviously, it is beyond the scope of a single paper to provide a full and complete account of the history of labor and capital market policies around the world over half a century of time. However, the summary presented here documents a close coincidence between movements in labor, domestic capital, and international capital wedges and substantive historical policy changes. This leads us to a structural interpretation of our wedges as measures of the impact of economic policy distortions. We next turn to a quantitative assessment of the importance of these distortions in driving capital flows.

Figure 5: The Capital Wedge



4.2 Counterfactuals and Decomposition

In the previous section we argued that movements in our estimated wedges are often closely associated with reforms in economic policy, leading us to give them a structural interpretation as policy distortions. We also found that these policy distortions fluctuated significantly through time. However, comparisons of the levels and movements of different wedges do not tell us which were the most important determinants of international capital flows. In this section, we assess the quantitative importance of changes in policy distortions in the determination of capital flows, and in particular whether they can explain why capital flowed into slow-growing Latin America in greater quantities than into fast-growing Asia.

To evaluate the effect of movements in the labor and capital wedges, we treat them parametrically and simulate their effect on the economy. Specifically, we fix the labor and capital wedges at their sample mean. We choose the sample mean because, as noted above, the levels of the labor and capital wedges cannot be recovered independently of households' taste for leisure and rate of time preference. As the *level* of our wedges is a normalization, we focus on shutting down the *movements* in these wedges around this level. To quantify the impact of changes in international capital market imperfections, we also treat the international wedge parametrically but fix it to its steady-state value of zero to ensure non-degenerate long-run relative consumption levels.

Note that every time we shut down movements in a wedge by fixing it parametrically, we resolve the model so that agent expectations reflect the assumptions of the counterfactual experiment.

This also implies that the effect of shutting down movements in a wedge will vary according to whether or not movements in other wedges have been shut down or are still operative. As a result, we present two types of results. First, we shut down movements in each individual wedge (one at a time) and for each evaluate its effect on capital flows keeping all other wedges operative. We interpret the results as the effect of removing the corresponding policy distortion while keeping other policy distortions unchanged and refer to these experiments as our *counterfactuals*. Second, we calculate the relative contribution of each wedge to observed patterns in capital flows as part of an experiment in which all wedges are shut down. We refer to this series of counterfactuals as our *decomposition*.

4.2.1 Counterfactuals

We begin by shutting down each wedge in isolation. Figure 6 depicts the results of these counterfactual experiments for Latin American and Asian capital flows, as measured by the ratio of net exports to output, respectively, while Figure 7 shows the results for the rest of the world. The figures show the effect of removing each region's own wedges. This means that, for example, the line labeled "No Labor Wedge" in the panel for Latin America corresponds to the trajectory followed by net exports in Latin America when the Latin American labor wedge is set parametrically to its mean value. In the same manner, "No Capital Wedge" and "No International Wedge" correspond to the path followed by net exports when the own-region's capital wedge is set to its mean value and its international wedge is set to zero, respectively.

Consider first the effect of shutting down the international wedges. In both Latin America and, especially, Asia, the international wedge was negative at the start of the sample, indicating a tax on borrowing that led both regions to accumulate relatively more foreign assets, or borrow less, than they would have otherwise chosen to do. In the case of Latin America, removing the wedge lowers wealth growth over time and implies correspondingly lower consumption relative to the rest of the world during the first three decades, as well as higher hours worked (see Figure 8, which plots the absolute level of hours, and the level of consumption relative to the data, under each counterfactual) and an outflow of capital (compare the black line for the data with the dash-dotted blue lines). Under this counterfactual, the pattern is reversed in the 1980s as Latin America avoids a debt crisis and relative wealth rises.

In the case of Asia, where the tax on foreign borrowing was larger, removal of the tax leads to an initial increase in consumption and a decline in hours worked, which generates inflows of capital into Asia on the order of 5 percent of GDP during the 1950s. However, with wealth no longer rising quickly thereafter, counterfactual consumption soon drops below the level in the data, while hours worked rise, and for the rest of the sample Asia experiences a large capital outflow. In fact, for the bulk of the sample, capital outflows from Asia would have been even greater were it not for the

Figure 6: The Effect of Own Domestic Wedges on Capital Flows for Latin America and Asia (Net Exports % GDP)

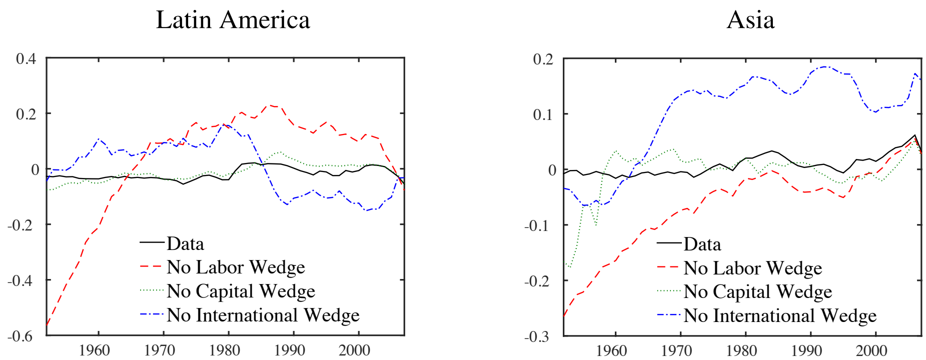
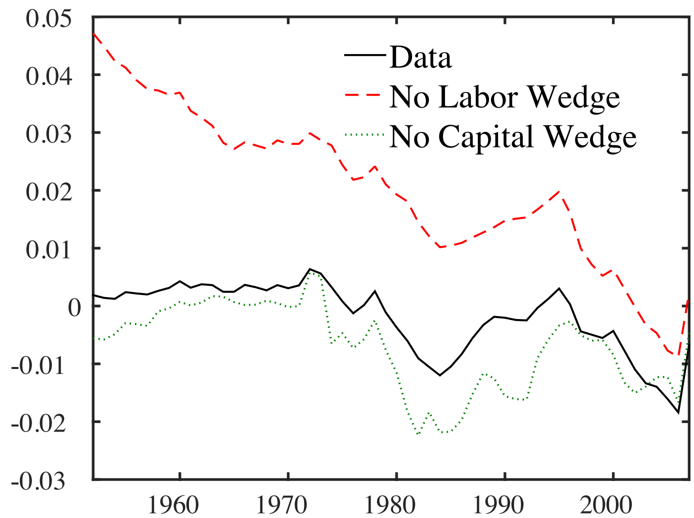


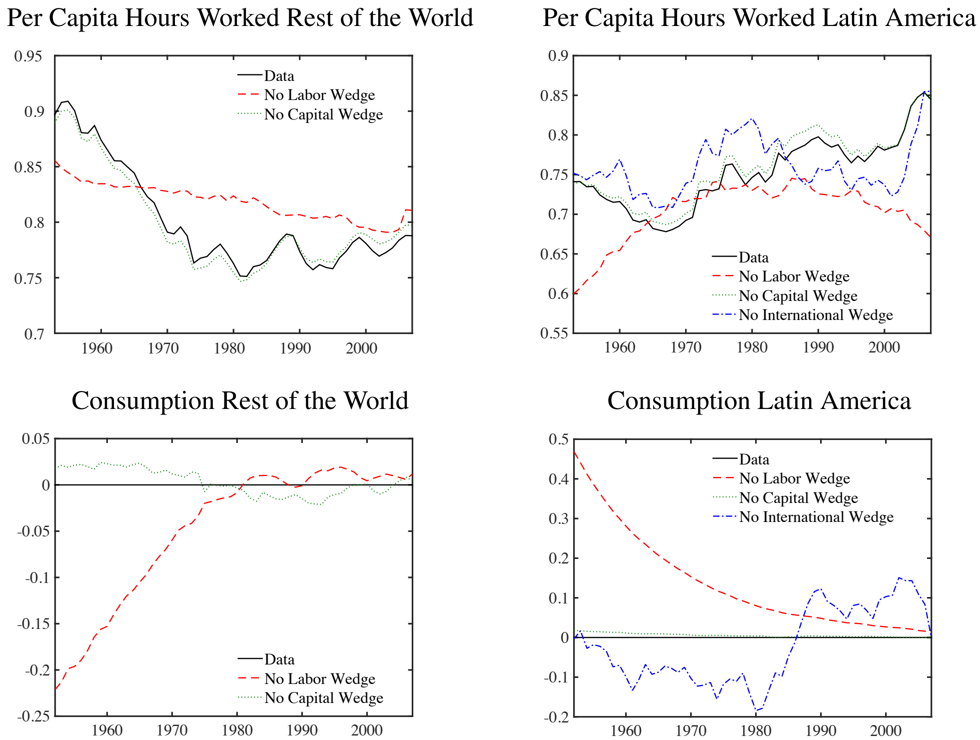
Figure 7: The Effect of Own Domestic Wedges on Capital Flows for the Rest of the World



cumulative effect of past international capital market distortions. Note that the mechanism by which this occurs is the accumulation of net foreign assets, which in turn is driven by the entire history of the international wedge; the period-by-period impact of the international wedge on capital flows is much smaller.

These results suggest that international capital market distortions played a role in generating the perverse pattern of capital flows in the 1950s; absent these distortions, more capital would have flowed into Asia, while capital flows into Latin America would have been muted and eventually reversed. International capital market distortions also play a large role in driving capital flows in the latter decades of the sample. However, these distortions only deepen the puzzle surrounding the direction of capital flows in the 1960s and 1970s: surprisingly, eliminating these distortions leads to a much *larger* outflow of capital from Asia.

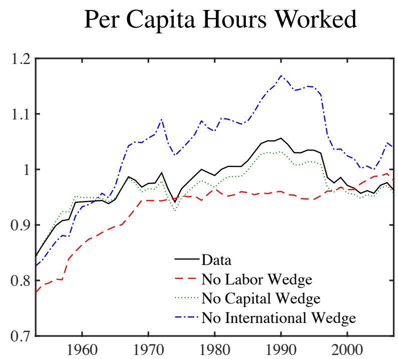
Figure 8: The Effect of Own Domestic Wedges on Hours and Consumption for Latin America and the Rest of the World

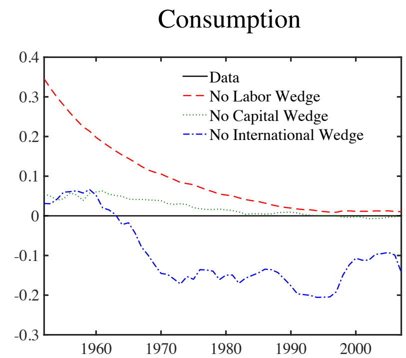


Moreover, the effect of international distortions is small compared to the effect of distortions in domestic labor markets. As shown in Figures 6, 8, and 9, shutting down movements in domestic labor market distortions produces a large increase in wealth with higher consumption and lower hours worked leading to much larger capital inflows in both Asia *and* Latin America. In the case of Asia, these capital inflows remain significant until the 2000s. In Latin America, capital begins to flow out starting in the mid-1960s and the apparently perverse pattern in capital flows is gone. In that sense, the labor wedge plays a quantitatively more significant role in explaining capital flows to Asia and Latin America in the decades after World War II. Removing domestic capital market distortions also increases capital inflows into both regions in the 1950s, although the effects are quantitatively far less significant and shorter lived.

In summary, our results indicate that while international capital market distortions can help to explain qualitatively why capital flowed into slow-growing Latin America and not fast-growing Asia in the 1950s, the quantitative magnitude is quite modest. Moreover, international distortions only seem to deepen the puzzle for the 1960s and 1970s, as their removal implies very large capital outflows despite continuing strong growth in Asia. Labor market distortions, on the other hand, especially in Asia have a much larger quantitative impact and, beginning in the 1960s, explain why

Figure 9: The Effect of Own Domestic Wedges on Hours and Output for Asia





capital flowed into Latin America and not into Asia.

4.2.2 Decomposition

The above results are derived from counterfactual experiments in which only one type of distortion is removed at a time. This leaves open the possibility that the relative marginal contributions of the international and labor wedge to determining capital flows might depend on the order in which various distortions are removed. To assess this possibility, in our second experiment we remove all factor market distortions and quantify the contribution of each wedge to the overall change in capital flows. Given that the marginal contribution of each wedge will in general depend upon the order of its removal,[5] we remove the wedges in random order 10,000 times[6] and then average over all of these combinations to compute the absolute relative contribution of the labor, capital, and international wedges for capital flows in each decade of our sample. These results are collected in Tables 4 and 5. Each number in each table is then the decade average of the absolute marginal contribution of each wedge over the sum of the marginal contributions of all labor, capital, and international wedges.

[5] For example, the marginal contribution of the labor wedge is different if the capital wedge has been previously removed than if the international wedge has been previously removed.

[6] There are more than 40,000 ways (orderings) in which we can remove them, but given the computational constraints, we approximate all of the possible combinations by a random sample of 10,000.

Table 4: Contribution of the Different Wedges to Latin American Capital Flows

Wedge Contributions	1950s	1960s	1970s	1980s	1990s	2000s
τ_R^h	0.32	0.28	0.20	0.17	0.16	0.15
τ_L^h	0.27	0.20	0.26	0.31	0.24	0.17
τ_A^h	0.10	0.09	0.06	0.03	0.03	0.02
τ_R^k	0.05	0.05	0.06	0.09	0.08	0.04
τ_L^k	0.06	0.05	0.04	0.06	0.06	0.06
τ_A^k	0.07	0.09	0.05	0.03	0.02	0.03
τ_L^B	0.08	0.18	0.26	0.22	0.27	0.39
τ_A^B	0.04	0.07	0.09	0.10	0.14	0.14

Table 5: Contribution of the Different Wedges to Asian Capital Flows

Wedge Contributions	1950s	1960s	1970s	1980s	1990s	2000s
τ_R^h	0.30	0.27	0.21	0.18	0.13	0.14
τ_L^h	0.09	0.07	0.03	0.02	0.02	0.03
τ_A^h	0.29	0.30	0.18	0.15	0.14	0.07
τ_R^k	0.04	0.04	0.04	0.08	0.05	0.04
τ_L^k	0.03	0.03	0.02	0.01	0.01	0.01
τ_A^k	0.13	0.08	0.04	0.05	0.09	0.15
τ_L^B	0.03	0.05	0.05	0.03	0.03	0.05
τ_A^B	0.09	0.17	0.43	0.47	0.53	0.53

Table 4 shows the results for Latin America. As we can see during the 1950s and 1960s, Latin American labor market distortions explain between 20 and 30 percent of capital flows into Latin America. Labor market distortions in Asia and, particularly, in the rest of world explain roughly another 40 percent of capital flows into Latin America. In sum, labor market distortions in all three countries explain roughly two-thirds of the movements in Latin American capital flows, while international capital market distortions around the world explain between one-tenth and one-quarter. These numbers also point to the importance of general equilibrium effects of changes in distortions in one country on capital flows into another. Starting in the 1970s, the contribution of the international wedge to Latin American capital flows rises as the accumulated effect of this wedge on net foreign asset accumulation grows. A large jump in the international wedge associated with the Latin American debt crisis also plays a role.

Table 5 presents analogous results for Asia and shows that during the decade of the 1950s, labor market distortions were five times more important than international capital market distortions in explaining capital flows. During the 1960s, labor market distortions explained two-thirds of capital flows, while international capital market distortions explained roughly one-fifth. International capital imperfections matter, with the accumulated effect of past distortions explaining half of Asian capital flows from the 1980s onward, although it primarily acted to decrease capital outflows. Importantly, the role of contemporaneous international capital market distortions is small; rather, it is the accumulated effect of past international distortions on net foreign asset accumulation that leads the contribution of the international wedge to increase over time.

In summary, while these results show that the accumulation of international capital market distortions over time can play a very large role in determining capital flows, the effect of contemporaneous movements in these distortions on capital flows is modest. Hence, we view them as playing a quantitatively subsidiary role in explaining why capital flowed into Latin America, and not into Asia, after World War II. Labor market distortions played the dominant role in explaining capital flows after the war; they are quantitatively more significant in general, their removal would have led to greater capital flows into Asia throughout the entire postwar period, and, at least after the 1960s, their removal would have caused capital to flow out of Latin America.

4.3 Relation to the Literature

With our results in hand, we now compare our findings to those from two recent and influential papers, Caselli and Feyrer (2007) and Gourinchas and Jeanne (2013).

4.3.1 Caselli and Feyrer (2007)

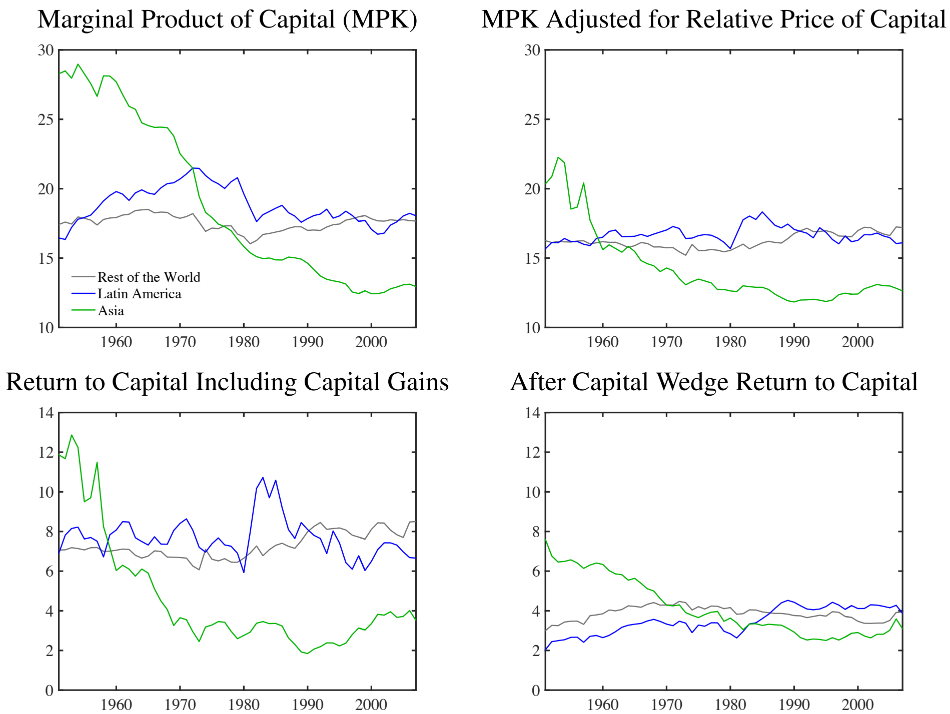
Our finding that distortions to both domestic and international capital markets play a subsidiary role in explaining why capital did not flow into Asia after World War II might, at first glance, seem to be consistent with Caselli and Feyrer's (2007, hereinafter CF) finding that marginal products of capital are surprisingly similar across countries, at least toward the end of our sample. However, this is misleading. We do find significant differences in returns across countries, especially in the 1950s and 1960s, that existed due to the presence of international distortions. Rather, these differences are smaller than differences in marginal products of capital alone, and would have been even larger if not for the presence of distortions in labor markets.

To understand why this is the case, it is useful to abstract from uncertainty and rearrange equations (3) and (4) to obtain

$$1+r_{t+1} = \frac{1-\tau^K_{jt+1}}{1-\tau^B_{jt+1}} \frac{\alpha Y_{jt+1}/K_{jt+1} + P^{*K}_{jt+1}}{P^K_{jt}}, \tag{15}$$

where $r_{t+1} = 1/q_{t+1} - 1$ is the world interest rate between periods t and $t+1$. This equation states that, in the absence of distortions to domestic and international capital markets ($\tau^K_{jt+1} = \tau^B_{jt+1} = 0$, for all t and j), the return to capital should be equalized in every country at the world interest rate. CF abstract from the contribution of capital gains P^{*K}_{jt+1}/P^K_{jt} to the return to capital and focus

Figure 10: Different Measures of the Marginal Product of Capital



on how appropriately measuring the relative price of capital goods P_{jt}^{K} and the output elasticity of capital α, which in their frictionless economy equals the share of capital in national income, leads to the equalization of the marginal product of capital across countries. We defer a discussion of differences in capital shares until Section 5 and discuss first how our findings on marginal products and returns to capital compare to CF under the assumption of a common output elasticity of capital $\alpha = 0.36$.

The four panels of Figure 10 plot the components of the return to capital for each of our three regions. In the first panel, we plot the expected marginal product of capital $\alpha Y_{jt+1}/K_{jt+1}$ (what CF call the naive marginal product, or MPKN); in the second we adjust for the model-implied relative price of capital (CF's PMPKN); in the third, we add in the contribution of capital gains to the return to capital (which is absent from CF); and in the fourth, we adjust for the role of the domestic capital wedge. Adjusting for the international wedge ensures by construction that the returns to capital in Asia and Latin America equal the line for the rest of the world in panel 4.

Our estimates for the naive marginal product in Latin America and the rest of the world rise in the first two decades of the postwar period to between 18 and 21 percent, before falling thereafter to between 17 and 18 percent. Marginal products in Asia, on the other hand, start at roughly 28 percent and decline to roughly 13 percent by the end of our sample, remaining higher than those in Latin America until the 1970s. This further emphasizes the puzzling behavior of capital flowing into Latin America instead of Asia immediately after the war. These naive marginal products for Asia and the rest of the world are higher at the end of the sample than those from CF (Japan and the United States are at 9 and 12 percent, respectively) but are similar for Latin America (Mexico's is 22 percent and Colombia's is 28 percent, for example). After adjusting for the relative price of capital, returns in Latin America and the rest of the world converge dramatically, even more so than in CF's estimates, albeit to somewhat higher levels. Asian returns remain higher than those in Latin America for only the first decade.

Including capital gains (which includes the effect of depreciation and is shown in panel 3) lowers returns in Latin America and the rest of the world to around 8 percent and in Asia to around 4 percent by the end of the sample. Accounting for the capital wedge (panel 4) lowers returns at the start of the sample and compresses them toward the end, with all three countries between 3 and 4 percent. The international wedge, by construction and given our normalization, causes all returns to converge to that of the rest of the world in the fourth panel.

Panel 4 shows that, if there were no international wedge, during the 1950s, an investor in the rest of the world would have made an additional 4 percent return investing in Asia and a negative return of roughly 1 percent investing in Latin America. In that sense, there were bad investments in Latin America and missed opportunities in Asia. Returns in Asia remain higher than those in Latin America until the 1980s, although both returns are lower than in the rest of the world after the 1970s. In this sense, the international wedge helps to explain the puzzling absence of capital inflows into Asia in the 1950s and 1960s, and the puzzling inflows of capital into Latin America up until the mid-1980s. Interestingly, absent both the international and capital wedges, the investor would have made 1 percent (Latin America) to 3 percent (Asia) higher returns from investing abroad in either region in the 1950s.

This is the main difference between our results and those of CF: we find significant differences in returns to capital across countries—especially in the 1950s and 1960s—that persist only due to international capital market distortions. However, our results are closer in spirit to CF in that we find that differences in returns would have been even larger still had it not been for distortions in labor markets. To see this most clearly, consider Asia, which, according to our results for 1950, had a marginal product of capital (panel 1) that is 11 percentage points higher, and a return to capital after capital gains and domestic capital market distortions (panel 4) that is 4.5 percentage points higher, than in the rest of the world. These differences are large but were entirely erased by 1980. However, the differences in 1950 and the declines thereafter would have been much larger still were it not for high and declining labor market distortions in Asia. To see this, note that hours worked per person in Asia were roughly one-third lower in 1950 than they were in 1980. Had hours worked per person in 1950 been closer to their 1980 levels, the marginal product in Asia would have been almost 17 percentage points higher than in the rest of the world. Similarly, had labor market distortions not been unwound over the decades after 1950, the marginal product of capital would have fallen to roughly 3 percentage points below that in the rest of the world by 1980, instead of being within a percentage point. We therefore conclude that labor market distortions played a more significant role in driving differences in returns and the incentives to reallocate capital.

So far, we have not considered CF's argument that capital shares as typically constructed in the data may overestimate the true share of reproducible capital due to the inclusion of returns to non-reproducible factors such as land and natural resources. We have three reasons for this. First, measured capital shares will not correctly identify the output elasticity of capital if capital market distortions are not recorded as payments to capital, even in the absence of non-reproducible capital returns. Thus, we prefer to calibrate the output elasticity of capital to a common value. Second, measured capital shares need not accurately reflect after-tax and subsidy payments to capital. Third, CF's adjustments to capital shares often result in returns to capital that seem implausibly low (see also Ohanian and Wright (2008)). Specifically, under CF's assumption of a 6 percent depreciation rate, their implied return to capital is non-positive in 17 out of 52 countries. Allowing for an additional decline in capital prices of between 3 and 4 percent due to technological progress (Greenwood and Yorukoglu (1997) find that equipment prices fell 3.3 percent per year prior to 1974 and 4 percent thereafter) results in negative returns to capital for all but 8 (if we use 3 percent) or 7 (if we use 4 percent) countries in their sample. Note that these returns are negative; they are certainly less than the return on a real government bond. Nonetheless, in the robustness section below, we report results from experiments in which we calibrate capital shares to the levels estimated for reproducible capital by CF and show that, when the model is re-estimated under these assumptions, our results are largely unchanged.

4.3.2 Gourinchas and Jeanne (2013)

Our finding that the international wedge plays only a small role in determining capital flows stands in stark contrast to the finding of Gourinchas and Jeanne (2013, hereinafter GJ) that this wedge (GJ call it a savings wedge) plays the dominant role in accounting for observed capital flows. There are several complementary reasons for this. One of the most significant reasons results from GJ's different definition of the capital wedge. Specifically, whereas we define our capital wedge as the difference between a household's marginal rate of substitution and domestic capital returns, GJ define their capital wedge as the difference between domestic capital returns and the world interest rate. That is, their capital wedge is equivalent to the ratio of our capital wedge to our international wedge. More importantly, their experiments varying their savings wedge while keeping their capital wedge constant are equivalent to varying both our international and capital wedges simultaneously, which produces a compounded effect. Combined with an absence of transitional dynamics in their model, this results in much larger effects of the savings wedge on capital flows.

The other major difference comes from their treatment of the labor supply. This has two dimensions. First, empirically, GJ measure labor input as the working-age population. This means that in their measurement of productivity growth, GJ attribute any variation in hours per person to changes in productivity. This also leaves no role for the labor wedge in their analysis. Second, in their theory, the labor supply is held constant, which is strongly at variance with the very large changes in hours per worker documented here. This matters because, when they vary their savings wedge, their measure of productivity (which includes any implicit effect from a variable labor supply) is held constant. When labor supply is endogenous, changes in the savings wedge would imply changes in wealth that lead to changes in labor supply that would change their measure of productivity. Specifically, the positive savings wedges (which act as taxes on borrowing) necessary to explain why capital did not flow into Asia in their analysis, *taking as given their measure of productivity growth* for Asia, would in fact lead to declines in hours worked per person and an endogenous decline in their measure of productivity growth. This amplifies the effect of changes in the savings wedge in their framework, relative to ours.

5 Robustness and Extensions

In this section, we briefly discuss the robustness of our findings. We consider robustness with respect to changes in the specification of our benchmark model and the robustness of our structural interpretation of the wedges as reflecting factor market distortions. We also consider how our results relate to some other studies of international capital flows that have emphasized different and complementary moments of the data. A more detailed discussion of these issues is available in Appendix E.

5.1 Parameter Values

Above we wrote down a benchmark model against which the data could be compared, with a view toward 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 combination of taxes and subsidies and non-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 functional forms and parameter choices. In this subsection, we illustrate how alternative assumptions about parameter values affect the identified wedges and the resulting analysis.

A number of parameter choices have precisely no effect on our results, as they serve only to scale up or down the estimates of the wedges, and our experiments set wedges to their mean levels. These include the discount factor β, which, as long as it is constant across countries, only affects the steady-state level of the capital wedge in each country. It also includes the preference for leisure parameter φ, which is indistinguishable from the steady-state labor wedge and could be allowed to vary across countries. Other parameters appear to have small effects: for example, allowing the intertemporal elasticity of substitution to depart from 1 changes the levels of the wedges—the lower the elasticity, the more wedges must vary to explain changes in behavior. But this departure seems to have only small effects on our experiments—a low elasticity also dampens the response to setting these wedges constant. Likewise, increasing the Frisch elasticity of labor supply dampens movements in the recovered wedges, but correspondingly increases the response from shutting down these same movements.

Of the remaining parameters, one that might have a significant effect on the model is the level of the capital adjustment cost ν, which is known to be a very important determinant of capital flows in open economy macroeconomic models (see, for example, Baxter and Crucini (1993) for a discussion). In our benchmark, we set this to generate an elasticity of the price of capital to the ratio of investment to capital of 1/2, which is the upper bound of what Bernanke, Gertler, and Gilchrist (1999) consider plausible, but arguably better describes emerging market countries. In the online appendix, we also present results using Bernanke, Gertler, and Gilchrist's preferred value of 1/4 for the United States and show that it leads to very similar results.

Another parameter that has been a focal point of the literature is the output elasticity of capital, which in an undistorted economy equals the capital share. As noted above, CF argue that the true capital share should exclude payments to non-reproducible factors of production, such as land, and provide an adjustment that shows significant differences in these shares across countries. Changing the output elasticity of capital α not only will directly affect the labor and capital wedges, as can be seen in equations (13) and (14), but also will affect the entire equilibrium of the model. To assess whether this makes a significant difference to our results, we calculated our wedges after re-estimating the model with output elasticities of capital calibrated to be different across regions and equal to the income-weighted share of the estimates of CF. Whereas in the baseline we imposed $\alpha = 0.36$ for all countries, this results in output elasticities of capital of $\alpha_{ASIA} = 0.23$, $\alpha_{LATAM} = 0.26$, and $\alpha_{ROW} = 0.18$. The resulting estimates of the capital and labor wedges using heterogeneous capital shares look like scaled versions of those computed in our benchmark. This is perhaps not surprising: ignoring the effect of the equilibrium of the model, increasing/decreasing α serves mostly to decrease/increase the estimated capital wedge each period. Given that our experiments set the capital wedge equal to its sample mean, the resulting outcomes of our experiments also turn out to be both qualitatively and quantitatively similar to those for our benchmark.

A recent literature has pointed to movements in the capital share in the United States and some other countries over time 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 consistent with the mechanism of our paper is that changes in factor market distortions are responsible for the changing levels of the factor share. This would be the case if these factor market distortions are not priced or otherwise measured as compensation for the relevant factor of production and would imply that measured factor shares do not identify the relevant parameter of the Cobb-Douglas production function nor indicate any departure from Cobb-Douglas. Differences in the levels of factor market frictions across countries could also explain recorded differences in the levels of capital shares across countries, and not just time-series variation in factor shares. Given these possibilities, we do not further explore them.

Lastly, we imposed the assumption that our wedges were uncorrelated across countries. This was for simplicity, as it drastically reduced the number of parameters to be estimated on less than 60 years of annual data; instead of 34 parameters, a vector autoregressive structure for our 17 wedges would require the estimation of $17^2 = 289$ autoregressive coefficients and a further 153 parameters in the covariance matrix. Nonetheless, correlation among the labor, capital, and international wedges could matter for the interpretation of our experiments, in which movement in a given wedge is shut down. To examine the potential for this issue, we looked at the empirical relationship among our recovered wedges. Economically, the correlations between the wedges are typically small, with 66 percent of the parameters in the correlation matrix being less than 0.5 in absolute value. The largest correlations tend to be associated with the cross-country relationships between population and productivity.

As our experiments concerned shutting down the international, capital, and labor wedges, with a focus on those wedges specific to Latin America and Asia, we are mostly concerned with interactions among these wedges and all other wedges. One way to assess this is to compute the principal components of the covariance matrix of the wedges.

The first two principal components explain almost 92 percent of the variation in the data. Of these, the first principal component, which explains roughly 73 percent of the variation in the data, loads primarily on the population and productivity wedges of Asia and Latin America as well as on Asian government spending. The second principal component, which explains 19 percent of the variation in the data, loads primarily on the productivity of Asia and the capital wedge for the rest of the world and Asia. While one might tell an economic story in which these are related, we think it more likely reflects a spurious relationship in the short sample. As a consequence, we conclude that the correlation among the wedges that we focus on is small and not an important factor driving our results.

5.2 Alternative Structural Interpretations of Wedges

In this subsection, we briefly discuss some examples of alternative models of, and explanations for, observed patterns in international capital flows. In each case, we briefly sketch how the alternative explanation would manifest as patterns in the wedges recovered from our analysis. Further details are provided in Appendix E.

5.2.1 Multiple Goods and Transport Costs

Our benchmark model featured one tradable consumption good for the world and one non-tradable investment good in each country. This means that the terms of trade are constant and that any movements in the terms of trade in the data will be attributed to our wedges. To see how this affects our wedges, consider the two-country model of Backus, Kehoe, and Kydland (1994) in which a domestically produced tradable good is combined with a foreign-produced tradable good to produce a non-traded domestic good that is both consumed and invested. The assumption of two countries simplifies the analysis by making relative price calculations obvious.

It is straightforward to show (see Appendix E) that if data generated by this model were confronted with the capital flow accounting procedure above, the resulting wedges in our benchmark model would be correlated with the level and change in a country's terms of trade. Specifically, when the price of a country's export good falls relative to the price of the good it imports, so that its terms of trade deteriorate, both the labor and capital wedges get larger. This is intuitive: for a given nominal wage, an increase in import prices reduces the real returns to suppliers of labor and capital while leaving the real costs to the firm unchanged. The international wedge, on the other hand, will in general respond to the growth rate of the terms of trade as relative inflation across countries, and hence also relative real returns, move in opposite directions. Inspection of the wedges recovered from the data shows at best modest evidence for these patterns, suggesting that this explanation does not play a major role in explaining observed capital flows.

Relatedly, Obstfeld and Rogoff (2001), Fitzgerald (2012), and others have argued that transport costs in international trade can drive movements in relative prices that provide a qualitative, and possibly also a quantitative, explanation of some observed patterns in capital flows. Regarding the level of capital flows, intuitively, in a finite horizon economy, a country that is a borrower (net importer) today will be a net exporter at some point in the future when these debts are repaid. If this causes a country to shift from importing a given set of goods (at a high price due to payment of transport costs) to exporting them (at a lower price due to foreigners paying these same costs), there will be domestic deflation and a high real cost of borrowing from abroad. Likewise, a country that saves will tend to receive lower real returns. Thus, the level of capital flows may be reduced. 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. However, it is not clear that this mechanism plays a quantitatively significant role in explaining *relative levels* of capital flows to Latin America and Asia in practice. Further discussion is provided in Appendix E.

5.2.2 Financial Frictions

Our finding of a dominant role for labor market distortions may be viewed as surprising when set against the large literature that has examined the role of various financial frictions in determining capital flows. In the case of Latin America in particular, which experienced a sovereign debt crisis in the middle of our sample, one might expect frictions resulting from the enforcement of contracts to play a significant role. In this subsection, we briefly review the implications of the class of limited commitment models for our results.

Consider a limited commitment model of international financial frictions along the lines of Kehoe and Perri (2002; see also Wright (2001)). In Appendix E, we show that the shadow cost of binding enforcement constraints shows up directly in our international wedge. In a limited commitment model, regardless of whether or not capital flows are motivated by consumption smoothing, capital scarcity, or a desire to shift consumption through time (that is, tilt the consumption profile), the model predicts that the participation constraint should never bind when net exports are negative. Intuitively, this is because a country is never tempted to refuse a positive inflow of resources from the rest of the world. As we can see in Figure 3 above, the upward movement in the international wedges in Asia and Latin America in the 1980s coincides with the switch from negative to positive net exports for both regions, providing support for this model in the 1980s (see also Restrepo-Echavarria (2018)). However, this mechanism appears to play no role in explaining capital flows in the 1950s and 1960s, which is the focus of our analysis. Moreover, limited commitment models imply an international wedge that is highly correlated with the capital wedge, and these models generate no labor wedge at all. We find no support for these predictions in the data.

5.3 Public Capital Flows and Ricardian Equivalence

Some authors, such as 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. 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 leading hypothesis must be 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. 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. Other possibilities, such as myopia on the behalf of consumers, would also show up as both an international and a capital wedge.

These possibilities should not necessarily be taken as evidence against the claim that public capital flows drive national capital flows during this period. Instead, it might simply imply a different departure from Ricardian equivalence. 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.

6 Conclusion

Between 1950 and 1990, Asia grew much faster than Latin America but received fewer capital inflows from abroad. This is surprising because, all else equal, rapidly growing countries should generate higher capital returns and thus should receive more capital than slow-growing countries. Some studies implicitly adopt the "all else equal" aspect of this argument and analyze capital flow patterns by focusing on imperfections and inefficiencies of international capital markets that either depress the incentives, or limit the opportunities, to move capital to fast-growing regions. In this paper, we removed the "all else equal" assumption and explored the role of domestic *labor* market distortions in influencing the return to capital and the incentives for capital flows.

Specifically, we developed a capital flow accounting framework that can be thought of as a form of open economy business cycle accounting. We then applied this to a novel dataset of output, consumption, investment, hours worked, and international capital flows for Asia, Latin America, and the rest of the world from 1950 to 2007. We used this framework and data to measure implied labor market and both domestic and international capital market distortions and to quantify the impact of these factors on international capital flows.

We found that labor market distortions, and their removal over time, play the dominant role in explaining both why Asia grew relatively fast as well as why it received little in the way of capital inflows. Perhaps surprisingly, in light of the preceding literature, the impact of international and domestic capital market distortions was not quantitatively important in deterring capital flows into

Asia after the 1950s, and in fact acted to decrease capital outflows from Asia. Latin American capital flows were also primarily driven by the Latin American labor wedge. International capital market distortions had much larger effects on Latin American capital flows during and after the Latin American debt crisis of the 1980s.

These findings have both positive and normative implications. On the positive side, the results indicate that there is no presumption that rapidly growing countries should receive disproportionately high capital flows, as domestic labor and capital market distortions can sufficiently depress the incentives to move capital to these countries. On the normative side, our findings also suggest that the welfare effects of reforming domestic institutions can be much larger than often assumed, as changes in domestic distortions can have large direct and indirect effects on world allocations.

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Appendix not for Publication

Appendix A: Model Solution and Computation

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

The Pseudo Social Planners Problem

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

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

subject to a world resource constraint for each state and date

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

capital evolution equations for each country j of the form

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

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

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

$$\ln \chi_{jt+1}^{H} = \left(1-\rho_j^h\right) \ln \chi_{jSS}^{H} + \rho_j^H \ln \chi_{jt}^{H} + \sigma_j^H \varepsilon_{jt+1}^{H}, \tag{16}$$

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

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

with $\varepsilon_{jt+1}^{\varepsilon^C}$ 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.

$$\begin{aligned}\rho_j^I &= \rho_j^K,\\ 1+g_{jSS}^{\chi^I} &= 1-\tau_{jSS}^K\\ \sigma_j^{\chi^I} &= \sigma_j^K.\end{aligned} \tag{17}$$

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

$$C_{jt} \quad : \quad \beta^t \chi_{jt}^C \frac{N_{jt}}{C_{jt}} = \lambda_t^{PSPP}, \tag{18}$$

$$h_{jt} \quad : \quad \beta^t \chi_{jt}^C \chi_{jt}^H \psi h_{jt}^{\gamma} = \lambda_t^{PSPP} (1-\alpha) \frac{Y_{jt}}{h_{jt} N_{jt}} \tag{19}$$

$$\begin{aligned} K_{jt+1} \quad : \quad \mu_{jt}^{PSPP} = E \Bigg[& \lambda_{t+1}^{PSPP} \chi_{jt+1}^I \alpha \frac{Y_{jt+1}}{K_{jt+1}} \\ & + \mu_{jt+1}^{PSPP} \left(1 - \delta - \phi\left(\frac{X_{jt+1}}{K_{jt+1}}\right) + \phi'\left(\frac{X_{jt+1}}{K_{jt+1}}\right) \frac{X_{jt+1}}{K_{jt+1}} \right) \Bigg] \end{aligned} \tag{20}$$

$$X_{jt} \quad : \quad \lambda_t^{PSPP} \chi_{jt}^I = \mu_{jt}^{PSPP} \left(1 - \phi'\left(\frac{X_{jt}}{K_{jt}}\right) \right) \tag{21}$$

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 (18). 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

$$\lambda_{jt}^{HH} = \frac{\lambda_t^{PSPP}}{\chi_{jt}^C}. \tag{22}$$

Likewise, the FOC of the PSPP with respect to hours (19) can be compared with the corresponding FOC of the households problem from the CEP

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

Hence, the two conditions are equivalent iff

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

But imposing (22), we can see that the conditions will be equivalent if

$$W_{jt} = (1-\alpha)\frac{Y_{jt}}{h_{jt}N_{jt}}, \tag{23}$$

$$1-\tau_{jt}^h = \frac{1}{\chi_{jt}^H}. \tag{24}$$

Note that (23) implies that the FOC in hours for the firm producing the consumption good in the CEP is now satisfied. Moreover, given assumption (16), the derived process for $1-\tau_{jt}^{h}$ satisfied the law of motion (8) 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 (12) 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 (20) combined with the FOC with respect to investment (21) can be rearranged to yield

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

Comparing this with the FOC in capital from the households problem

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

we can see that the two will be equivalent if

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

$$1-\tau^K_{jt+1} = \frac{\chi^C_{jt+1}}{\chi^C_{jt}}\frac{\chi^I_{jt+1}}{\chi^I_{jt}}, \tag{25}$$

where in the last line we substituted from (22). 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

$$\ln\left(1-\tau^K_{jt+1}\right) = \ln\left(\chi^I_{jt+1}/\chi^I_{jt}\right) + \ln\left(\chi^C_{jt+1}/\chi^C_{jt}\right),$$

so that after substituting for (25) and imposing the restrictions in (17) we obtain the evolution equation for the capital wedge in the CEP

$$\ln\left(1-\tau^K_{jt+1}\right) = \left(1-\rho^K_j\right)\ln\left(1-\tau^K_{jSS}\right) + \rho^K_j \ln\left(1-\tau^K_{jt}\right) + \sigma^K_j \varepsilon^K_{jt+1}.$$

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

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

$$+\left(1-\tau^{K}_{jt}\right)\left(r^{K}_{jt}+P^{*K}_{jt}\right)k_{jt}.$$

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

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

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

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

But note that for the return to capital

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

so that no scaling of capital returns is required.

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

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

Assuming a capital accumulation equation with adjustment costs of the form

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

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

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

The FOC in x implies

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

while the one in k yields

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

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

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

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

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

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

From the labor-leisure condition we get

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

From the Euler equation in physical capital we get

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

After substituting for λ^{CE} we obtain

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

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

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

Pseudo Social Planners Problem

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

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

which is equivalent to maximizing

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

The resource constraint becomes

$$\sum_j\left\{c_{jt}+\chi_{jt}^{I}x_{jt}+g_{jt}\right\}$$

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

while the capital evolution equation is

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

The first order conditions of this problem are

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

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

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

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

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

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

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

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

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

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

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

Substituting gives

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

The intensive form analog is then

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

so that

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

which after recursively substituting becomes

$$\begin{aligned} b_{jt} &= -E_t\left\{nx_{jt} + \beta\eta_{t+1}\frac{c_{Rt}}{c_{Rt+1}}nx_{jt+1} + \beta^2\eta_{t+1}\eta_{t+2}\frac{c_{Rt}}{c_{Rt+2}}nx_{jt+2} + \ldots\right\} \\ &= -E_t\left\{\sum_{s=0}^{\infty}\beta^s\left(\prod_{r=1}^{s}\eta_{t+r}\right)nx_{jt+s}\right\}, \end{aligned} \tag{26}$$

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 (26), 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 $\left(B_j/Y_j\right)_{ss}$ we have that

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

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

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

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

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

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

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

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

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

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

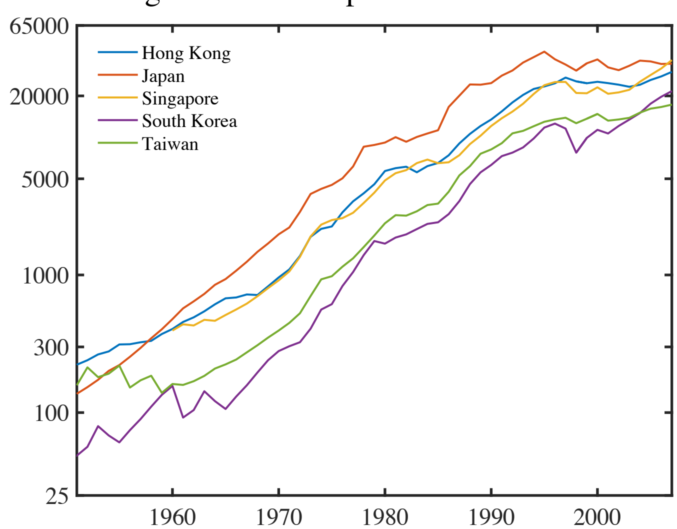
Appendix B: Data and Methods

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

Sample Definition

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 11, 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 11: Per Capita GDP in Asia



Other Asian economies were excluded on the grounds that their development proceeded differently. Most notably, as shown in Figure 12, 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 13, where they graphed separately to avoid clutter, the "Tiger Cub Economies" of Malaysia, Thailand, the Philippines and Indonesia also developed far less rapidly.

Figure 12: Per Capita GDP in Asia, Including China and India

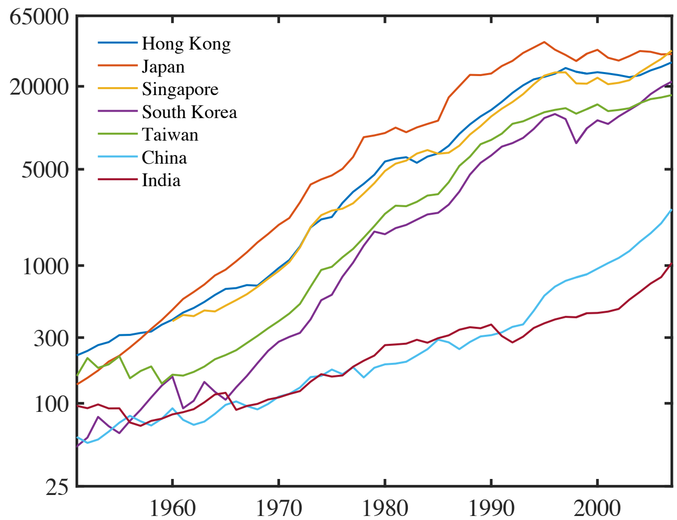
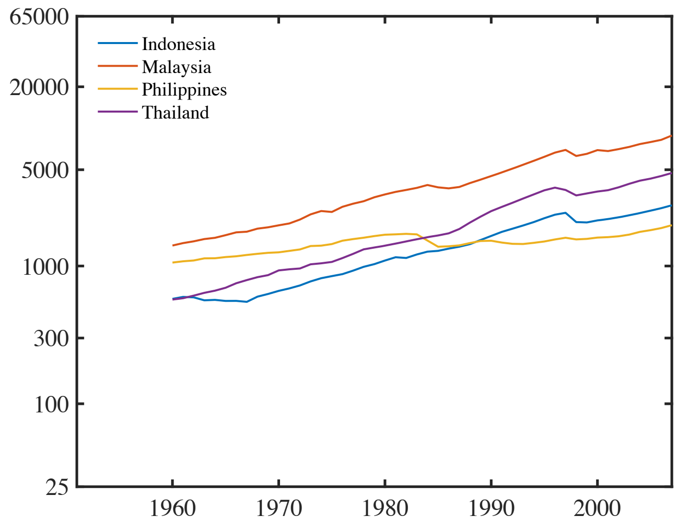
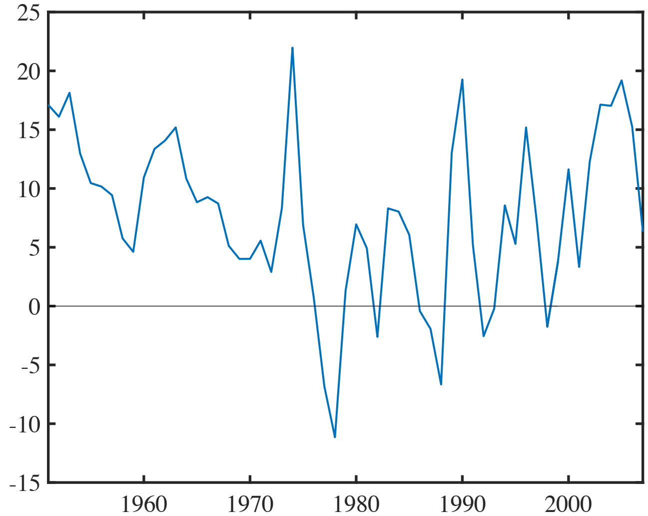


Figure 13: Per Capita GDP in the "Tiger Cub Economies"



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 14, stands apart as a major oil exporter that has run large trade surpluses during this period.

Figure 14: 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 15 to 18 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 15: Gross Domestic Product

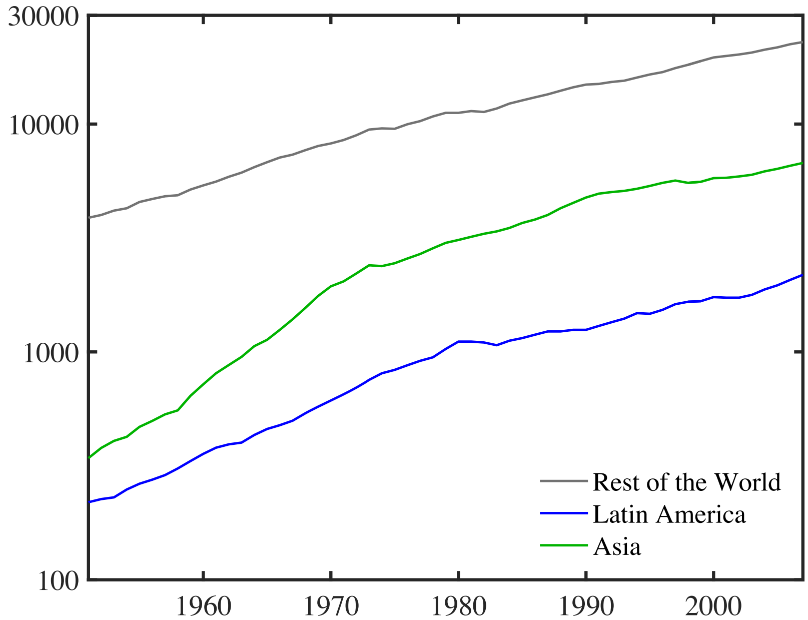


Figure 16: Consumption

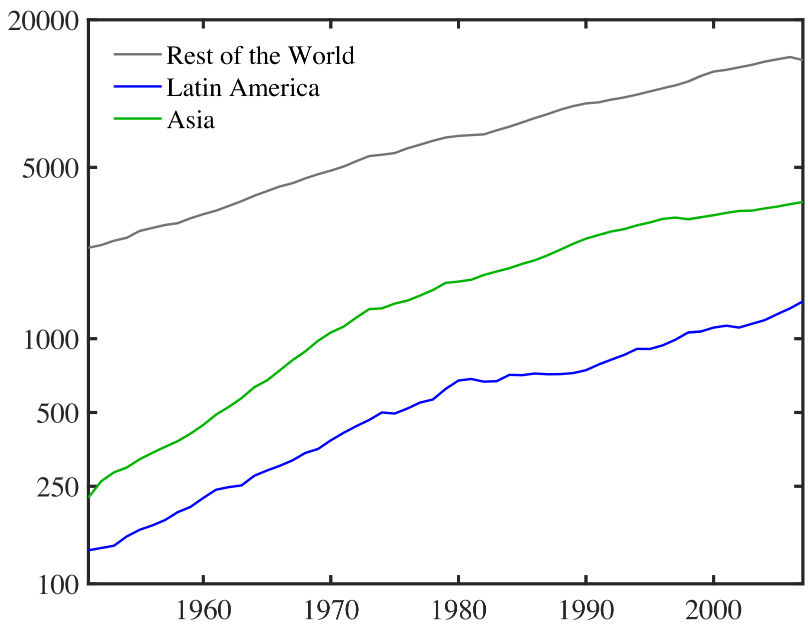


Figure 17: Investment

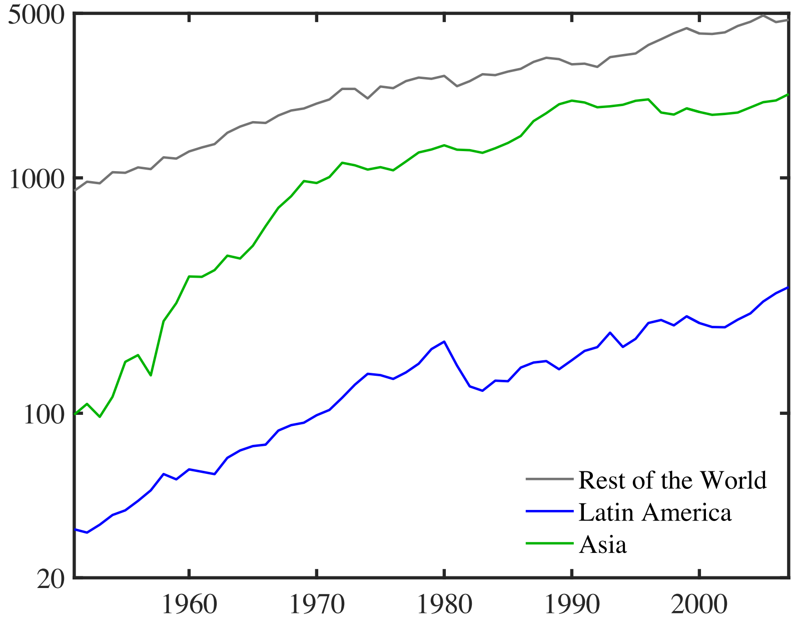
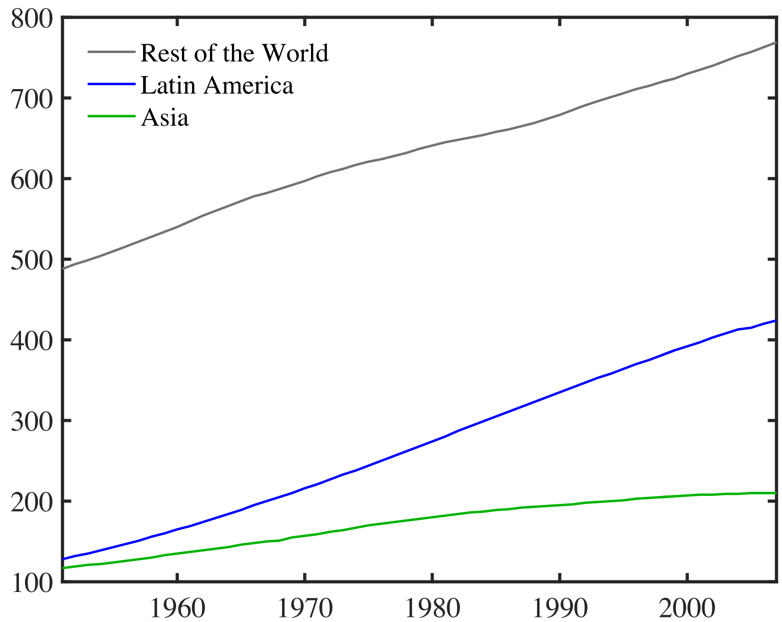


Figure 18: Population



Estimation

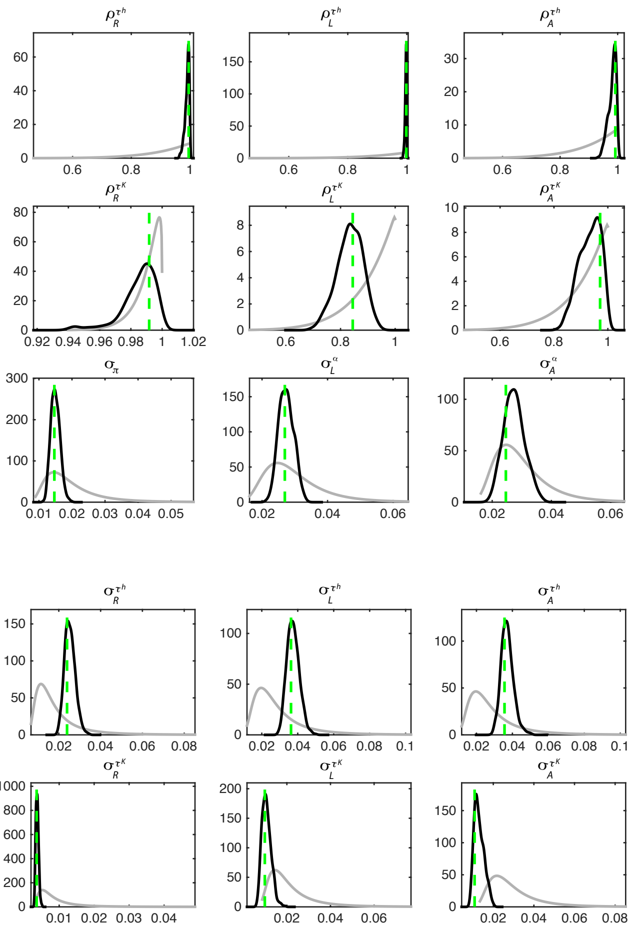
Figure 20 shows a plot of the prior distributions, posterior distributions and modes of the parameters estimated using Bayesian methods. From that figure it can be seen that our chosen priors are not restrictive with the estimated parameters reflecting the information contained in the data.

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 19 reports the prior and posterior distributions of the persistence and variance parameters of the wedges that we estimate.

Figure 19: 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 20: 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 21 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 21: Campos and Nugent Labor Market Rigidity Index for Asia and Latin America

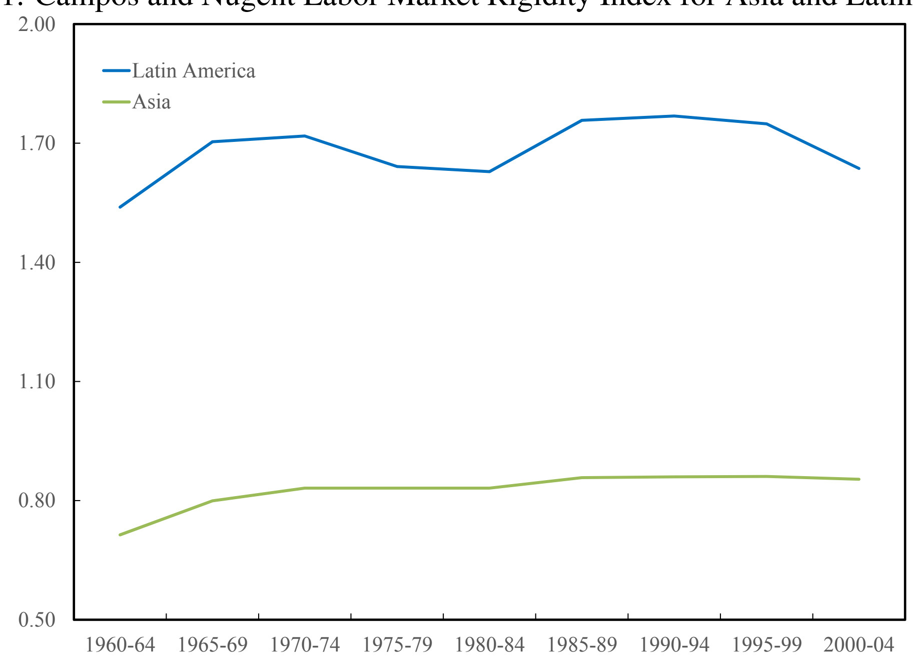
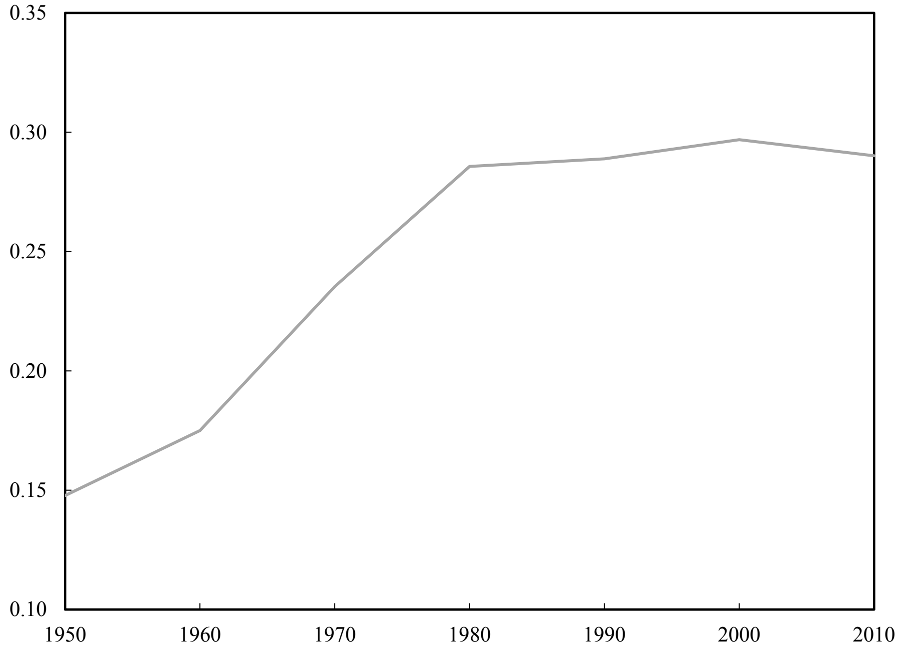


Figure 22 plots the tax wedge for European countries. The tax wedge is defined as

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

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 22: Tax Wedge for Europe



Domestic Financial Reforms Index

Figures 23 to 25 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 23: Domestic Financial Reforms Index for Latin America

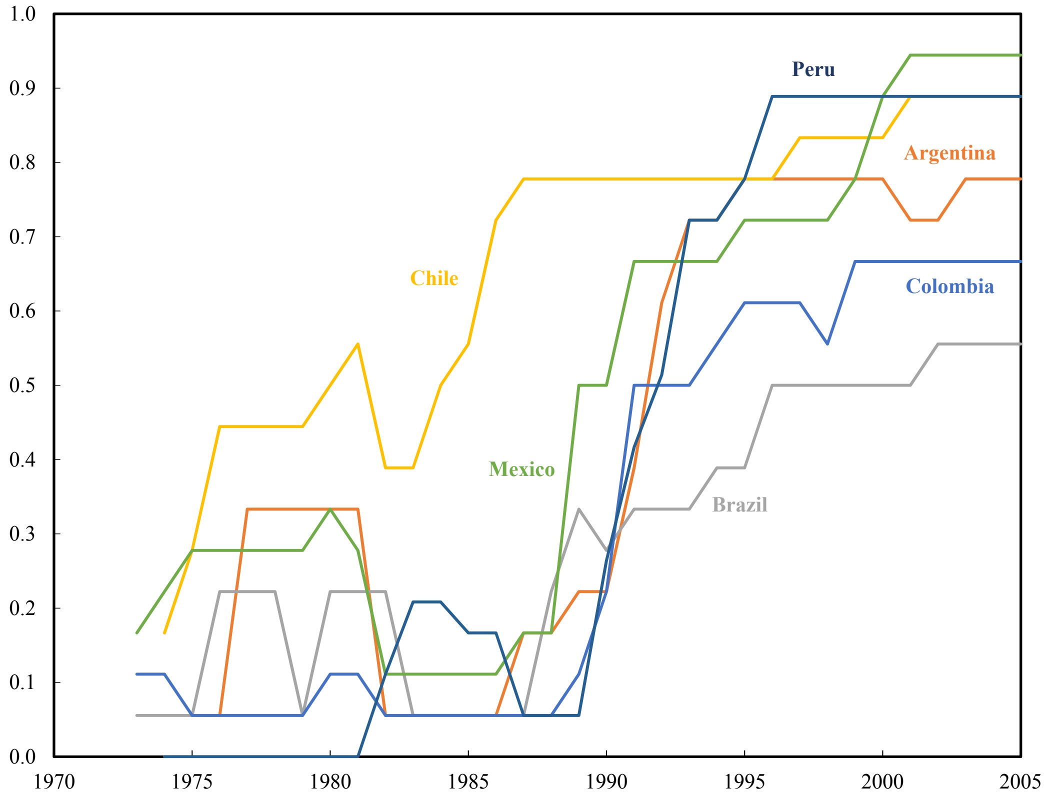


Figure 24: Domestic Financial Reforms Index for Asia

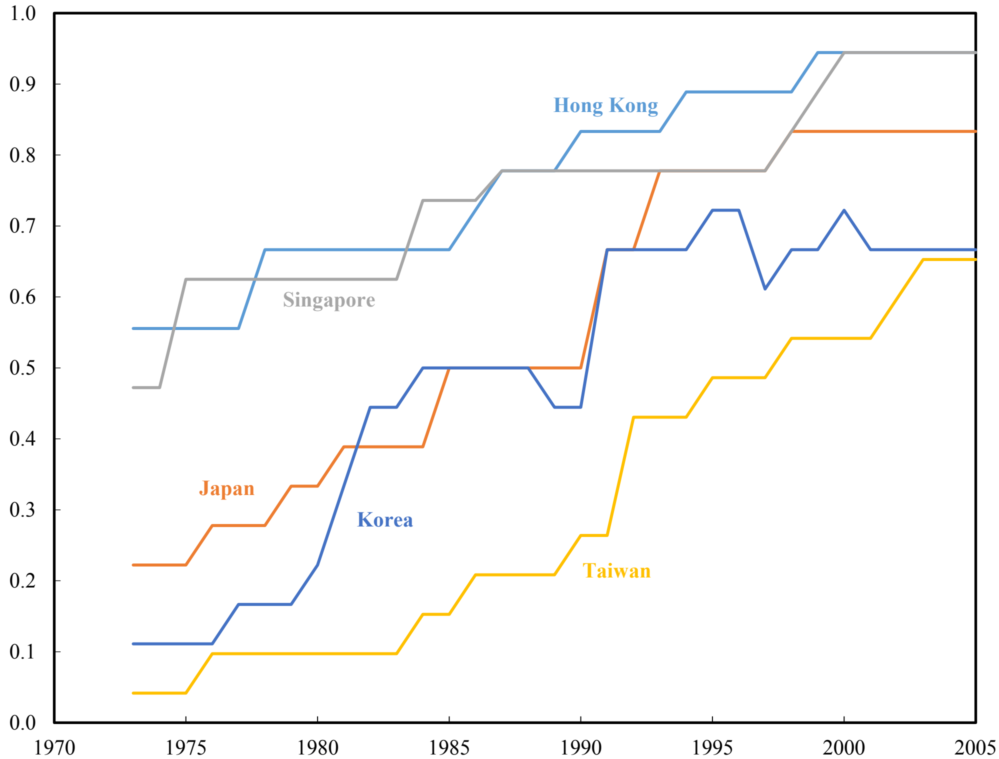
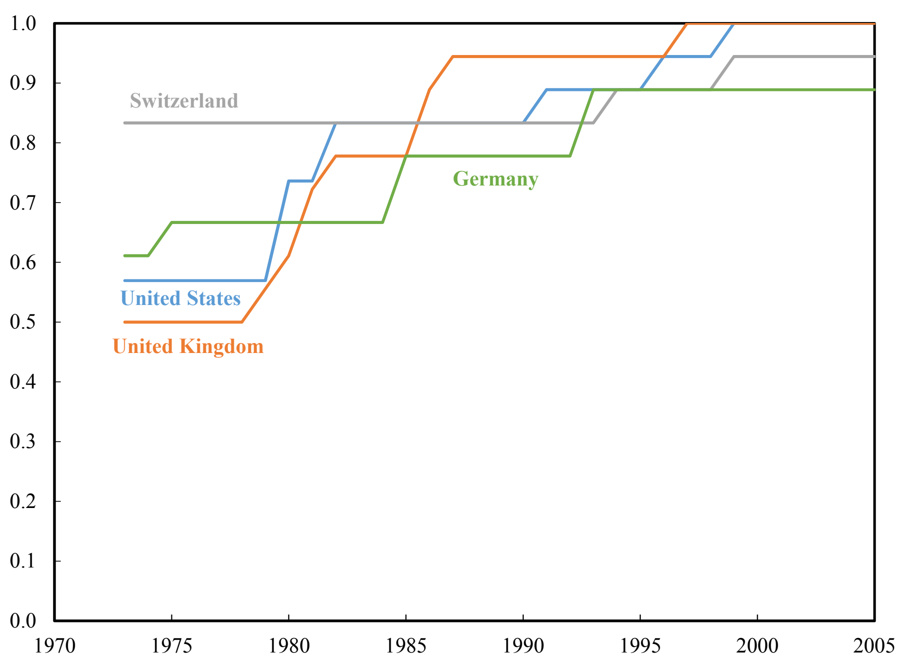


Figure 25: Domestic Financial Reforms Index for the Rest of the World



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 26: International Financial Reforms Index for Latin America

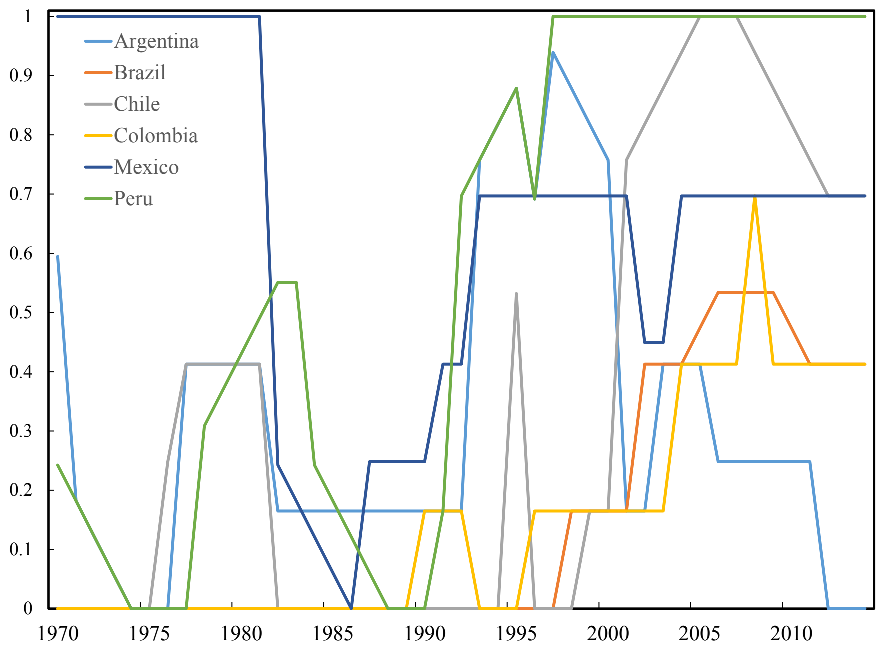


Figure 27: International Financial Reforms Index for Asia

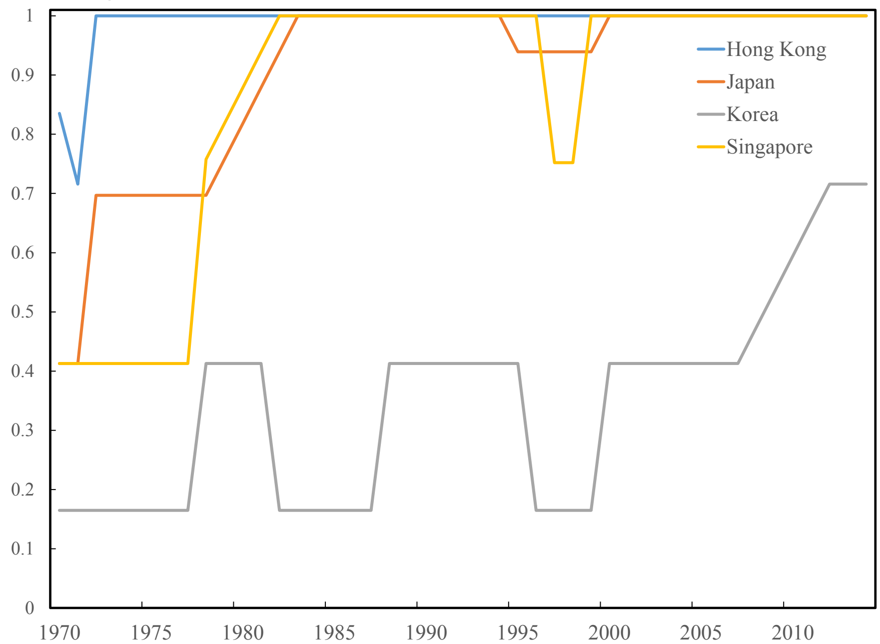
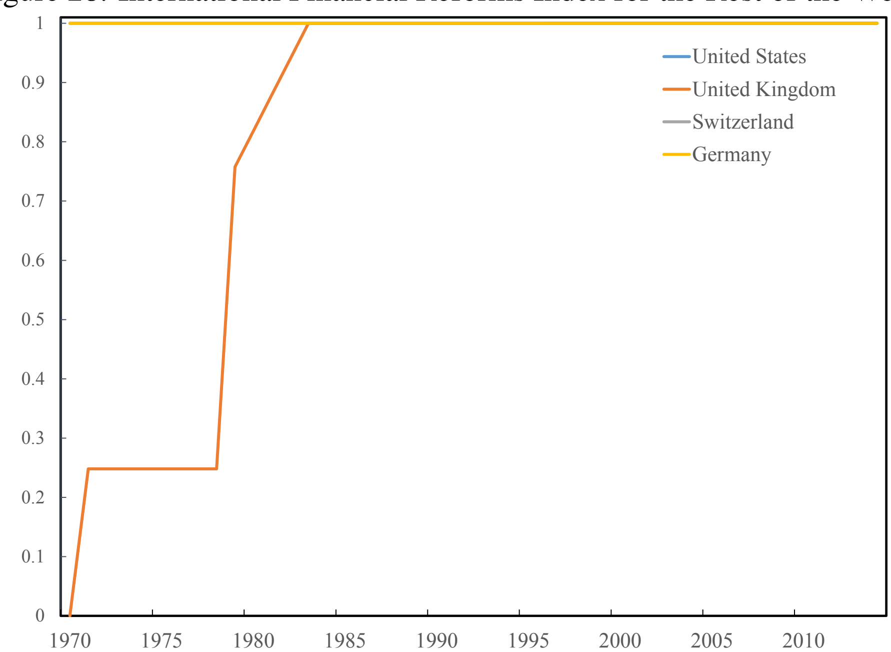


Figure 28: International Financial Reforms Index for the Rest of the World



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

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

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

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

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

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

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

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

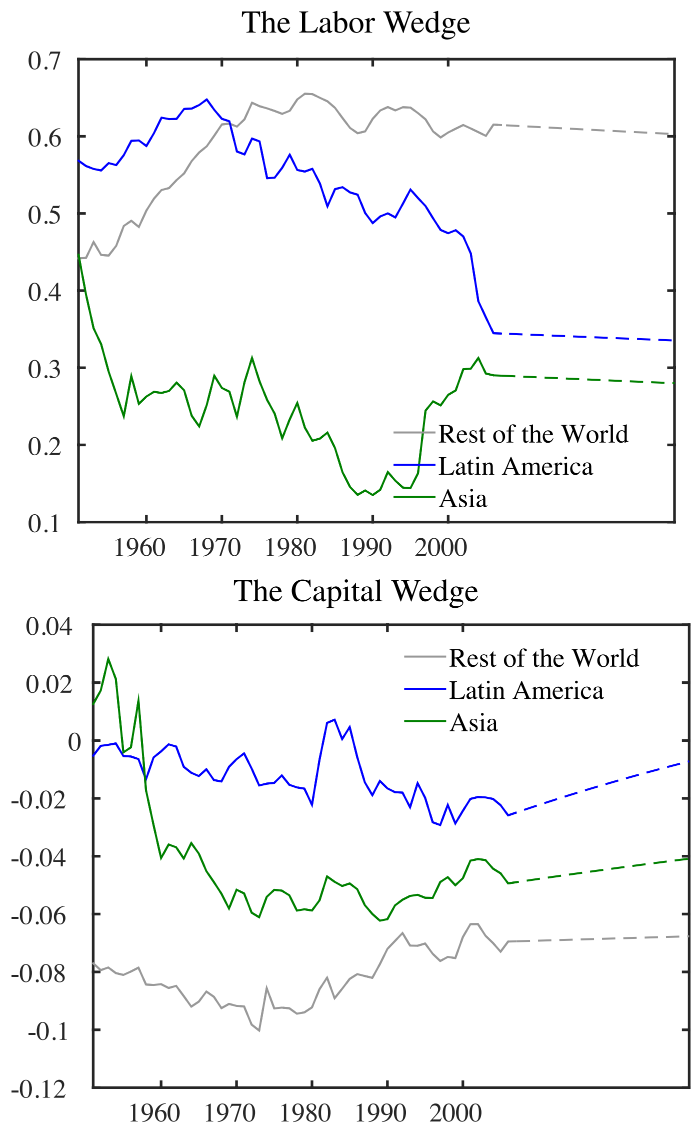
As shown in the expression, given data for country j at time t on hours h_{jt}, consumption C_{jt} and output Y_{jt}, and given the parameter γ, we can pin down the product of the labor wedge with the labor share divided by the parameter governing the value of leisure ψ. This means that we cannot separately 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 29: 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 29. Comparing these with the ones appearing in the paper (Figures 4 and 5), 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_{jt}^{h}, firms face a distortion that increases the cost of hiring labor above the wage rate. We will call this τ_{jt}^{hFIRM} 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

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

where the distortion faced by the firm enters positively (that is, as $1+\tau_{jt}^{hFIRM}$) 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

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

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 $\nu = 1/(4\kappa)$. 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 $\nu = 1/(2\kappa)$ 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 30 and 31 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 4, and 5 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 30: The Labor Wedge (Elasticity of 0.25)

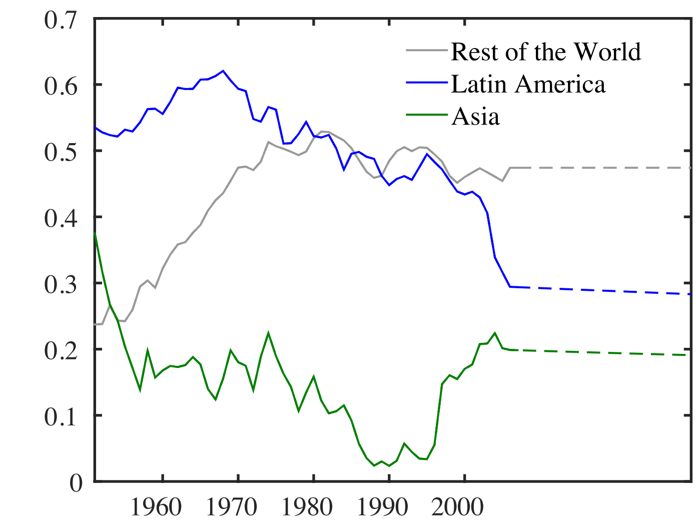
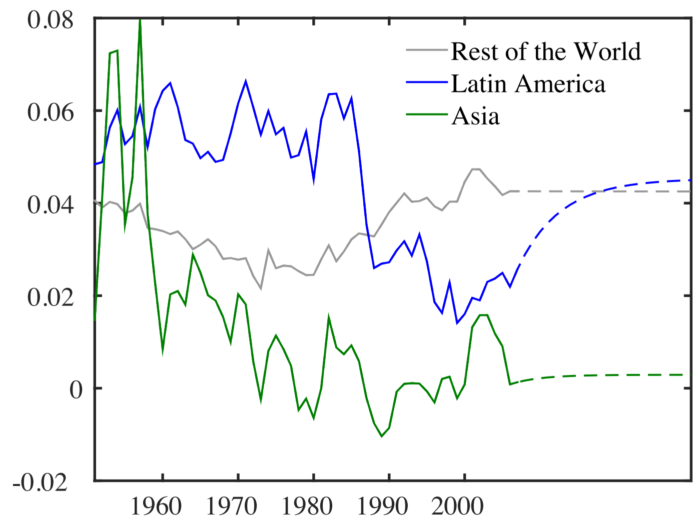


Figure 31: The Capital Wedge (Elasticity of 0.25)



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

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

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

so that the capital wedge is given by

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

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

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

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

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

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

$$GDP^T_{jt} = p_{jT}A_{jt}K^{\alpha}_{jt}\left(h_{jt}N_{jt}\right)^{1-\alpha},$$

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

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

where p^i_{jt} 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

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

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

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

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

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

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

$$\begin{aligned}
\beta^t\left(\chi_{jt}^C + \sum_{s=0}^{t} \mu_{js}\right)\frac{1}{C_{jt}} &= \lambda_t, \\
\beta^t\left(\chi_{jt}^C + \sum_{s=0}^{t} \mu_{js}\right)\psi H_{jt}^{\gamma} &= \lambda_t (1-\alpha)\frac{Y_{jt}}{H_{jt}},
\end{aligned}$$

$$\lambda_t = E_t \left[\lambda_{t+1} \left(\alpha \frac{Y_{jt+1}}{K_{jt+1}} + 1 - \delta \right) - \mu_{jt+1} \frac{dV_j^A \left(K_{jt+1}, s_{t+1} \right)}{dK_{jt+1}} \right].$$

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

$$\frac{C_{jt}}{C_{it}} = \frac{M_{jt}}{M_{it}}. \tag{27}$$

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

$$\tau_{jt}^h = 1 - \frac{\psi}{1-\alpha} H_{jt}^\gamma \frac{H_{jt}}{Y_{jt}} C_{jt} = 0, \tag{28}$$

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

$$\tau_{jt+1}^B = 1 - \frac{C_{jt+1}/C_{jt}}{C_{Rt+1}/C_{Rt}} = 1 - \frac{M_{jt+1}/M_{jt}}{M_{Rt+1}/M_{Rt}}. \tag{29}$$

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

$$\begin{aligned} 1 &= \beta E_t \left[\left(\frac{M_{jt+1}}{M_{jt}} \right) \frac{C_{jt}}{C_{jt+1}} \left(\alpha \frac{Y_{jt+1}}{K_{jt+1}} + 1 - \delta \right) - \mu_{jt+1} \frac{dV_j^A \left(K_{jt+1}, s_{t+1} \right)}{dK_{jt+1}} \right] \\ &= \beta E_t \left[\frac{C_{jt}}{C_{jt+1}} \left(\frac{M_{jt+1}}{M_{jt}} - \mu_{jt+1} \frac{C_{jt+1}}{C_{jt}} \frac{1}{A_{jt+1} \alpha k_{jt+1}^{\alpha-1} + 1 - \delta} \frac{dV_j^A \left(K_{jt+1}, s_{t+1} \right)}{dK_{jt+1}} \right) \right. \\ &\quad \left. \times \left(\alpha \frac{Y_{jt+1}}{K_{jt+1}} + 1 - \delta \right) \right]. \end{aligned} \tag{30}$$

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

$$1 = \beta E_t \left[\frac{C_{jt}}{C_{jt+1}} \left(1 - \tau_{jt+1}^K \right) \left(\alpha \frac{Y_{jt+1}}{K_{jt+1}} + 1 - \delta \right) \right]. \tag{31}$$

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.

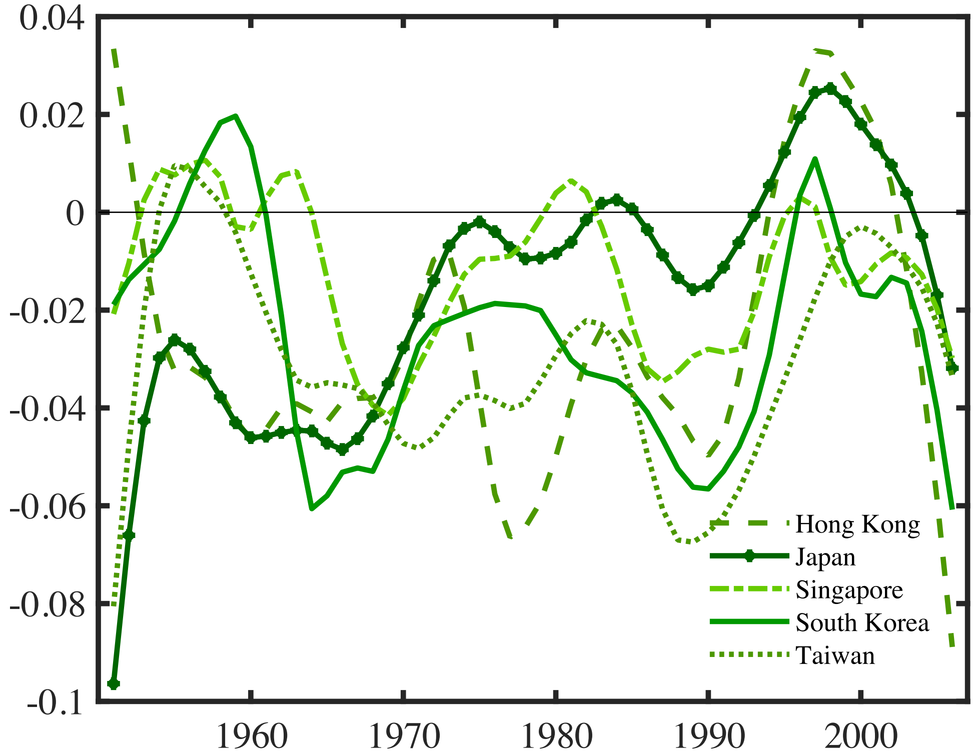
Appendix F: Country Level Wedges

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 32 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.

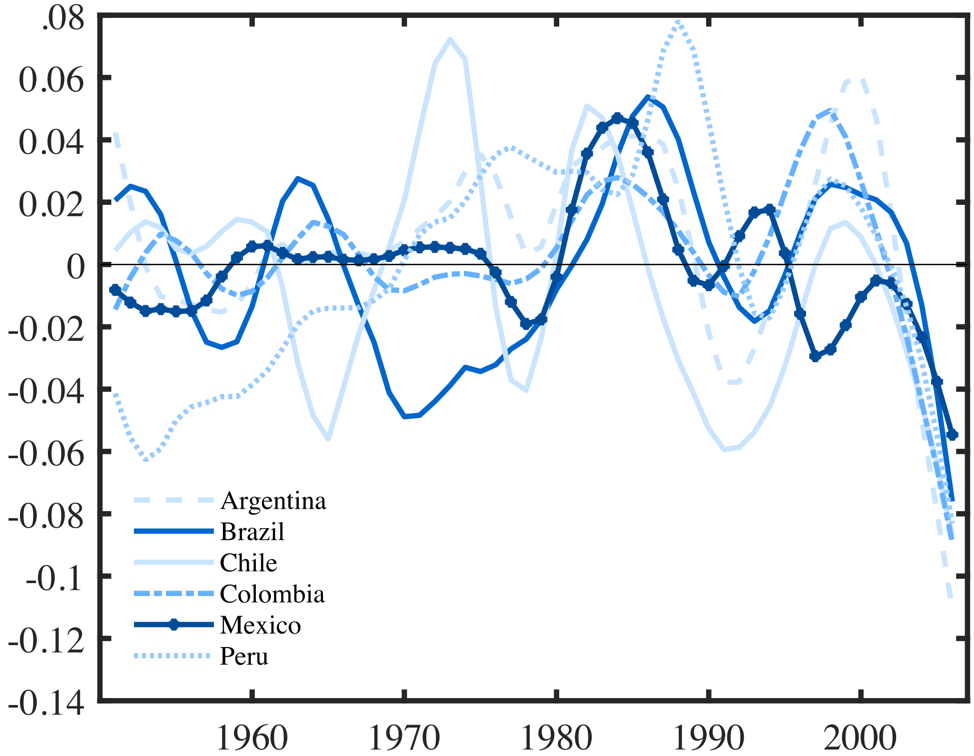
These overall common patterns are quite close to those for the Asian region aggregate found in Figure 3 of the paper. Note that, as a result of the fact that Japan and South Korea are the largest countries in the region, the aggregate international wedge in the paper most closely follows the individual 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 32: International Wedge for Asian Countries



Next, Figure 33 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 33: International Wedge for Latin American Countries

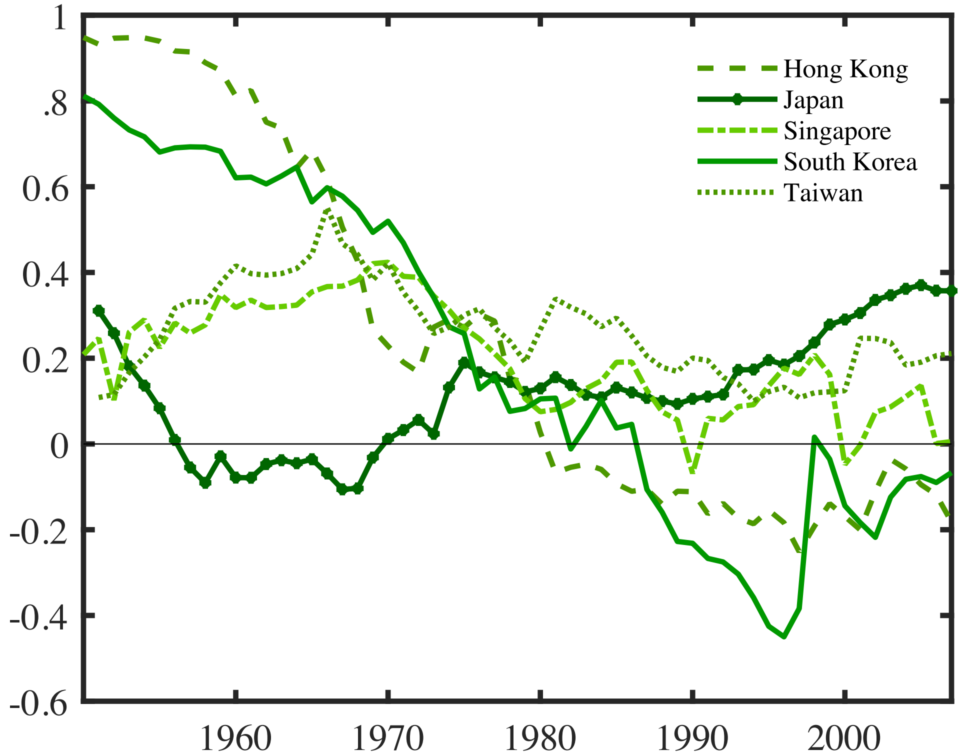


The case of Mexico is particularly interesting. Like the other countries, the tax on borrowing for Mexico starts falling when it signs its Brady plan (Mexico signed its first agreement in March 1989 and its second in February 1990, and the international wedge for Mexico reaches its local minimum in 1989 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.

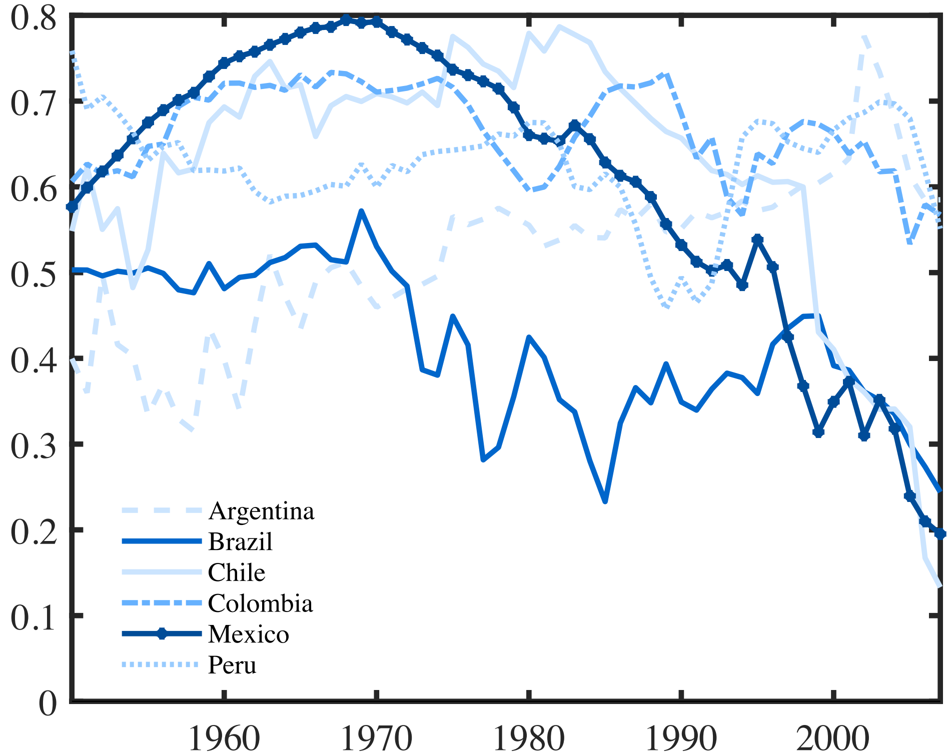
Figure 34: Labor Wedge for Asian Countries



Turning to the labor wedge, Figure 34 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 35 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 35: 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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